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# RUSC (VOL. 9, No. 1, JANUARY 2012)

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# Editorial

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Vice President for Postgraduate Studies and Lifelong Learning, Open University of Catalonia (UOC)
and director of RUSC

In the number we are presenting now, the first one in the ninth year of our Universities and Knowledge Society Journal *RUSC*, there are several major new features and changes that we hope our subscribers and readers will like.

Firstly, we have changed and improved the journal's header. After a period of reflection, the journal's Editorial Board, Director and Editorial Secretary decided on a header in which the acronym *RUSC* acquires greater prominence and a more contemporary look. The name of the journal appears in Spanish and English, which is a clear indication of our commitment to publish all articles in both languages, and the three concepts that are key to the focus of *RUSC* are highlighted: network, university and e-learning. We hope you like the result!

The second new feature of *RUSC* from 2012 is the adoption of the Digital Object Identifier (DOI) System for identifying content objects in the digital environment. Each DOI unmistakably and persistently identifies the object with which it is associated, and allows digital object citations to be identified. As an ISO standard, it represents yet another step towards the journal's standardisation. For more information, please go to www.doi.org.

Thirdly, we have added the option to print an issue in its entirety, including the front cover.

Besides these new features, which undeniably improve *RUSC*'s publication and facilitate its positioning as a journal of reference in the field of university e-learning research, we have improved our indexing references. Having recently been incorporated into the bibliographic database Scopus, *RUSC* has attained a higher dissemination index in the *Matriz de Información para la Evaluación de Revistas* (MIAR, Information Matrix for Journal Evaluation), which now stands at 7.345 (http://miar.ub.es/consulta.php?issn=1698-580X). This improvement in the secondary dissemination compound index (ICDS) will allow *RUSC* to be reclassified into category B in the next update of the CARHUS Plus+ lists (AGAUR, Agency for Management of University and Research Grants).

At *RUSC*, work on the journal's internationalisation continues. In this regard, in 2012 we plan to sign international agreements with important institutions that will allow us to raise the quality and increase the periodicity of the journal.

Between January and November 2011, *RUSC* had a mean of 9,957 visits and a mean of 5,891 users. The total number of PDF downloads in that period was 23,886.

*RUSC* has 1,587 subscribers, and we would like to thank each and every one of them for their trust and interest in the journal.

Finally, we would like to present this number, which we hope you will find interesting. In the Research Articles section, we are publishing:

- "University Students' Digital Reading and Writing Migration" by L. A. Argüello.
- "Preservation of Learning Objects in Digital Repositories" by J. Boté and J. Minguillón.
- "University Teaching in the 2.0 Era: Virtual Campus Teaching Competencies" by M. E. del Moral and L. Villalustre.
- "Social Networks and University Spaces. Knowledge and Open Innovation in the Ibero-American Knowledge Space" by D. Domínguez and J. F. Álvarez.
- "Wikis in Teaching: An Experiment with WikiHaskell and StatMediaWiki" by M. Palomo, I. Medina, E. J. Rodríguez and F. Palomo.

And the Dossier section of this number is about mathematical e-learning. Coordinated by Ángel A. Juan and María Antonia Huertas (Open University of Catalonia, UOC), Hans Cuypers (Eindhoven University of Technology) and Birgit Loch (Swinburne University of Technology, Melbourne), the Dossier offers an interesting selection of five articles (originals in English and translated versions in Spanish) providing a complete, international view of the latest advances in mathematical e-learning:

- "The Role of Digital, Formative Testing in e-Learning for Mathematics: A Case Study in the Netherlands" by D. T. Tempelaar et al.
- "A Knowledge-Skill-Competencies e-Learning Model in Mathematics" by G. Albano.
- "Activity Theory and e-Course Design: An Experience in Discrete Mathematics for Computer Science" by J. L. Ramírez et al.
- "Distance Training of Mathematics Teachers: The *Early Statistics* Experience" by M. Meletiou-Mavrotheris and A. Serradó.
- "On How Moodle Quizzes Can Contribute to the Formative e-Assessment of First-Year Engineering Students in Mathematics Courses" by M. Blanco and M. Ginovart.

The Dossier also includes a review by H. Cuypers of the book *Teaching Mathematics Online: Emergent Technologies and Methodologies*, which has recently been published by IGI Global.

And finally, two reviews of new books conclude this January 2012 number.

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ARTICLE

# University Students' Digital Reading and Writing Migration

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## Abstract

This paper discusses the impact of new electronic media on young university students' reading and writing habits. The methodological design is ethnographic and involved an observation register of reading and writing situations. The analysis was based on several categories: written-material culture, text-screen interaction, intertextuality, digital migration and the convergence of literacies. The results show that the digital migration of university readers and writers is evident from the way they structure a document, from Google's influence on the search for and selection of documentary and bibliographic sources, and from the way they incorporate citations in texts.

## Keywords

digital natives, digital screens, written-material culture, young university students

## *Migraciones digitales de lectura y escritura en estudiantes universitarios*

### *Resumen*

*Este texto presenta un fenómeno comunicacional de lectura y escritura en el horizonte de los nuevos medios electrónicos. El diseño metodológico es de carácter etnográfico por cuanto se ha realizado un registro de observación de situaciones de escritura y lectura. El análisis se realiza a partir de las categorías de cul-*

*tura material escrita, interacción texto-pantalla, intertextualidad, migraciones digitales y convergencia de alfabetos. Los resultados se hacen evidentes en las migraciones digitales del lector y escritor universitario al organizar una página, en la influencia de Google en la búsqueda y selección de fuentes documentales y bibliográficas, así como en la forma de incorporar citas en los textos.*

***Palabras clave***
*nativos digitales, pantallas digitales, cultura material escrita, jóvenes universitarios*

# Introduction

## 1. Field of inquiry

The convergence of digital screens has familiarised young people with ICT-mediated lifestyles. From this perspective, the questions that arise are:

- *What communicative interactions and digital interactivities do young university students construct around the electronic screens that mediate in their textual production?*
- *Do electronic screens structure young university students' textual production?*
- *What are young university students' reading and writing practices?*

## 2. Background

The prior research on which this article is based requires an acknowledgment of three referential domains: *young people, screens and digital media*; *the Internet and young university students*; and *university reading and writing practices.*

### 2.1 Young people, screens and digital media

Research on *young people, screens and digital media* has generated a wealth of studies in Latin America. These studies have gradually forged concepts such as *jóvenes.com* (akin to Generation Z), the *multimedia generation* and the *digital generation*. Professor María Teresa Quiroz has published two books entitled *Jóvenes e Internet. Entre el pensar y el sentir* (2004) and *La edad de la pantalla. Tecnologías interactivas y jóvenes peruanos* (2008). The setting for the first one was the city of Lima, and it deals with the city's schoolchildren's thoughts on and feelings about television, computers, video games and the Internet. Based on interviews and focus groups, it explores the schoolchildren's conceptions of books, virtual communication (chats, instant messaging), schools, teachers, the country and their own life projects. The second books deals with the changes arising from ICT access and use, and new forms of sensibility, taking schools and new communication media as the reality, although the work settings were Chiclayo (a city on the coast), Iquitos (a city in the rainforest) and Cusco (a city in the mountains).

The article "Navigators and castaways in cyberspace: psychosocial experience and cultural practices in schoolchildren's appropriation of the Internet" by José Cabrera Paz (2001) forms part of a research project that comes under the "PAN-LAC Small-Grant Program on ICT Research Issues". It explores the Internet's incorporation into school culture and Internet use. The methodological design had a psychosocial approach based on an ethnographic qualitative model. Seventy-six interviews were conducted in six schools in Bogotá (Colombia) and a focus group comprising 16 participants was held.

In Bolivia, work has been undertaken on the "ICT for Development" research line. Researchers Patricia Uberhuaga Candia, Orlando Arratia Jiménez and Mariela García Miranda did a study on young people from Cochabamba (2005 and 2006). The results were published in two books: *Entre lo colectivo y lo individual. El puente de transición de las identidades de los jóvenes en el uso del Internet* (2005) and *Jóvenes.com. Internet en los barrios populares de Cochabamba* (2006). The first one explores the impact of ICTs, Internet use and its expression in the subjectivity of young Bolivian people from three working-class neighbourhoods of Cochabamba. The second one deals with the cultural practices inherent to the working-class neighbourhoods of Cochabamba and young people's interaction with the Internet for entertainment purposes.

Roxana Morduchowics wrote the book entitled *The Multimedia Generation. Young People's Cultural Meanings, Consumptions and Practices*, in which she offers an insight into how new generations use ICTs. The book is based on a survey carried out in Argentina on a sample of 3,330 young people, 3,300 adults and 3,300 households, under the Ministry of Education's "Schools and Media" programme. The book explores the cultural meanings, uses and practices of *watching television*, *listening to music*, *reading books*, *talking on mobile phones* and *surfing the Internet*.

Research on *young people, screens and digital media* has also generated a wealth of important works in Canada, France, the United Kingdom, the United States and Norway. The works entitled "Les jeunes et Internet: Représentations, usages et appropriations" (2001) by Évelyne Bevort and Isabelle Bréda, and "Les jeunes et Internet. Représentations, utilisation et appropriations" (2001) by Jacques Piette, Christian-Marie Pons, Luc Giroux and Florence Millerand contain the results obtained in France and Canada (Québec) of a joint project on "Young People and the Internet" involving France, Canada (Québec), Belgium, Spain, Italy and Switzerland.

The first one was undertaken in Paris (a large city) and La Rochelle (a small city); the second one was undertaken in Montreal (a large city) and Sherbrooke (a small city). The parameters of the joint reports' common protocol were to explore young people's representations of the Internet phenomenon, online content, and the social, family and school impact of Internet use. In addition, the work examined the appropriation of Internet technologies in daily life on the basis of conducts, learning methods, media consumption habits and attention. Finally, they ascertained frequency of use, duration of connection, and place and conditions of access. The methodological design was based on a questionnaire and interviews (24 in both cases), with a sample of 524 young people (for the French part) and 576 young people (for the Canadian part).

The work entitled "Living and Learning with New Media: Summary of Findings from the Digital Youth Project" (2008) is the summary publication of results from the "Digital Youth Research" project

undertaken in the United States under the guidance of anthropologist Mimi Ito at the University of California, Irvine. The results identified three kinds of participation: "hanging out" (a conduct of young internauts who use messages with digital tools to keep in touch with their friends without any pre-established intention), "messing around" (an interactive social practice in which young surfers search for online information without any prior intention, with access to online digital resources) and "geeking out" (a digital social practice of surfing under the expertise of digital tools and participation in specialist communities of online experts). In the project design, 659 semi-structured interviews were conducted, 28 study diaries were kept and focus groups comprising 67 participants were held. There were also 10,468 Myspace and Facebook profiles, and 15 online focus group discussion forums.

"Young people, new media" by Sonia Livingstone and Moira Bovill (1999) is the final report of the "Children, Young People and the Changing Media Environment" project undertaken in the United Kingdom. This project was undertaken on the basis of category references that went from childhood to childhood and youth, from television to the media ecosystem, and from the impact to the uses and meanings of media. It explored new media in relation to social change in accordance with the public/private context, lifestyle diversity, activity convergence (work, relationships and education) and changes in modes of communication. The project's methodological design had a qualitative phase (interviews conducted with the more than 200 children and young people in 27 groups) and a quantitative phase (a questionnaire completed by 1,303 children).

"Onliners. A report about youth and the Internet" by Taran L. Bjørnstad and Tom Ellingsen (2004) is a report on research undertaken in Norway for The Norwegian Board of Film Classification on young people and Internet use in accordance with various parameters: role, uses and meanings, and encounters between available content and personal preferences in terms of content use. The study dealt with young people's initial contact with the Internet, places of use, e-mail (Hotmail), chats, online gaming, the Internet and Obvies (music downloads), the Internet and school culture, and uses of available content. The methodological design employed a qualitative approach. In the research process, the researchers selected a school A and a school B. The Internet was a focal area of teaching in school A but not in school B. In total, interviews with 40 pupils (years 8 and 10) were conducted.

## 2.2 The Internet and young university students

Research on *the Internet and young university students* has left a trail of works in which *representations*, *uses* and *meanings of the Internet* are studied. The report entitled "Patrones de uso de internet en estudiantes universitarios" by Montserrat Sánchez Ortuño, María Raquel Sánchez Ruiz and Agustín Romero Medina (2000) contains the research results of a project that analysed differences in accordance with several variables of Internet use: the most commonly used applications, reasons for connecting, session duration and addictive Internet use. The methodological design involved a survey of 113 students at the University of Murcia.

"Uso de internet por los estudiantes de la Universidad Autónoma de Madrid" by Eva Medina and José Vicens Otero (2002) analysed Internet use by students at the Autonomous University of Madrid. It was about professional and academic use, and the most commonly used services were e-mail,

general information searches and study information searches. The research design was based on a sample of 765 surveyed students from a variety of faculties and schools (Teacher Training, Medicine, Law, Psychology, Philosophy, Economics, Chemistry, Biology, Physics and Information Technology).

"Conocimientos, habilidades y características del acceso a Internet en estudiantes de medicina de una Universidad Peruana" by Pedro Horna, Walter Curioso, Carlos Guillén, Carla Torres and Jorge Kawano is an article that examines knowledge, skills and the Internet access characteristics of Medicine students at Cayetano Heredia Peruvian University. The most commonly used services were e-mail and gaming. The students had no command of tools focusing on health-related information searches. The research design was structured around a survey of 272 Medicine students (out of an enrolled total of 690).

## 2.3 University reading and writing practices

Research on *university reading and writing practices* involves several variables, such as access to texts, reading habits and frequency, and text types. "Realidad y simulación de la lectura universitaria: el caso de la UAEM" by Guadalupe Carrillo Torea (2007) is an exploratory study based on surveys conducted with students at the Autonomous University of Mexico State to ascertain their reading levels, their reading defects and the projection of their cultural levels. The research design was structured around a survey.

"Las prácticas de lectura en estudiantes universitarios" by Ana Teberosky, Joan Guhrdia and José Escoriza (1996) reports on exploratory research into study reading practices, or exercising study reading skills, in a sample of 243 Psychology students and 156 Teacher Training students at the University of Barcelona. It also describes the study and reading materials that the students used for their courses, as well as the availability of such materials in the library. The methodological design was based on an indirect measurement test of exposure to reading materials and its correlation to the university students' academic levels. The conclusion drawn from the research was that the future of reading in higher education could be categorised into three types: superficial reading, which only extracts information for an exam; fragmentary reading, which severs the relationship between the content and the medium; and anonymous reading, in which titles and/or authors are unknown.

*Lectura y escritura en la universidad: una investigación diagnóstica* by Mireya Cisneros (2005) is a book published following the research project entitled "Estrategias de lectura y escritura usadas por estudiantes que ingresan a la universidad". The project was structured around a corpus of expository and argumentative texts read by 1,413 students at the Technological University of Pereira, with whom work was undertaken on reading comprehension and text construction processes.

The book entitled *Lecturas y escrituras juveniles. Entre el placer, el conformismo y la desobediencia* by Giovanna Carvajal Barrios (2008) presents the results of a research project on young university students' reading practices in the context of cultural consumption and production processes. The research examined the reading and writing practices of five students at the University of Valle, as well as their modes of reading and writing. The methodological design was qualitative in nature, and the five cases were registered through discussion groups and in-depth interviews.

# Methodology

## 3. Methodological design

This qualitative research was structured around the observation and monitoring of communicative and educational situations, the description of textual representations and the systematisation of descriptive notes.

In order to organise the focus groups, the topics of discussion were the Communicative Competencies and Research Design courses that the students took in the first and second academic periods of 2009. There were three focus groups:

- Group 1: "University Readers and Writers", comprising 11 students.
- Group 2: "The Internet in Universities", comprising 11 students.
- Group 3: "Evaluation of Books", comprising 33 students.

In the focus groups, interviews were conducted with 20 students on the Systems Engineering academic programme's Communicative Competencies course that the students took in the first and second academic periods of 2009.

The students forming part of these focus groups were young people aged 16-21 from the urban and suburban catchment areas of the university. Their personal technology appropriation traits were defined by the ownership of mobile devices that they brought with them to the university, as well as by having competencies to access social networks and websites.

Textual information for the documentary register was collected for the first academic period of 2008, the second academic period of 2008 and the first academic period of 2009 through assignments for the Formulating Research Projects course on the Systems Engineering academic programme. In the first academic period of 2008, six hardcopy and electronic assignments (the latter attached as files to e-mails) were registered. In the second academic period of 2008, nine hardcopy and two electronic assignments (the latter attached as files to e-mails) were registered. In the first academic period of 2009, five hardcopy and electronic assignments (the latter attached as files to e-mails) were registered. In the second academic period of 2009, 20 hardcopy assignments were registered.

## 4. Analysis categories

The questions that need to be posed here are: Which angle of analysis should be adopted in order to approach the complexity of adolescent events associated with an academic world that has fixed the printed word in books? And how do these young people turn reading and writing into a subject of interconnection and intertextuality?

The matter of interconnection deals with the young university students' links to an interactive world that generates rites of passage from an analogue culture to a digital culture. The matter of

intertextuality questions hardcopy textual production, taking account of the shift from text written down on paper to the production of documents on the surface of a screen.

In this web of concepts, attempts are made to study the university students' answers, uses, practices, habits and endeavours in reading and writing processes on the basis of the following analysis categories: written-material culture, text-screen interaction and digital migration.

### 4.1. Written-material culture

A textual culture is evident in hardcopy and on-screen inscriptions that structure the cognitive domains of reading and writing processes (Chartier, 1995; Vanderdorpe, 2003) in the light of new media for reading, writing, looking up and processing textual information, and in the light of a type of written-material culture (Petrucci, 2003). This textual evaluation means distinguishing, as Raffaele Simone (1998, 2001) does, between books as a closed textual medium and text as a material surface open to any medium.

### 4.2 Text-screen interaction

The on-screen display and manipulation of text, or its 'screenisation' (Turkle, 1998; Levis, 2009), together with the transformation of the reading and writing medium, is evident in a new generation of young people whose cultural capital focuses on popular things and on electronic media (Morduchowics, 2003; Buckingham, 2000); these are the young people who instigate a discursive interaction between human beings and computers (Herrings, 2001).

### 4.3 Digital migration

In the context of the research on which this study is based, the digital migration of the students (digital natives) does not go through the linear sequences of the print culture (Mead, 1970). Rather, the students interconnect by means of the electrification and digitisation of the mind; a mind that is connected to surfing, searching and browsing networks. At this level, there are two vocabularies and two literacies that come together in a clash of generations (Mead, 1970): analogue hardcopy and digital on-screen text. This gives rise to an ontological and semantic regime of digital natives and immigrants (Prensky, 2001; Boschma, 2008; Montgomery, 2006; Palfrey & Glasser, 2008).

# Results

## 5. Digital reading and writing migration

The rise of the Internet has changed the way we look up documentary and bibliographical sources to write university assignments. In its unlimited space of search potential, it is possible to find digital

books, electronic periodical publications, specialised databases, and content and search websites that help us locate topics, texts and authors.

University students reading and writing processes leave a trail of the value they place on books as learning objects, of Internet use and access habits in universities, and of texts that interact with other texts (referred to here as "digital palimpsests").

## 5.1 Evaluation of books

Books are still the point of reference from which young university students value reading processes. This indicates that, in spite of not having strong linear reading habits, students consider books as an immediate reference, associated with the processing of information that is not available in its entirety. Books are still the constituent axis of searching for information for study purposes.

> **Student N:** *Books give more comprehensive information about lecture topics, the Internet only gives summarised information… there are so many documents on the Internet about the same topic… a book is more comprehensive.*
>
> **Student J:** *Well, Mr Argüello, books are very important for studying… but they're not fun… take Penney's* Calculus, for example… *the* Calculus *book isn't fun.*

Books are at an intersection of interests, between being fun and existing as physical objects of compulsory reading. In this move, they are perceived as physical objects associated with compulsory reading for the purpose of studying lecture topics.

> **Student M:** *Students don't like the books our lecturers bring to lectures… and the worst thing is that they bring us blurry – and even scrappy – photocopies… without any titles and without knowing who wrote them… so reading is really boring… and then what do I do? Well, I enter the name of the author and the title of the photocopied book… everything comes up on Google…*

On this point, books as objects of knowledge are valued for their curricular practicality because access to information is limited to course content, so the content is cross linked and there is proximity between the content of the book and of the course. At this level, an encounter between two modes of access to academic information takes place: from books, which are limited and course focused, and from the Internet, which is open and complementary to course content.

> **Student J:** *(continued)… The* Calculus *book isn't fun… and the answers to the exercises are on the Internet… what the lecturer explains on the board is sometimes so confusing that it's easier to do with simulations on computer screens… there may be exercises in the book that are easier to see on maths web pages.*

When evaluating books as textual complements available in various formats, students add a component of compulsoriness to hardcopy books. They consider books to be restricted, didactic objects of knowledge, which discourages them from approaching them. For the university students, books carry the burden of seriousness and difficulty associated with study reading, within the context of a university schooling tradition that has encouraged the association books with *study reading* as a compulsory academic activity.

> **Student N:** … *it's not that we don't read… if the books we use on Systems are practical… there isn't time to think about the* Calculus *book… or about the one on Operating Systems… some lecturers don't even bring us a reading list… and some don't even hand out the course programme… you need time… and patience to get into a book… I work on and read the lecture stuff…*

## 5.2 The Internet in universities

Students' Internet use in universities is proportionate to the impact of personal meanings and uses of Internet services, owing to the newness and up-to-date nature of the information viewed on social-contact and information websites' pages. Internet uses are evaluated on the basis of access to personal contacts and information searches in accordance with the individual interests of each student.

> **Student L:** *If students don't know how to surf the Internet… how do they do the assignments they are asked to do in lectures? All the information is on the Internet… if they don't know how to use it, how do they do their assignments?*

Here, it is possible to observe that the students evaluate certain parts to refer to the whole: a service (Messenger) is taken as the Web as a whole, and a utilitarian function is assigned to it (doing university assignments).

Thus, it is found that when students access the digital screen, they do so in accordance with certain sequentiality criteria involving the same interests of attention and connectivity: this conduct is regulated by the type of service that they access first (Messenger) and by the one that they access last (Google).

> **Student V:** … *when I go into the university's Systems room, I get anxious because I can't see Messenger… so that's why, when I'm in the Systems room, I only use the computer to open Google… to open tabs… to choose paragraphs… to copy stuff to hand in an assignment… I feel fine on my own computer because I can see Messenger while I'm doing a university assignment.*

In terms of access and availability, accessing the Internet from a public place (the university's IT Systems room) is not that same as accessing it from home, although, according to focus Group 2 "The Internet in Universities", the routine is the same.

> **Student K:** *It's like this Mr Argüello, I turn my computer on… if I'm in my room, of course… the first screen is Messenger, I open YouTube to watch some videos, check out Facebook and then I open Google to search for information for an assignment…*

**Student B:** *At home, everyone shares the computer… when I get back from university, the first thing I do is go onto Messenger to chat with my friends about what has happened to us during the day… on Facebook I try to find about a cousin who lives in another city… I leave my university work to last, and I do it in the Systems room…*

The university students have three spatial routines for accessing the Internet: from the university's IT Systems Department's computer rooms, from computers installed in the Library's rooms and the from the classroom (using Wi-Fi).

## 6. Digital palimpsests

For university readers and writers who take recourse to Internet file and storage resources, reading is associated with the fragmentation of documents. This practice turns a fragment into an intertext without any author or publisher references or any explicit title. However, the result of selecting and incorporating fragments into a blank document is that the stability of the closed text is destroyed.

In a university academic assignment, this textual instability of the on-screen register of writing could be called a 'digital palimpsest', owing to the fact that the university students reuse fragments of digitised texts. In other words, they copy and paste fragments to a file that they then delete and forget about. The surface of the text (on paper or on screen) becomes a 'digital palimpsest' when the student structures an on-screen document by using fragments of digitised texts like a collage.

### 6.1 Searching for documentary and bibliographical sources

Of the 25 documents reviewed, seven have bibliographical references with the entries:

- *www.google.com.co*
- *http://www.monografias.com/…/tesisgrado/tesisgrado.shtmltesisymonografias.blogspot.com/*
- *http://es.wikipedia.org/wiki/informaci%C3%B3n*

These entries correspond to a search query requested by the lecturer to review textual structures on how to draft a monograph. Their transcription is given in terms of the address (domain name and route), but no account is taken of the document's title or authorship.

**Lecturer:** *In terms of constructing these Google, monografía.com and Wikipedia bibliographical references, where did you get the model from?* (interviewer)

**Student N:** *Well, if the lecturers don't give us a reading list, I do a general search on Google… a lot of these photocopied book chapters don't give any details about the author or the title… that's why Google, Wikipedia or monografía.com appear in the bibliographical references… I looked at another piece of work and that's why I put it down like that.* (interviewee)

On this point, bibliographical references are presented as a hybridisation of hardcopy references and electronic references, with entry types like the following:

- *http://books.google.com/books?id=x2LpgZ*
- *Beekman G. Introducción a las computadoras, publicado por Pearson Educación. 2000.*

In the first entry, the address (route) for the electronic book is given without any details about the author, the title or the publisher; in the second, there is a bibliographical reference to a hardcopy book with the following structure: *author, title, publisher and year,* while *the place of publication* and *pages* are missing.

> **Lecturer:** *What idea did you have in mind when you wrote these two entries for digital bibliographical references?* (interviewer)
>
> **Student Y:** *No … I didn't make it up… you told us that we had to put the full details of the location of the document… and that's what I did… that's the address for these pages… there's the page.* (interviewee)
>
> **Lecturer:** *Are these links to pages of documents that can be found in these web pages?* (interviewer)
>
> **Student Y:** *No … they are links to the web pages… the documents and the pages are the same thing… if a page doesn't state who wrote it, well it doesn't have an author… how do you put it down in the bibliographical references…and if the lecturer doesn't tell us how to do it, you put down something you don't know how to do.* (interviewee)

From the time when a fragment of text is located to the time when it is incorporated into another text, like a textual collage on the on-screen Word document, a hypertextual structuring that organises the surface of the screen takes place.

> **Lecturer:** *So you enter a word on Google. Then what do you do?* (interviewer)
>
> **Student M:** *Well… I open all the tabs at the same time… I review them and highlight what I understand, and choose what I want to use in a Word document… Control C and Control V.* (interviewee)
>
> **Lecturer:** *What do you search for on Google?*
>
> **Student M:** *I search for information that the lecturer tells us about… for an essay… it seems that the lecturers have all decided to set essays…*

## 6.2 Copy and paste

'Copy and paste' is a form of textual production based on the appropriation of intertexts without acknowledging the source from which a fragment has been taken; it is the literal copying of a fragment of text by citation or reference through a modality of composition called 'Ctrl C + Ctrl V'.

In these academic assignments, the university students show two 'copy and paste' variants: textual form and typographical form (Argüello, 2009a).

*6.2.1. Copy and paste: the textual form.* In these documents produced by the university students, the following 'copy and paste' practices can be found:

- The extraction of a fragment from a text A, found online, and its incorporation into a text B, a university assignment, without acknowledging any textual link to the original appropriated text and without maintaining any correspondence with the linking text.
- The incorporation of citations from a linked text A in the textual body of a linking text B, without any explicit reference through a footnote or a reference structure (surname, date, page).
- The mention of an author in the textual body, but without presenting an internal reference in the document, or giving a footnote or inserting the reference in the bibliography at the end.

*6.2.2. Copy and paste: the typographical form.* In these documents produced by the university students, the following 'copy and paste' practices can be found:

- A multiplicity of font types in the same text (four assignments contained a combination of Verdana and Times New Roman, 13 contained a combination of Arial Normal and Arial Web, and two contained a combination of Arial Web and Trebuchet).
- Different font sizes in the same text (four assignments contained a combination of Verdana 8.5 and Times New Roman 12, 13 contained a combination of Arial Normal 12 and Arial Web 10, and two contained a combination of Arial Normal 12 and Trebuchet 10.5).
- Line spacing in the formatting of texts (21 assignments had a combination of single and 1.5 line spacing, 12 had a combination of single and double line spacing).

# Discussion

## 7. University students' digital migration

To remain in the position of university readers and writers is to remain in a subjective state of information searching, browsing and processing through on-screen displays on computers (Turkle, 1998; Quiroz, 2008; Levis, 2009), with the scaffolding and textualities of new reading and writing surfaces that restructure textual comprehension and production processes.

Looking up documents and bibliographical references is a related activity but not the only one in young people's on-screen textual interactions, owing to the fact that, in a sequential order, Messenger and Facebook services account for most of these socio-technical interactions, and that the academic activity of looking up documents and textualities is a non-exclusive activity within the uses and meanings of digital media for young university students.

Among university students, the reading and writing (Cassany, 2006; Gubert, 2010) of new electronic textualities represents an angle of approach to the electronic text as a book open to new forms of knowledge circulation, and the surface of the text as an entity of scholarly register that is not exclusive to the pages of the hardcopy book.

## 8. Open books

Books have lost their academic weight (Darnton, 2010) as stable, universal works of reference, and have now become complementary to the processing of academic information, on a par with online documentary and bibliographical reference works.

This loss of academic reference centrality does not mean that they will disappear. Rather, the stable closed text (Petrucci, 2003; Simone, 1998, 2001) will shift towards a text on which other textualities converge.

The book format, as the nucleus of consultation in the reading practices of young university students, has been decentred and replaced by the on-screen browsing of web pages, which does not mean that the status of university readers and writers has been dissolved, although the mode of reading with full awareness has shifted from *what it means to read texts* to *seeing web pages of documents that contain information*.

## 9. Text surfaces

In addition to the decentring of books is the fact that the surface of the page is no longer based on the linear structure of written documents. Rather, it is based on the on-screen display of electronic pages through the practice of cutting and pasting fragments of text (Argüello, 2009a). Consequently, the surface of the computer screen is transformed into the search query itself: students present the pages, the screen and the documents accessed as if they were one and the same thing; they mix up the surface of the textual content with the surface of the format.

The Internet has redefined the state of reading comprehension and textual production; university readers and writers become internauts that surf websites; on-screen text is a collage of textualities; and personal interests dominate search, browsing and connection habits.

# References

ARGÜELLO, L. A. (2009a). "Cortar y pegar. La producción textual de trabajos escolares universitarios" [online article]. *Revista Question*. No 21. [Accessed: 20 August 2008]. <http://perio.unlp.edu.ar/question/numeros_anteriores/numero_anterior21/files/arguelloguzman_1_informes_verano2009.htm>

ARGÜELLO, L. A. (2009b). "Convergencia de alfabetos: la formación de profesores en Educación Superior" [panel lecture]. In: *X Congreso Latinoamericano de Lectura y Escritura*. 29 July, 1 and 2 August. Lima: Apelec Perú / International Reading Association / Universidad Marcelino Champagnat.

BEVORT, É.; BRÉDA, I. (2001). "Les jeunes et Internet. Représentations, usages et appropriations" [online]. [Accessed: 15 April 2008]. <http://www.clemi.org/fr/ressources/publications/outils-d-analyse-et-de-reflexion/bdd/page/2>

BJØRNSTAD, T. L.; ELLINGSEN, T. (2004). **"**Onliners. A report about youth and internet" [online report]. [Accessed: 25 August 2006]. <http://www.saftonline.org/vedlegg/1789/SAFTOnliners.pdf>

BOSCHMA, J. (2008). *Generación Einstein. Más listos, más sociables y más rápidos*. Barcelona: Ediciones Gestión 2000.

BUCKINGHAM. D. (2000). *After the death of childhood. Growing up in the age of electronic media*. London: Polity Press.

CABRERA PAZ, J. (2001). "Náufragos y navegantes en territorios hipermediales: experiencias psicosociales y prácticas culturales en la apropiación de Internet en jóvenes escolares"/"Navigators and castaways in cyberspace: psychosocial experience and cultural practices in schoolchildren's appropriation of the Internet". In: M. BONILLA, G. CLICHE. *Internet y sociedad en América Latina y el Caribe*. Quito: FLASCO. Pages 39-129.

CARRILLO CORREA, G. (2007). "Realidad y simulación de la lectura universitaria: el caso de la UAEM". *Educere*. No 36, pages 97-102.

CARVAJAL BARRIOS, G. (2008). *Lecturas y escrituras juveniles. Entre el placer, el conformismo y la desobediencia*. Cali: Editorial Universidad del Valle.

CASSANY, D. (2006). *Tras la línea. Sobre la lectura contemporánea*. Barcelona: Anagrama.

CHARTIER, R. (1995). *Forms and Meanings. Text, performances, and audiences from codex to computer*. Philadelphia: University of Pennsylvania Press.

CISNEROS, M. (2005). *Lectura y escritura en la universidad: una investigación diagnóstica*. Pereira: Universidad Tecnológica de Pereira.

DARNTON, R. (2010). *Las razones del libro. Futuro, presente y pasado*. Madrid: Trama Editorial.

GUBERN, R. (2010). *Metamorfosis de la lectura*. Barcelona: Anagrama.

HERRINGS, S. (2001). "Computer-mediated discourse". In: D. SCHIFFRIN, D. TANNEN & H. HAMILTON (eds). *Handbook of discourse analysis*. Oxford: Blackwell. Pages 612-634.

HORNA, P.; CURIOSO, W.; GUILLÉN, C. [et al.] (2002). "Conocimientos, habilidades y características del acceso a Internet en estudiantes de medicina de una Universidad Peruana" [online article]. *Anales*. [Accessed: 10 December 2008]. <http://sisbib.unmsm.edu.pe/BVrevistas/anales/v63_n1/pdf/conocimientos_internet.pdf>

ITO, M. (ed.). (2008). "Living and Learning with New Media: Summary of findings from the Digital Youth Project" [online]. [Accessed: 13 December 2008]. <http://digitalyouth.ischool.berkeley.edu/files/report/digitalyouth-WhitePaper.pdf>

LEVIS, D. (2009). *La pantalla ubicua (Televisores, computadoras y otras pantallas)*. Buenos Aires: La Crujía Ediciones. 2nd ed.

LIVINGSTONE, S.; BOVILL, M. (1999). "Young people new media" [online]. [Accessed: 11 December 2008]. <http://www.lse.ac.uk/collections/media@lse/pdf/young/foreword.pdf>

MEAD, M. (1970). *Cultura y compromiso. Estudio sobre la ruptura generacional.* Buenos Aires: Granica editor.

MEDINA, E.; OTERO, J. V. (2002). "Uso de Internet por los jóvenes de la Universidad Autónoma de Madrid" [online article]. *Madrimasd.* [Accessed: 18 December 2008]. <http://www.madrimasd.org/revista/revista11/investigacion/investigacion1.asp>

MONTGOMERY, C. (2006). *Generation digital. Politics, commerce, and childhood.* Cambridge, Massachusetts: MIT Press.

MORDUCHOWICS, R. (2008). *Generación multimedia. Significados, consumos y prácticas culturales de los jóvenes / The Multimedia Generation. Young People's Cultural Meanings, Consumptions and Practices*. Buenos Aires: Paidós.

PALFREY, J.; GASSER, U. (2008). *Born digital: Understanding the first generation of digital natives.* New York: Basic Books.

PIETTE, J.; PONS, C. M.; GIROUX, L.; MILLERAND, F. (2001). "Les jeunes et Internet. Représentation, utilisation et appropriation" [online]. [Accessed: 30 March 2008]. <http://www.mcccf.gouv.qc.ca/publications/info/jeunes_internet_2001.pdf>

PRENSKY, M. (2001). "Digital natives, digital immigrants" [online]. *On the Horizon*. Vol. 9, No 5. [Accessed: 15 July 2008]. <http://www.marcprensky.com/writing/Prensky%20%20Digital%20Natives,%20Digital%20Immigrants%20-%20Part1.pdf>

QUIROZ, M. T. (2004). *Jóvenes e Internet. Entre el pensar y el sentir*. Lima: Fondo Editorial de la Universidad de Lima.

QUIROZ. M. T. (2008). *La edad de la pantalla. Tecnologías interactivas y jóvenes peruanos*. Lima: Fondo Editorial de la Universidad de Lima.

ROMERO MEDINA, A.; SÁNCHEZ ORTUÑO, M.; RUIZ, M. R. (2000). "Patrones de uso de Internet en estudiantes universitarios" [online]. [Accessed: 10 December 2008]. <http://www.um.es/docencia/agustinr/pca/internet4.PDF>

SIMONE, R. (1998). "El cuerpo del texto". In: G. NUMBERG. *El futuro del libro. ¿Esto matará aquello?* Barcelona: Paidós. Pages 247-256.

SIMONE, R. (2001). *La tercera fase. Formas de saber que estamos perdiendo.* Madrid: Taurus.

TURKLE, S. (1997). *La vida en la pantalla. La construcción de la identidad en la era de Internet*. Barcelona: Paidós.

UBERHUAGA CANDIA P.; ARRIAGA JIMÉNEZ, O.; GARCIA MIRANDA, M. (2005). *Entre lo colectivo y lo individual. El puente de transición de las identidades de los jóvenes en el uso de internet*. La Paz: Ediciones PIEB.

UBERHUAGA CANDIA P.; ARRIAGA JIMÉNEZ, O.; GARCIA MIRANDA, M. (2006). *Jóvenes.com. Internet en los barrios populares de Cochabamba*. La Paz: Ediciones PIEB.

VANDERDORPE, C. (2003). *Del papiro al hipertexto. Ensayo sobre las mutaciones del texto y la lectura*. Buenos Aires: F.C.E.

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RESEARCH ARTICLES IN PEER-REVIEWED JOURNALS

ARGÜELLO, L. A. (2009b). "El oficio de profesor universitario en la era de los medios electrónicos" / "The Profession of University Lecturer in the Age of Electronic Media" [online article]. Revista de Universidad y Sociedad del Conocimiento (RUSC). Vol. 6, No 2. UOC. [Accessed: 6 August 2009]. <http://www.uoc.edu/ojs/index.php/rusc/article/view/v6n2-arguello/v6n2_arguello>

ARGÜELLO, L. A. (2009a). "Cortar y pegar. La producción textual de trabajos escolares universitarios" [online article]. Revista Question. No 21. [Accessed: 30 March 2009]. <http://www.perio.unlp.edu.ar/question/files/arguelloguzman_1_informes_verano2009.htm>

ARGÜELLO, L. A. (2008c). "Aproximación a un ecosistema comunicacional y computacional" [online article]. *Revista Question*. No 17. [Accessed: 17 March 2008]. <http://www.perio.unlp.edu.ar/question/nivel2/informe_de_investigacion.htm> ISSN 1669-6581

ARGÜELLO, L. A. (2008b). "Comunidades textuales" [online article]. *Revista Question*. No 19. [Accessed: 30 August 2008]. <http://www.perio.unlp.edu.ar/question/nivel2/informe_de_investigacion.htm> ISSN 1669-6581

ARGÜELLO, L. A. (2008a). "Trayectos informales de formación académica en educación superior / Informal lines of academic training in higher education" [online article]. *Revista de Universidad y Sociedad del Conocimiento (RUSC)*. Vol. 5, No 2. UOC. [Accessed: 20 November 2008]. <http://www.uoc.edu/rusc/5/2/dt/esp/arguello.pdf>

PEER-REVIEWED PAPERS AT ACADEMIC MEETINGS

ARGÜELLO, L. A. (2010). "El concepto de producción intelectual en la práctica académica del profesor universitario" [paper]. In: XXVI Congreso Nacional de Lingüística, Literatura y Semiótica. 22-24 September. Bucaramanga: Escuela de Idiomas / Universidad Industrial de Santander.

ARGÜELLO, L. A. (2009b). "Convergencia de alfabetos: la formación de profesores en Educación Superior". [panel lecture]. X Congreso Latinoamericano de Lectura y Escritura. 29 July, 1 and 2 August. Lima: Apelec / International Reading Association / Universidad Marcelino Champagnat.

ARGÜELLO, L. A. (2008). "Hacia una pedagogía de la proyección social en Educación Superior". In: 1er Coloquio Internacional de Didácticas. 2, 3 and 4 April. Ibagué: Universidad del Tolima.

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ARTICLE

# Preservation of Learning Objects in Digital Repositories

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## Abstract

The aim of this article is to analyse the different processes involved in the preservation of learning objects in a digital repository. Presented as a case study is a prototype repository for a collection of statistics-related e-learning materials used in the respective academic subjects offered by the Open University of Catalonia (UOC, Universitat Oberta de Catalunya). The purpose of these materials is to serve the whole community and not just the university. To that end, the repository was created with DSpace open-source software. The goal is to promote the reuse and the digital preservation of such e-learning materials, though certain aspects of these two objectives are somewhat contradictory. This article analyses the requirements of learning objects deposited in a repository and the needs of the various roles intervening in their handling and long-term preservation.

## Keywords

learning objects, repositories, digital preservation, metadata, archives, digital libraries

## *Preservación de objetos de aprendizaje en repositorios digitales*

**Resumen**

*El propósito de este artículo es analizar los diferentes procesos en la conservación de objetos de aprendizaje en un repositorio digital. Como caso de estudio se presenta un prototipo de repositorio basado en una colección de materiales de e-learning sobre estadística, usados en las asignaturas respectivas de la Universitat Oberta de Catalunya. Estos materiales tienen el propósito de servir a toda la comunidad, no tan solo a la universidad. Para ello, se ha creado este repositorio en una plataforma abierta basada en DSpace. El propósito es promover tanto la reutilización como la conservación digital de dichos materiales de e-learning, aunque ambos objetivos son, en ciertos aspectos, contradictorios. En este artículo se analizan los requerimientos de los objetos de aprendizaje depositados en un repositorio y las necesidades de los diferentes roles que intervienen en su manipulación y su conservación a largo plazo.*

**Palabras clave**

*objetos de aprendizaje, repositorios, preservación digital, metadatos, archivos, bibliotecas digitales*

# 1. Introduction

In many higher education institutions, there is a growing tendency to use Virtual Learning Environments (VLEs). In a VLE, every aspect of a course is managed via a Consistent User Interface (CUI), which is normally standard across the institution. One of the usual components of a VLE is a learning object repository, which is employed to manage teaching resources used throughout the course. There is no common definition of the repository concept (Conway, 2008), though it could be said that repositories are openly used to provide a specific community with materials or information. Among other resources, an institutional repository (Shreeves & Cragin, 2008) usually includes reports, publications, complete courses and manuals. It may also include learning objects and research project data, labelled in accordance with a metadata schema, preferably IEEE LOM or Dublin Core (Neven & Duval, 2002).

Digital preservation is a key element of repository design, given that the aforementioned resources are created with a specific software version and need to be updated to ensure that they can be accessed at a later date for as long as necessary. To do otherwise would mean that information might be lost.

It also entails the need to perform a risk assessment on such resources to establish the priorities of digital preservation operations. A risk assessment can also serve to assess whether the cost of digitally preserving software versions or out-of-date learning materials is acceptable.

Furthermore, owing to the considerable variability of the elements that can be found in the learning process, be it in terms of type (exercises, examples, simulations, etc.) or format, the specific characteristics of learning objects used in a VLE make it necessary to reconsider the usual preservation mechanisms connected with metadata labelling.

This article is structured in the following manner. The second section describes the pilot repository taken as the case study in order to analyse a digital preservation solution based on DSpace. The

third section describes the elements that need to be taken into account in order to establish the necessary criteria to assure the preservation of the deposited objects. The fourth section presents the preservation policies applied to the repository. Finally, the conclusions drawn from this project, as well as the present and future lines of work, can be found in the fifth section.

## 2. Open digital repositories

The Open University of Catalonia (UOC, Universitat Oberta de Catalunya) has created an open digital repository[1] containing a collection of statistics-related learning materials, in line with a user-centred design approach (Ferran et al., 2009). These learning materials take the shape of exercises, study materials, multimedia documents and specific statistics program data files.

These resources come in a wide range of formats, including Minitab, Word and Portable Document Format (PDF), although there is a growing number of teaching materials in video and other formats (both text and data), all of which have been created using multiple software and operating system versions. Given this considerable variety, it is necessary to think about the repository from the viewpoint of both learning material management and long-term digital preservation (Smith, 2005).

Since its creation, the UOC has generated a considerable number of statistics-related teaching resources. These resources have been created by means of a high-quality publication process involving various roles (authors, editors, lecturers, managers, etc.), and have been published in line with an editorial, design and production model based on modules. These modules are learning units – each having a small number of credits – designed for learning about a specific topic of course content. The process of creating and editing them takes about a year. Maintaining and updating them to reflect any changes is a costly, complex process, since it means that either the whole or part of the editorial process has to be repeated. Other types of resources associated with the materials in question also need to be managed in the same way. These associated resources are generated by teaching activities that take place in each academic semester, and include examples, exercises, experiments and self-directed learning exercises.

In this repository, the concepts inherent to a digital library and to reference services have been applied to an e-learning environment. Aspects such as searches and library services are similar though not identical. In a digital library, students are accustomed to searching for information by author and title. However, when it comes to learning objects, the titles of exercises, files and learning units are frequently duplicated. Consequently, given that the concept of title is ambiguous, a different taxonomy for their classification needs to be used.

The repository allows students and other people forming part of the learning community to have access to educational materials in an organised way. Regarding the case in hand, the materials were found to be spread across various academic subjects, inaccessible to the community as a whole, and neither classified nor ordered. Consequently, many students were at a loss when it came

1. http://oer.uoc.edu (currently under development).

to using these resources, and lecturers did not get the benefits they had hoped for (Barker et al., 2004). In addition, there were no suitable search criteria to be able to identify those resources that could be reused to create new educational materials. Exercises, notes, modules, articles, text books, software tools, virtual laboratories, audio resources, videos, curricula, timetables, calendars, activities, simulations and learning objects, among many other documents, are more accessible if a digital repository is used.

## 2.1. DSpace

There are many reasons for choosing DSpace[2] as a repository application. DSpace open-source software is a repository application that accepts various metadata schemata, incorporates long-term preservation policies, uses handles to identify each element forever, and is solid and stable. Equally important is the fact that it is in use in other parts of the UOC. As an open-source software application, DSpace has a large, active community of users and developers, including higher education institutions and digital libraries. DSpace is also suitable for long-term digital preservation because it accepts policies with that goal in mind. It includes tools like Checksum Checker, which allows the integrity of storage area bitstreams to be verified, and TechMDExtractor, which allows the formats of stored bitstreams to be validated and metadata to be extracted from bitstreams. It also includes a pre-ingest workflow step and an optional workflow that validates the format of each bitstream after ingest, thus providing the administrator with the metadata of invalid or badly formed files.

DSpace has communities and sub-communities (defined hierarchically), collections, items, bundles of bitstreams and bitstream formats. In terms of the data model, communities and sub-communities are top-level, whereas a collection is a set of items, such as statistics-related resources. Each collection has its own workflow, which can be defined by the management unit. An item is a useful set of content and metadata, added during the ingest process or later. Regarding storage, a bitstream is a stream of bits corresponding to the content of metadata files, whereas a bitstream format involves the capture of specific formats of files ingested, which can be improved using metadata extraction tools like DROID[3] or the NLNZ Metadata Extraction Tool[4].

By default, DSpace uses Dublin Core metadata to archive collections. However, in the ingest process, other metadata used for the long-term preservation of an object can be added. A fuller description allows for better retrieval of objects from the repository and the enhancement of their properties, identifying how an object was created and other similar data. Furthermore, an analysis of the usage of objects deposited in the repository allows metadata to be continuously enhanced (Ferran et al., 2007) by identifying and correcting labelling problems.

2. http://www.dspace.org
3. http://droid.sourceforge.net
4. http://meta-extractor.sourceforge.net

## 3. Digital preservation

The key issue is whether access to these materials will still be possible in a specific period of time, say in 20 years from now (the UOC was created just 15 years ago and has already encountered preservation problems). The technological obsolescence of statistics program files in this case has to be monitored to prevent any loss of information, thus minimising any potential risk. This means that digital preservation has to be considered from the viewpoint of information accessibility over time. The long-term preservation of these digital objects requires a risk assessment to establish priorities and a preservation plan to facilitate access to them. These elements will ensure that learning materials, among others, can be reused.

At the UOC, repository ingest processes usually take place in January and July, after (and before) each academic semester. At these times of the year, the repository has to be technologically analysed to assess the need to migrate existing digital objects towards later versions of software.

Before deciding which types of materials to store, a risk assessment needs to be performed to ascertain obsolescence risks, to establish priorities in the preservation plan and to determine the digital preservation costs that the institution can bear.

By performing a risk assessment, it is possible to establish which materials are less costly to re-edit and more economical to preserve. Such an assessment particularly takes account of software version IDs that are capable of supporting certain materials. In our study, we based the risk assessment on technological obsolescence.

One of the instruments available for repository risk assessment is DRAMBORA (DCC, DPE, 2007), which allows the risks associated with a repository's materials to be assessed and quantified.

The DRAMBORA method, which is based on the AS/NZ 4360:2004 standard, allows the environment and the digital resources to be assessed. DRAMBORA is applicable to digital collections that are, or are going to be, in repositories (McLeod, 2008). In the assessment of digital resources, their preservation priorities can be established.

DRAMBORA, a methodology applicable to open repositories, comprises six stages: identifying the organisational context; documenting the regulatory framework; identifying repository assets, activities and their owners; identifying the risks; assessing the risks; and managing the risks.

In addition, a radar chart can be created at the end of the process. This allows our statistics-related repository to be compared against the mean of other similar repositories.

One of the main questions is how to store materials created digitally by various types of institutions. Institutions need to store their digital information for a wide variety of reasons: administrative, legal, historical, personal, scientific value (scholarly articles, electronic theses, dissertations, etc.), and, of course, teaching. Such insitutions include universities, schools, libraries, museums and research centres, as well as people who want to have their own private collections of materials. This implies not only the meticulous management of technology, but also the ability to access old electronic documents with new technology (Lee et al., 2002). This is where digital preservation comes in. Such preservation makes electronic data accessible and useful for a long period of time. Electronic data should preserve their significant properties over time and be acessible to a designated community of

users. Long-term preservation means that electronic materials will be available in the future, retaining all of the significant properties they had when they were created.

## 3.1. Preservation in a digital repository

As mentioned earlier, digital preservation techniques need to be applied to ensure that learning materials are accessible to students and lecturers over time. The most common preservation strategies are migration and emulation. Some examples are VERS Encapsulated Object (VEO) (Waugh et al., 2000) and Universal Virtual Computer (UVC) (van der Hoeven et al., 2005), respectively.

Migration is the process of converting an electronic object into a higher version of its file format to make the information easier to access and handle. In the migration process, some significant properties may be lost (owing especially to software conversions), so information descriptions in the ingest process must be precise. The main objective of migration strategies is to retain all of the significant properties that a digital object had when it was created. An example would be the migration of Lotus Notes spreadsheets to Microsoft Excel or, better still, towards a standard XML file.

Emulation is the process of creating an environment towards which obsolete software must migrate so that it can function on a new platform. The new software will subsequently need to migrate when the simulator becomes technologically obsolete. Emulators for old games consoles like Atari and Sony PlayStation are well known. This means preserving the appearance of the platform and its functionality, and having an updated copy of the original object.

Finally, another approach to long-term preservation is the Open Archival Information System (OAIS) model, which has been adopted as ISO 14721:2003 (CCSDS, 2002). The main objective is to preserve information and make it available to a designated community indefinitely. The OAIS model is now a reference standard for archival systems.

## 3.2. The OAIS reference model

The OAIS model is widely accepted by institutions as a digital and non-digital archival model. The OAIS model is defined as: "an archive, consisting of an organisation of people and systems, that has accepted the responsibility to preserve information and make it available for a designated community".

It is based on information processes that facilitate a high-level information description of the objects managed by an archive or repository. The functional components of a digital archive are ingest, information storage, preservation planning, access, data management and administration. The OAIS model has three actors: producer, consumer and manager.

The producer is defined as the role played by those persons, or client systems, who provide the information to be preserved. This can include other OAISs or internal OAIS persons or systems.

The consumer is the role played by those persons, or client systems, who interact with OAIS services to find preserved information of interest and to access that information in detail. This can include other OAISs, as well as internal OAIS persons or systems. One class of consumer from the designated community should be able to understand the preserved information.

The manager is defined as the role played by those who set overall OAIS policy as one component in a broader policy domain. In other words, control of OAIS management is only one of the management responsibilities.

Management is not involved in the day-to-day operation of the archive. It can assign policies to the repository like, for example, the change of role of both producer and consumer. Figure 1 shows the OAIS model, in the form that the definition of the classic digital library model is understood. In this case, producers create content and, through a management workflow, consumers can retrieve content developed by producers.

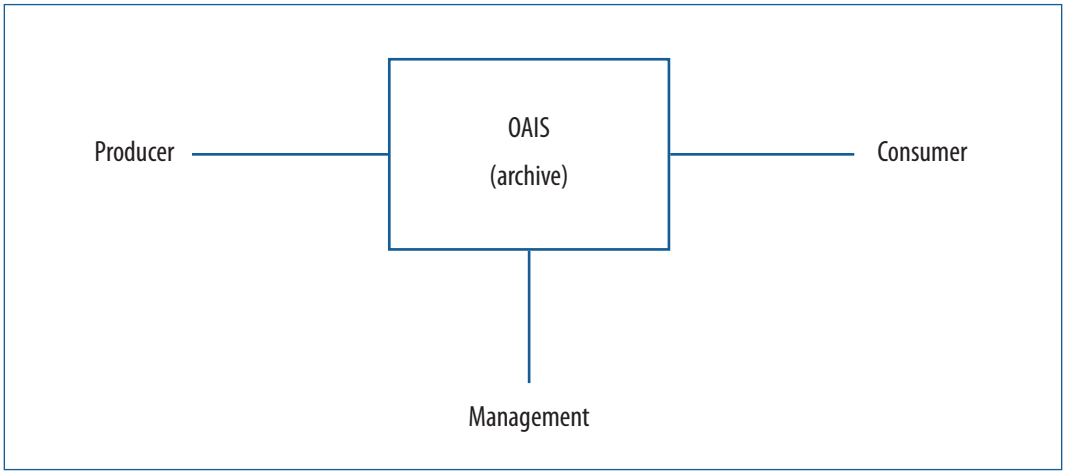


**Figure 1.** OAIS model reprinted with permission of the Consultative Committee for Space Data Systems.

The information is stored and managed in the OAIS archive. Consumers and producers of the designated community interact with OAIS services to find and acquire preserved information of interest.

The OAIS model allows workflows to follow each other in a new digital archive. Its implementation means that clear standards for digital preservation are required. So too is the creation of a set of terminology that can be understood by the designated community, and the clarification of procedures to make a reliable archive service available.

The functional components of a digital archive are ingest, information storage, preservation planning, access, data management and administration.

Ingest is defined as an open archival service. It is the process of a digital object's acceptance by producers and selected consumers in accordance with the concept of collaborative learning, and its entry into the digital archive. In our model, the ingest function includes the receipt of Submission Information Packages (SIPs) from producers and selected consumers, and the preparation of content for storage and management in the archive.

Archive storage facilitates Archival Information Package (AIP) services and functions.

Planning and preservation facilitates services and functions to ensure that the information stored in the OAIS remains accessible to the designated community in the long term, even when the computing environment is obsolete.

These actors are involved in some of the functional components. In a VLE, there may be a vision that differs from the OAIS model, in which the three actors have clear-cut roles. This is because all the roles are interchangeable in a VLE. Lecturers and students can be producers and consumers at one and the same time. Lecturers can be producers, consumers and managers. To give an example, a student may solve a statistics problems and the lecturer may consider it an appropriate solution to include in the repository, thus playing the role of manager. In the OAIS model, this variant can be defined through the management of workflows (Chen, 2004) that DSpace supports.

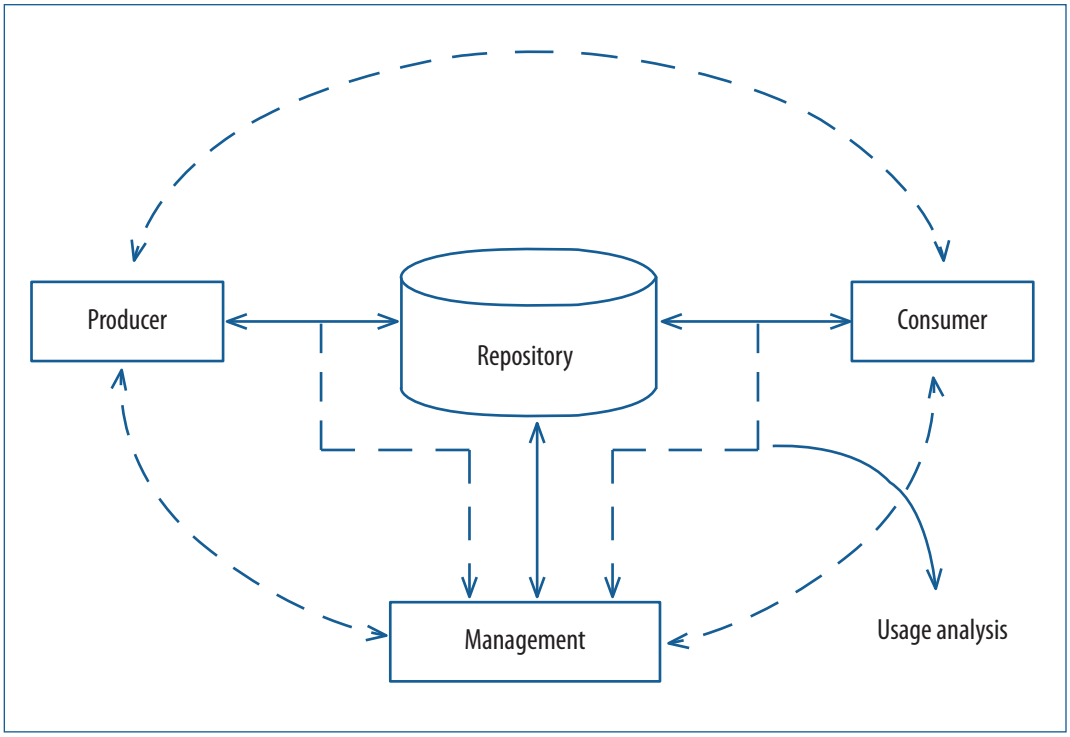


**Figura 2.** OAIS model in a VLE

Figure 2 shows a possible scenario for the OAIS model in a VLE, in which producers can play the role of consumers, and consumers can play the role of producers. Given that the workflow can be configured in the repository, it is possible to assign management rights to both producers and consumers.

If we apply the Web 2.0 concept to our Open Educational Resources (OERs), concepts such as collaborative learning and community participation in a classic OAIS model may change, as shown in Figure 1. It is also important to note that usage analysis is enhanced (Lee, 2002). Usage analysis would serve to switch between producer and consumer roles depending on resource usage.

## 4. Preservation plan for teaching materials

Before preserving a learning object, it is essential to know what its significant properties are, and especially those that make the object reusable, like file format, for example. The collection of statistics-

related resources that may become part of the repository includes MPEG videos, Microsoft Excel files, Minitab files, SPSS files, text documents, LaTeX documents, various versions of Microsoft Word files, PDF files, Microsoft PowerPoint presentations and, more recently, multiple versions of OpenOffice files. For example, files in proprietary code, such as SPSS, or Minitab files with associated formulas, pose one of the main challenges. Minitab files can be exported to XML or tagged files, whereas SPSS is the *de facto* standard in preservation formats.

## 4.1. Significant properties

Significant properties are characteristics of digital objects that need to be retained to ensure that they are accessible in the long term (Ashley, Davis & Pinsent, 2008). Significant properties can be classified into content, context, appearance, structure and behaviour. For reasons of space, this article will only examine those aspects connected with the first category. A metadata file description is required to preserve files. These metadata enhance the description of objects ingested into the repository. Metadata should be subject to a quality control check to prevent any noise in the retrieval process.

Prior to ingest, all the materials should be checked to ensure their preservation and their technological reusability. So, for example, the tags in a PDF/A file should be carefully checked to validate that the file format is correct and consistent. It is advisable to have two versions of various materials: one accessible to the public for versioning and usage data collection (Ferran et al., 2007), and one set aside for managers for long-term preservation, though both are linked via metadata. The versions for long-term preservation should be migrated to make them accessible before they become technologically obsolete, as soon as any problem connected with the accessible version is found. Thus, before an ingest, a file format description needs to be created and stored in the format metadata, while attempting to separate, as much as possible, the content descriptions from the descriptions of other significant properties, such as their appearance, for example. This process could be partially automated, since manual intervention represents a high cost that is unsustainable for large volumes of resources.

## 4.2. Format assessment for long-term preservation

Finally, another aspect that needs to be considered is file format sustainability. In the UOC's case, materials have been created digitally, albeit with hardcopy versions in mind. This situation shows that even with a wide variety of formats, the most important materials (from a teaching viewpoint) are created in PDF format. While this is acceptable to students, it limits the handling of such materials. However, in the process of ingesting learning objects into the UOC's repository, it is found that, owing to the wide variety of documents, some format migrations need to be carried out to simplify preservation needs and to reduce technological requirements. This is done in line with the following non-exhaustive criteria:

Portable Document File: PDF/A, based on PDF Reference Version 1.4. ISO 19005-1:2005, considered to be a standard.

Microsoft Word: converted into PDF/A or OpenOffice format. Account should be taken of the fact that a file may contain macros and/or formulas.

Microsoft Excel: converted into XML or OpenOffice formats.

Video: migrated to MPEG-2, AVI or QuickTime formats.

LaTeX documents: preserved in the original format but, in the long term, in DocBook XML with embedded MathML.

Images: converted into PNG, TIFF or JPEG formats.

PowerPoint files: converted into PDF/A or OpenOffice formats. Interactive sequences should be documented.

Audio file: converted into WAV or MP3 formats.

Minitab files: converted into XML format.

SPSS files: converted into SPSS portable (*.por) or XML formats.

Thus, in order to ascertain the priorities with regard to formats, we have taken the list of possible risk identifiers facilitated by DRAMBORA as the basis. While not exclusive, these identifiers are mainly the following:

- R11 (fails to preserve essential characteristics of digital information)
- R31 (software failure or incompatibility)
- R33 (obsolescence of hardware or software)
- R34 (media degradation or obsolescence)
- R66 (preservation strategies result in information loss)

In our case, these identifiers have allowed us to establish priorities with regard to migrating formats due to their technological obsolescence or versioning. They have also allowed us to ascertain what risk is acceptable in the interpretation of the risk.

After assessing the potential risks with regard to technological obsolescence, it was possible to establish a relationship between migration processes and the cost of implementing them.

As mentioned earlier, in format migration operations, the cost of converting a Microsoft Word file to PDF/A format differs considerably from the cost of video file migration operations.

In the video migration process, other substantial changes in the significant properties may occur, such as the loss of resolution, the deterioration of audio or the time established in the migration operation.

## 5. Conclusions

This article has presented an analysis of the preservation needs of learning objects deposited in an open educational repository, specifically in relation to a collection of statistics-related materials created by the UOC. This repository, which is based on DSpace open-source software, promotes the reuse of educational materials and their long-term preservation.

Before implementing digital preservation operations, operation priorities are established by using the DRAMBORA repository risk assessment methodology.

DRAMBORA has allowed us to establish priorities in the preservation plan, the aim of which is to prevent technological obsolescence. As a result of the assessment, we have been able to establish a relationship between costs and migration operations to help us decide which materials can be migrated without any major alterations to their significant properties.

The wide range of formats currently used to store learning objects means that long-term preservation strategies need to be established to ensure that such objects can be retrieved in the future, especially when taking account of the considerable variability of technology and the specific labelling needs of content used in a VLE, which are different from those of a digital library or an institutional repository. It is therefore necessary to choose formats that guarantee some degree of continuity and thus facilitate preservation policies, such as PDF for documents and XML for data files, although certain formats (video, images, etc.) need to be described with additional metadata for their subsequent retrieval or conversion in the event of their obsolescence. The use of open file formats based on open-source tools also enables some degree of preservation through emulation techniques, so long as the existing source code can be compiled and executed. In this respect, the existence of a software package like OpenOffice offers a combination of both elements: description using XML and the possibility to access the source code.

Today, the main challenge is to define semi-automated mechanisms to enable the proper labelling and processing of the thousands of learning objects that the institution has, without it resulting in a cost that is too high to bear. Likewise, the introduction of preservation policies entails taking a fresh look at the organisational aspects of the institution because such policies involve very different groups that have very different goals. This means that complex workflows will need to be established, bearing in mind that other actors may play the role of content producers. Moreover, as is the case in any contingency plan, it is essential to establish timelines, with simulations to periodically assess the obsolescence of content stored in the repository. Finally, we hope to make the preservation policy of the institutional repository publicly available in the near future.

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## References

ASHLEY, Kevin; DAVIS, Richard; PINSENT, Ed (2008). *Significant Properties of E-Learning Objects* [online]. [Accessed: 20 November 2010]. <http://www.jisc.ac.uk/media/documents/programmes/preservation/spelos_report.pdf>

BARKER, Ed [et al.] (2004). *Long-Term Retention and Reuse of E-Learning Objects and Materials* [online]. [Accessed: 20 November 2010]. <http://www.jisc.ac.uk/whatwedo/programmes/preservation/elo.aspx>

CCSDS (2002). *Reference Model for an Open Archival Information System (OAIS). Blue Book* [online]. [Accessed: 20 November 2010]. <http://public.ccsds.org/publications/archive/650x0b1.pdf>

CHEN, Su-Shing (2004). "Digital Preservation and Workflow Process". In: *Proceedings of the 7th International Conference on Asian Digital Libraries. Digital Libraries: International Collaboration and Cross-fertilization*. Vol. 3334, pages 61-72.

CONWAY, Paul (2008). "Modeling the digital content landscape in universities". *Library Hi Tech*. Vol. 26, No 3, pages 342-354.

Digital Curation Centre and DigitalPreservationEurope (2007). *DCC and DPE Digital Repository Audit Method Based on Risk Assessment v1.0*. [Accessed: 20 November 2010]. <http://www.repositoryaudit.eu/download>

FERRAN, Núria [et al.] (2009). "User Centered Design of a Learning Object Repository". In: *Proceedings of the 13th International Conference on Human-Computer Interaction. Lecture Notes in Computer Science*. Vol. 5619, pages 679-688.

FERRAN, Núria [et al.] (2007). "Enriching e-learning metadata through digital library usage analysis". *The Electronic Library*. Vol. 25, No 2, pages 148-165.

Van der HOEVEN, Jeffrey; van DIESSEN, Raymond; van der MEER, Kees (2005). "Development of a Universal Virtual Computer for long-term preservation". *Journal of Information Science*. Vol. 31, No 3, pages 196-208.

LEE, Kyong-Ho [et al.] (2002). "The State of Art and Practice in Digital Preservation". *Journal of Research of the National Institute*. Vol. 107, No 1, pages 93-106.

MCLEOD, Rory (2008). "Risk Assessment; using a risk based approach to prioritise handheld digital information". In: *Proceedings IPRESS 2008*. <http://www.bl.uk/ipres2008/presentations_day1/20_McLeod.pdf>

NEVEN, Filip; DUVAL, Erik (2002). "Reusable learning objects: a survey of LOM-based repositories" [online]. In: *Proceedings of the Tenth ACM international conference on Multimedia*. Pages 291-294. [Accessed: 20 November 2010]. <http://www.cs.kuleuven.ac.be/cwis/research/hmdb/publications/files/Lorsurvey.pdf>

SHREEVES, Sarah; CRAGIN, Melissa (2008). "Introduction: Institutional Repositories: Current State and Future". *Library Trends*. Vol. 57, No 2, pages 89-97.

SMITH, MacKenzie (2005). "Exploring Variety in Digital Collections and the Implication for Digital Preservation". *Library Trends*. Vol. 54, No 1, pages 6-15.

WAUGH, Andrew; WILKINSON, Ross; HILLS, Brendan (2000). "Preserving Digital Information Forever". In: *Proceedings of the Fifth ACM Conference on Digital Libraries*. Pages 175-184.

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ARTICLE

# University teaching in the 2.0 era: virtual campus teaching competencies

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## Abstract

The rise of the information technology society and the advent of the Web 2.0 phenomenon in university education contexts have brought about a profound shift in the functions of teaching staff. The teaching and technology training of such staff is becoming an imperative need in order to cope with the challenges of new teaching-learning situations generated in virtual settings and/or with the support of technological tools.

This article describes the *teaching, technology and tutoring competencies* that 2.0 lecturers should have, given the fact that they undertake their tasks in technology-mediated environments. These tasks are directly related to aspects inherent to the adopted instructional model, to the context and to the new mediating tools. Student guidance, the capacity to design motivating multimedia materials and the formulation of collaborative activities are but some of some of the forms that these professional competencies take.

After surveying 70 lecturers and more than 840 students at the Spanish universities belonging to the *Campus Virtual Compartido del G9* (a virtual campus comprising the universities of Cantabria, La Rioja, Extremadura, Oviedo, the Balearic Islands, the Basque Country, Zaragoza and Castilla-La Mancha, and the Public University of Navarre), the lecturers strengths and weaknesses were highlighted and the most pressing training needs were underscored, in keeping with the demands of European convergence plans.

Among the strengths mentioned by the lecturers and the students involved in the virtual education processes were the proper formulation of activities that foster learning, the variety of teaching resources used, content interactivity, etc. The main weaknesses were the lack of effective proposals for practicals that promote collaborative learning through participation and interaction among all students, and the lack of personalised comments of support and encouragement in relation to the students' learning progress.

## Keywords

teaching competencies, technology competencies, tutoring competencies, virtual environments, teaching assessment, Web 2.0

# *Didáctica universitaria en la era 2.0: competencias docentes en campus virtuales*

## *Resumen*

*La pujanza de la sociedad de las tecnologías y de la información, y la irrupción del fenómeno de la web 2.0 en los contextos formativos universitarios han provocado un profundo viraje en las funciones que deben desempeñar los docentes. La capacitación didáctica y tecnológica del profesorado se está convirtiendo en un imperativo para hacer frente a las nuevas situaciones de enseñanza-aprendizaje desarrolladas en escenarios virtuales y/o con el apoyo de herramientas tecnológicas.*

*En el presente trabajo se enuncian las competencias didácticas, tecnológicas y tutoriales que deben definir al docente 2.0 que desempeña sus tareas inmerso en entornos tecnológicos, las cuales están directamente relacionadas con aspectos intrínsecos al modelo instructivo adoptado, al contexto y a las nuevas herramientas mediadoras. Esas competencias profesionales van a plasmarse en la orientación dispensada a los estudiantes, en su capacidad para el diseño de materiales didácticos multimedia motivadores, en la formulación de actividades colaborativas, etc.*

*Tras encuestar a 70 docentes y a más de 840 estudiantes pertenecientes a las universidades españolas que integran el Campus Virtual Compartido del G9 (Cantabria, La Rioja, Extremadura, Oviedo, Pública de Navarra, Baleares, País Vasco, Zaragoza y Castilla-La Mancha), se ponen de manifiesto las fortalezas y debilidades detectadas en los docentes, y se subrayan las necesidades formativas más acuciantes, en consonancia con las demandas suscitadas por los planes de convergencia europea.*

*Entre las fortalezas señaladas por docentes y estudiantes –implicados en procesos formativos virtuales– destacan la correcta formulación de actividades que ha propiciado el aprendizaje, la variedad de recursos didácticos utilizados, la interactividad de los contenidos, etc. Y, como principales debilidades, la falta de propuestas efectivas de prácticas que promuevan un aprendizaje colaborativo a través de la participación e interacción entre todos los estudiantes, y la escasez de comentarios individualizados de apoyo y ánimo en relación a sus progresos en el aprendizaje.*

## *Palabras clave*

*competencias didácticas, competencias tecnológicas, competencias tutoriales, entornos virtuales, evaluación docente, web 2.0*

# Introduction

It is clear that one of the new functions of teaching staff is the effective integration and incorporation of teaching media in order to optimise learning. Teacher training and development aimed at using and handling ICTs is therefore one of the key ways of ensuring such integration (Del Moral & Villalustre, 2010).

This new teaching profile will almost certainly involve the espousal of change from the point of view of being open to innovation by incorporating new technologies and Web 2.0 tools as resources that contribute to the optimisation of the teaching-learning process in universities.

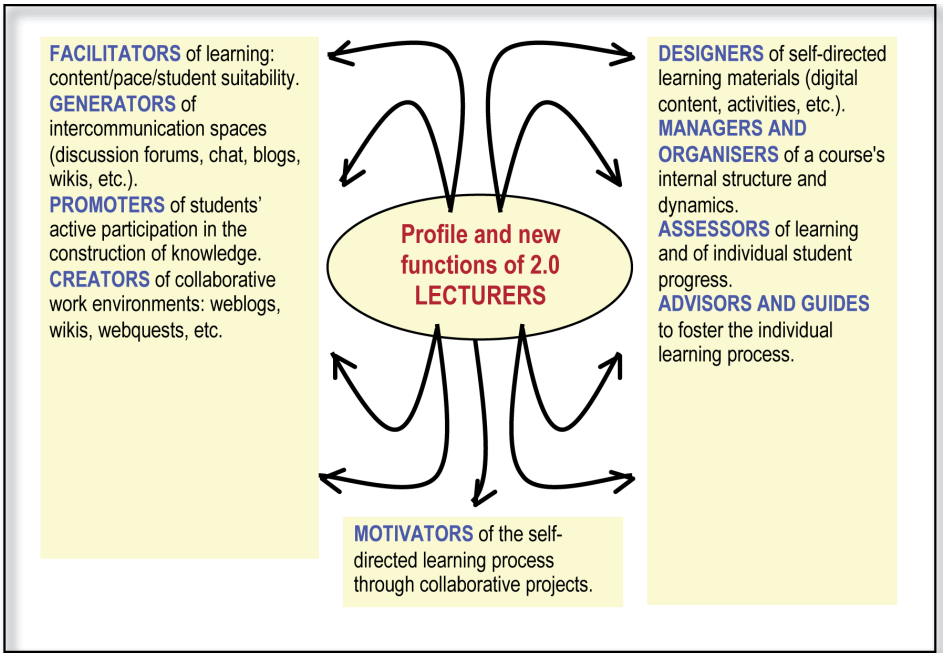


**Figure 1**. Profile and new functions of 2.0 lecturers (Del Moral & Villalustre, 2004)

Consequently, besides their traditional lecturer, tutor and researcher functions, university lecturers will need to add a fourth ICT expert function that enables them not only to use Web 2.0 tools and applications as yet another teaching resource in the classroom, but also to undertake their own teaching duties in new virtual settings.

Moreover, with the advent of new learning contexts that are supported by Learning Management Systems (LMSs), together with the university environment's advocacy (within the new European Higher Education Area, EHEA) of teaching formulas that combine face-to-face and e-learning (blended learning), 2.0 lecturers are required to know how to undertake their professional activities in these new virtual settings, not only to make full use of the opportunities that the tools they contain offer, but also to discover the potential they hold in terms of fostering learning. However, it is worth recalling the fact that students must be central axis of the education process; a process that shall necessarily be oriented towards fostering the acquisition and strengthening of their capacities and abilities, as concluded in the research coordinated by Del Moral (2007) and funded by the Spanish Ministry of Education and Science, later published in Del Moral y Villalustre (2009a)."

Thus, besides being experts in their respective academic disciplines, 2.0 lecturers have to be equipped with the necessary professional competencies (cognitive, teaching, technology, communicative, emotional, etc.) to successfully rise to the challenge of their duties in the 2.0 era.

Likewise, the progressive and greater planning of teaching in competency terms has led to a significant change in the education practices of teaching staff, which require specific professional training to help and accompany students throughout their education processes.

From this perspective, we believe that is necessary to know which competencies teaching staff employ in their day-to-day practice and, ultimately, to ascertain their professional competency levels as a way of identifying strengths and weaknesses in order to contribute to the enhancement of teaching practice.

# Professional Competencies Of 2.0 Lecturers

## Context

In the second semester of the 2009/2010 academic year, 70 university lecturers teaching one of several subjects in e-learning mode on the *Campus Virtual Compartido del G9*[1] were asked to complete a questionnaire (2010); 840 students that had taken any of those subjects were asked to complete a similar questionnaire. The information requested referred to the methodological and teaching aspects of the e-learning subjects in order to infer – from the data obtained – an assessment of the lecturers' professional competencies in education practices as applied to virtual environments. It should be noted that the students' and the lecturers' opinions were taken into account.

## Participants

### Surveyed university lecturers:

Briefly, in the sample of surveyed lecturers, 65% were male and 35% were female, from various knowledge areas. In both cases, most of them were aged 38-45 and had a mean of 2-5 years of virtual teaching experience.

### Surveyed university students:

In the sample of surveyed university students, just over 45% were female and 55% were male, from various degree courses. In terms of age, most of them fell within the 20-24 age range. The highest percentage of students was from the University of Oviedo (25%), followed by the University of

1. Comprising the universities of Cantabria, La Rioja, Extremadura, Oviedo, the Balearic Islands, the Basque Country, Zaragoza and Castilla-La Mancha, and the Public University of Navarre.

Extremadura (22%), the Public University of Navarre (15%) and the universities of Cantabria (11%), Castilla La Mancha (10%), the Basque Country (8%), La Rioja (6%) and the Balearic Islands (3%).

## Data gathering instruments

Two similar questionnaires were used. Through the questionnaire for lecturers, data were gathered on the methodological aspects that they said they adopted to teach their respective subjects. Through the questionnaire for students, data were gathered on their perceptions of the lecturers' performance in the various e-learning subjects, particularly in relation to: 1) Aspects referring the lecturers' *technology competencies*; 2) Aspects referring to the lecturers' *teaching competencies;* 3) Aspects referring to the lecturers' *tutoring competencies*.

## Presentation of results

### 1) The lecturers' technology competencies

On the basis of several items, the lecturers were asked to assess certain aspects that served as indicators to identify their technology competencies, such as the level of skill and ability that they believed they had with regard to handling the tools of the virtual environment in which the various subjects were taught; the tools for designing teaching materials; and their level of skill with regard to office-automation and web-browsing programs.

Table 1. Percentage distribution of the level of skill and ability of use that the lecturers said they had with regard to the handling of various tools

| ***Level of skill*** | ***SKILL AND ABILITY IN THE USE OF TOOLS:*** | | |
|---|---|---|---|
| | ***Of the virtual environment*** | ***For designing teaching materials*** | ***Office automation and web browsing*** |
| Very low | - | - | - |
| Low | - | 3% | - |
| Medium | 5% | 23% | - |
| High | 55% | 41% | 42% |
| Very high | 40% | 33% | 58% |

Just over half of the lecturers (55%) said that they had a *high* level of skill in the use of the tools of the virtual environment in which they taught, while 40% said that they had a *very high* level of skill. However, when asked about their level of skill with regard to handling tools for designing teaching materials (presentations multimedia, web pages, etc.), 3% considered that their level was *low* and 23% *medium*. This is a handicap that needs to be overcome because, to teach a subject in a virtual environment, it is an essential requirement that lecturers elaborate motivating, attractive materials that facilitate the study of and approach to the content dealt with in each subject.

With regard to the level of skill and ability in the use of office-automation programs (Word, PowerPoint, Excel, etc.) and web-browsing programs, 58% of the lecturers stated that they had a *very high* level, while 42% stated that they had a *high* level. This undoubtedly gives an idea of the lecturers' predisposition to access various technological tools.

## 2) The lecturers' teaching competencies

Through several items, which served as indicators, the lecturers and the students were asked to assess various aspects directly related to: a) the lecturers' ability to adopt, in their subject, a suitable *instructional design*; and b) their capacity and skill to *design teaching materials*. The results are presented below:

*a) Teaching competencies connected with instructional design*

Through the first set of items, data were indirectly gathered on the personal assessments that the lecturers made of their level of teaching competency. Data were also gathered on the same issue through the assessments that the students made. For that purpose, the lecturers and the students were asked about the suitability of the presentation of the objectives that guided the subject taught or taken, respectively. Thus, it was found that while 83% of the lecturers stated that they had always given their students a clear, explicit presentation of the objectives (Table 2), only 60% of the university students were of the same opinion. In addition, it should be underscored that 19% of the students surveyed pointed out that they had not perceived that the lecturers had presented the objectives with the desired clarity and transparency.

Something similar occurred with the assessments that the students made of the existence of a clear definition of the competencies that they were supposed to attain from the subject taken online, since 18% of them stated that they had *never* or *hardly ever* been made known to them.

Table 2. Percentage distribution the lecturers' (LEC) and the students' (STU) assessments of teaching competencies connected with instructional design

| *Items* | *Never/Hardly ever* | | *A Sometimes* | | *Always/Nearly always* | |
|---|---|---|---|---|---|---|
| | *LEC* | *STU* | *LEC* | *STU* | *LEC* | *STU* |
| 1. Gives a clear, explicit presentation of the learning objectives | 1% | **19%** | 16% | 20.5% | **83%** | **60.5%** |
| 2. Defines and makes known the competencies that students should attain and/or develop | 6.7% | **18%** | 41.7% | 26.5% | 51.6% | 55.5% |
| 3. Offers suitable content to attain the objectives of the subject | 1.6% | 18% | 11.3% | 18.6% | **87%** | 63.4% |
| 4. Proposes activities that allow content to be assimilated and to achieve good learning | - | 15.6% | 11.5% | **20%** | **88.5%** | 64.4% |

Table 2. Percentage distribution the lecturers' (LEC) and the students' (STU) assessments of teaching competencies connected with instructional design

| Items | Never/Hardly ever | | A Sometimes | | Always/Nearly always | |
|---|---|---|---|---|---|---|
| | LEC | STU | LEC | STU | LEC | STU |
| 5. Sets ongoing assessment or self-assessment tests or exercises | 6.4% | 11.3% | 6.5% | 14% | **87%** | 74.8% |
| 6. The assessment formula adopted allows the assimilation of content and the attainment of objectives to be demonstrated | - | **15.2%** | 11.5% | 18% | **88.5%** | 66.8% |
| 7. Fosters collaborative work among students through activities | 38.3% | 32% | 20% | 21.7% | **21.7%** | **46.3%** |

Most of the lecturers surveyed considered that they had offered suitable content to attain the objectives (87%) and proposed activities that allowed such content to be assimilated (88.5%) (Table 2). However, the students' opinions in this respect were very divided: 15.6% stated that the lecturers had *never or hardly ever* proposed any activities that allowed them to assimilate content and achieve good learning, while 20% pointed out that the lecturers had only *sometimes* done so (Table 2).

These data are worthy of serious reflection because, according to Cabero and Román (2006), if educational activities help students to approach the content dealt with in the subject while developing cognitive operations of various kinds, then there is no doubt that great pains should be taken to ensure the proper formulation of suitable activities that are relevant to each learning situation, because such formulation is one of the fundamental tasks of the teaching function that demonstrates teaching competency.

Likewise, the establishment of an assessment system that is consistent with the objectives and content of the subjects is something that needs to be thoroughly planned and not left to chance. Nor should arbitrary or simplistic formulas be adopted (Del Moral & Villalustre, 2009b). On this issue, it should be pointed out that over 88.5% of the lecturers considered that the mode of assessment they had adopted was suitable for ascertaining the attainment of the objectives and the students' level of assimilation of content, while the remaining 11.5% stated that this was *sometimes* the case (Table 2).

In contrast, just over 15% of the students (Table 2) perceived that the planned assessment system was not suitable for measuring their advances and progress on the subject. This therefore brings into question the relevance and suitability of the assessment criteria and formulas that are often adopted in virtual and blended-learning contexts.

According to Miller (2000), collaborative learning arises as a response to the subject's need to learn alongside others. And there is no doubt that fostering situations that encourage such learning does indeed contribute to a mutual enrichment and a transfer of knowledge. However, 38% of the lecturers surveyed (Table 2) stated that they had *never or hardly ever* proposed or undertaken any activities aimed at fostering collaborative learning among their students, while 20% had *sometimes* done so and only 22% had *always or nearly always* done so.

Consequently, we found an association with the data gathered from the students because 46% of them (Table 2) stated that their lecturers had regularly fostered collaborative learning, while only 22% had *sometimes* done so and 32% had *never or hardly ever* done so.

*b) Teaching competencies connected with the design of materials*

Another set of items was aimed at finding out about the teaching competencies that the lecturers stated they had with regard to designing teaching materials, and about the students' assessments of them. For that purpose, they were first of all asked about aspects connected with the structure and design of teaching materials. And, in this respect, over 88% of the lecturers (Table 3) considered that the materials elaborated on digital media were suitable for facilitating study and had a suitable structure. The students' opinions in this respect were very disparate: 16% and 19% of them pointed out that the presentation and the structure of the teaching materials, respectively, were not suitable.

Table 3. Percentage distribution the lecturers' (LEC) and the students' (STU) assessments of teaching competencies connected with the design of teaching materials

| *Items* | *Never/Hardly ever* | | *Sometimes* | | *Always/Nearly always* | |
|---|---|---|---|---|---|---|
| | *LEC* | *STU* | *LEC* | *STU* | *LEC* | *STU* |
| 8. Includes teaching materials that facilitate study | 3.3% | **16%** | 8.2% | 20.5% | **88.5%** | 63.5% |
| 9. The teaching materials for the subject have a suitable structure | 5% | **19%** | 6.5% | 19% | **88.5%** | 62% |
| 10. Considers that the times chosen for the presentation of the teaching materials were appropriate | - | 17% | 16% | 23% | **84%** | **60%** |
| 11. Facilitated the students' access to the teaching materials and activities | - | 12% | 3% | 18% | **97%** | **70%** |

Likewise, a large majority of the lecturers considered that the times chosen for the presentation of the teaching materials and for access to them were suitable (84% and 97%, respectively) (Table 3). However, the students' perceptions of these aspects were considerably lower (60% and 70%, respectively). Worthy of note are the percentages of students who judged their lecturers harshly for not facilitating the teaching materials at the time and in the manner that they would have liked (17% and 12%).

## 3) The lecturers' tutoring competencies

This set of items contained indicators that served to find out about the level of the lecturers' tutoring competencies. It was possible to infer this aspect from the answers that the lecturers and the students gave on various matters connected with the guidance or with the tutoring offered by their lecturers, as well as the stated abilities to manage participation. The results were as follows:

*a) Tutoring competencies connected with tutorial guidance*

In an attempt to assess the level of the lecturers' tutoring competencies, the lecturers and the students were asked about matters connected with the guidance and tutorial actions offered by the lecturers and received by the students in the course of educational actions.

Among other things, the aim was to establish whether strategies had been put in place to deal with the students' cognitive diversity, since such strategies greatly help to ensure optimum results in the learning process, as highlighted in the research projects undertaken by Del Moral and Villalustre (2004). The data show that 57% of the lecturers (Table 4) stated that they had made efforts to adapt to the prior knowledge that the students had, as well as to the cognitive particularities of their learning styles. Similarly, 41% of the students confirmed that this was the case, though it is significant that 28% of them pointed out that they had *never or hardly ever* perceived that the lecturers had made any effort to adapt to the students' knowledge and personal styles.

Table 4. Percentage distribution the lecturers' (LEC) and the students' (STU) assessments of tutoring competencies connected with guidance

| Items | Never/Hardly ever | | Sometimes | | Always/Nearly always | |
|---|---|---|---|---|---|---|
| | LEC | STU | LEC | STU | LEC | STU |
| 12. Makes an effort to adapt to the students' prior knowledge and learning styles | 10% | 28% | 33% | 31% | **57%** | **41%** |
| 13. Regularly sends messages to guide and orientate the students' learning | 5% | **30%** | 22% | 24% | **73%** | 46% |
| 14. Quickly and clearly answers the students' queries on activities | - | 21% | 2% | 19% | 98% | 60% |
| 15. Provides specific results and comments to support the students' learning progress | 3% | **28%** | 17% | 19% | **80%** | 53% |

According to Mingorance (2001), another good practice that helps to explain a lecturer's tutoring competency is the promotion of self-regulated and collaborative learning through various methodological and communicative strategies both inside and outside virtual contexts. A tutorial action centred on guiding and orientating students becomes the backbone of the educational action. In this respect, 73% of the lecturers (Table 4) considered that they had regularly sent messages to motivate and guide the students' learning, though this statement was not shared by 30% of the students, who seemed to feel a little unaccompanied.

Likewise, while 80% of the lecturers (Table 4) considered that they had provided the students with specific results and comments to foster the students' learning progress, 28% of the students (Table 4) were critical of the fact that they had not received personalised comments of support and encouragement in relation to their progress, and indirectly demanded that their tutors provide them with that motivation.

Nevertheless, as García and Troyano (2009) point out, we should not lose sight of the fact that tutorial action is conceived as a student support system that allows students to receive personalised accompaniment in order to ensure successful learning.

*b) Tutoring competencies connected with participation management*

Given that these subjects are taught in a virtual environment, the participation mechanisms that the lecturers mediate become very relevant because the students' continuance on a subject will greatly depend on them.

Thus, the lecturers and the students were asked about the existence of tasks to facilitate the introduction of the participants in the educational action in the first few days. Just over 70% of the lecturers (Table 5) stated that they had *always/nearly always* undertaken these tasks. However, over 28% of the students (Table 5) did not share that statement. It is essential to foster initial contacts between all the participants so that they can get to know each other and establish links that encourage interaction and favour the subsequent realisation of joint educational activities.

Table 5. Percentage distribution the lecturers' (LEC) and the students' (STU) assessments of tutoring competencies connected with participation management

| *Items* | *Never/Hardly ever* | | *Sometimes* | | *Always/Nearly always* | |
|---|---|---|---|---|---|---|
| | *LEC* | *STU* | *LEC* | *STU* | *DO* | *LEC* |
| 16. Proposes tasks to facilitate the introduction of all participants in the first few days | 18.3% | **28.3%** | 10% | 25% | **71.7%** | 46.7% |
| 17. Quickly and effectively deals with problematic situations | - | **22.3%** | 15% | 26% | 85% | 51.7% |
| 18. Fosters participation and communication among the subject's students | 15% | **23.4%** | 20% | 24% | 65% | 52.6% |
| 19. Guides participation in forums/wikis and encourages the compilation of conclusions | **23.3%** | 14.6% | 30% | 26% | 46.7% | 59.4% |
| 20. Asks the students to give arguments and reasons for their statements, suggestions, etc. | 8.4% | 17% | 16.7% | **24%** | **74.9%** | 59% |
| 21. Redirects the contributions towards the original activity or topic, if they have gone off track | 6.7% | 20.8% | 25% | 28.6% | 68.3% | 50.6% |

Likewise, just over 22% of the students (Table 5) perceived that the feedback given by the lecturers had not been as fluid as they would have liked, while 23.4% considered that the lecturers had not fostered participation and communication among all fellow students. These factors are considered to be of vital importance because the students' continuance in the subject's virtual environment often depends on them to a large extent.

Furthermore, 74% of the lecturers (Table 5) stated that they had asked the students to give arguments and reasons for their statements and suggestions. However, 24% of the students considered

that the lecturers had only *sometimes* asked them to undertake this task. This is an essential prerequisite for ensuring optimum learning that is not subject to relativism, but to thoroughness and grounding.

Finally, it should be noted that just over 23% of the lecturers (Table 5) stated that they had not regularly guided the students' participation through forums or wikis that had been set up on the various institutional LMSs of the universities. This finding is easy to understand if the volume of students is high, since it increases the amount of time that lecturers need to spend on monitoring collaborative practices through such tools.

## Conclusions

In order for ICTs to contribute to achieving the quality, mobility, diversity and competitiveness that the new EHEA wishes to foster for all education agents involved in the university education progress, they must become a substantial part of those agents' teacher training and preparation (De Pablos, 2005). In this regard, university education practices applied in virtual learning environments represent a major challenge. It is necessary to underscore the fact that they are spaces that can help lecturers generate and take actions that foster students' learning through the adoption of new forms of communication, tutoring and interaction (Area & Adell, 2010).

The study carried out highlights the fact that just over 80% of the lecturers considered that good teaching planning had been undertaken. However, the percentage fell to around 60% when the students were asked about the same issue. Likewise, around 75% of the lecturers made a positive assessment of their capacity to carry out tutorial actions, an assessment that is shared by approximately 50% of the students. Similar data were obtained for the surveyed lecturers and students with regard to the lecturers' capacity to manage participation; 70% of the lecturers and 53% of the students made a positive assessment of this issue.

Thus, from the results obtained, it was possible to identify a whole series of strengths and weaknesses in relation to the professional competencies that the lecturers had in order to undertake their activities in virtual contexts.

Among the *strengths* found in relation to the *teaching and technology competencies* that the lecturers employed, according to the lecturers' and the students' opinions, the following stand out: the proper formulation of activities that foster learning, the consistency of objectives/content with the assessment made, the setting of self-assessment tests, etc. Likewise, for the most part, the surveyed lecturers and students highlighted the fact that they had perceived clarity in the presentation of content, the variety of resources used, the potential for content interaction, etc.

The main *weaknesses* were the lack of effective proposals for practicals that promote collaborative learning through participation and interaction among all students to foster a suitable context that encourages the shared construction of knowledge, as well as the lack of a suitable structure of teaching materials that facilitates the students' journey through the content and their understanding of the interrelation and connection that may exist between the various sections such materials comprise.

With regard to the *strengths* stated by the surveyed lecturers and students in relation to the tutoring

competencies that the lecturers perceived they had, worth underlining is the existence of individual and group tutoring practices fostered by fluid communication through clear, quick answers to the students' queries. However, the lack of personalised comments of support and encouragement in relation to the students' learning progress was the main *weakness* found by the students.

Finally, from the results obtained, it was possible to establish the competencies considered essential for 2.0 lecturers to have:

*Teaching and technology competencies*

- The capacity to motivate, through the design of content focusing on practical application and the formulation of activities adapted to the students' cognitive characteristics and interests.
- The capacity to assess learning, adopting continuous assessment that checks the assimilation and practical application of content.
- The capacity to handle digital tools suited to the content and to the activities that need to be undertaken, and to the students' cognitive characteristics.
- The ability to suitably select and use 2.0 resources to promote learning.

*Tutoring competencies*

- The capacity to communicate, as well as social skills and empathy, to foster the process of communication and interaction with and among students in the virtual context.
- The ability to create and manage work groups and to promote the students' active participation by previously selecting the right 2.0 tools to make that effective (blogs, wikis, etc.).

# References

AREA, M.; ADELL, J. (2009). "E-learning: enseñar y aprender en espacios virtuales". In: J. DE PABLOS (coord.). *Tecnología educativa. La formación del profesorado en la era de Internet*. Malaga: Ediciones Aljibe. Pages 391-424.

CABERO, J.; ROMAN, P. (2006). *E-actividades. Un referente básico para la formación en Internet*. Seville: Editorial Eduforma.

CVC DEL G9 (2010). *Oferta formativa para el curso académico 2010/2011*. [Accessed: 20 October 2010]. <https://www.uni-g9.net/portal/asignaturas2010-2011.html>

DE PABLOS, J. (2005). "El Espacio Europeo de Educación Superior y las Tecnologías de la información y la Comunicación". In: P. COLÁS & J. DE PABLOS (coords). *La Universidad de la Unión Europea. El espacio Europeo de Educación Superior y su impacto en la docencia*. Malaga: Ediciones Aljibe. Pages 57-73.

DE PABLOS, J. (2008). "Nuevas formas de trabajo en las aulas universitarias con el soporte de las Tecnologías de la Información y la Comunicación". In: M. E. DEL MORAL & R. RODRÍGUEZ (coords). *Experiencias docentes y TIC*. Barcelona: Editorial Octaedro. Pages 43-58.

DEL MORAL, M. E. (coord.) (2007). *Proyecto MATRIX: Modalidades de aprendizaje telemático y resultados interuniversitarios extrapolables al nuevo EEES* [online report]. Project funded by the Spanish Ministry of Education and Science. EA 2007-0015. <http://82.223.210.121/mec/ayudas/CasaVer.asp?P=29~~260>

DEL MORAL, M. E.; VILLALUSTRE, L. (2004). "Indicadores de calidad en la docencia virtual: adaptación de los entornos a la diversidad cognitiva de los estudiantes". *Aula Abierta*. No 84, pages 155-172.

DEL MORAL, M. E.; VILLALUSTRE, L. (2009a). "Modalidades de aprendizaje telemático y resultados interuniversitarios extrapolables al nuevo EEES". Proyecto MATRIX. Barcelona: Octaedro. <http://www.octaedro.com/pdf/16036.pdf>

DEL MORAL, M. E.; VILLALUSTRE, L. (2009b). "Las competencias didácticas y tutoriales de los docentes en contextos virtuales, evaluadas por los aprendices, y sus implicaciones". In: R. ROIG (dir.). *Investigar desde un contexto educativo innovador*. Alicante: Editorial Marfil. Pages 83-102.

DEL MORAL, M. E.; VILLALUSTRE, L. (2010). "Formación del profesor 2.0: desarrollo de competencias tecnológicas para la escuela 2.0". *Revista Magíster*. No 23, pages 59-70.

GARCÍA, A.; TROYANO, Y. (2009). "El tutor universitario en el Espacio Europeo de Educación Superior: guiando a estudiantes de pedagogía". In: R. ROIG (coord.). *Investigar desde un contexto educativo innovador*. Alicante: Editorial Marfil. Pages 171-182.

MINGORANCE, P. (2001). "Aprendizaje y desarrollo profesional de los profesores". In: C. MARCELO (coord.). *La función docente*. Madrid: Síntesis. Pages 85-101.

MILLER, L. (2000). "La resolución de problemas en colaboración". In: REIGELUTH (ed.). *Diseño de la instrucción. Teorías y Modelos. Un nuevo paradigma de la teoría de la instrucción. Parte I*. Madrid: Santillana. Pages 255-259. (Aula XXI).

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ARTICLE

# Social Networks and University Spaces. Knowledge and Open Innovation in the Ibero-American Knowledge Space[1]

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## Abstract

Information technology-based social spaces can open up new ways to facilitate the university community's participation in decision-making processes. Although the appropriation of technology is very high and widespread among university groups, there is a very weak presence of suitable structures and processes that enable institutions to channel online participation, to analyse their

1. Article based on the work and results of the research project "Online Knowledge Management: UniversiaG10" funded by the Santander Universities Global Division of Banco Santander.

impact on improving organisational goals and, ultimately, to make use of such open processes as a means of generating innovations in their main lines of action. Based on the experience of coordinating the UniversiaG10 project, the Social Web platform of the 2nd Universia International Meeting of Rectors, this article proposes some innovations and elements that justify the need to move towards true e-governance of universities.

Drawing on the design and results of this project, we review the bases of sociability on the Web by taking account of grassroots movements and new hybrid models of interaction on social networks, both on- and offline. Building on these experiences and a critical analysis of them, we consider ways to nudge towards open-innovation processes in higher education institutions by taking the dynamics of participation in the Social Web as the point of reference. In particular, two cases of socio-educational innovation stemming from the actions implemented while the project was running are conceptualised: firstly, the institutionalisation of participatory logics and, secondly, community-based dynamics. The conclusions highlight the opportunity to move towards e-governance models in universities in order to integrate open innovation and university-community participation dynamics through social technologies.

## Keywords

distributed knowledge, higher education, social networks, open innovation, grassroots movements, nudge, e-governance

# *Redes sociales y espacios universitarios. Conocimiento e innovación abierta en el espacio iberoamericano del conocimiento*

## *Resumen*

*Los espacios sociales basados en las tecnologías de la información pueden abrir nuevas vías para facilitar la participación de la comunidad universitaria en los procesos de toma de decisiones. Aunque la apropiación de tecnología sea muy elevada y generalizada entre los colectivos universitarios, resulta muy débil la presencia de procesos y estructuras adecuadas que permitan a las instituciones canalizar la participación online, analizar su impacto para la mejora de los fines de la organización y, en última instancia, hacer uso de esos procesos abiertos como base para generar innovaciones en sus principales líneas de acción. Partiendo de la experiencia en la coordinación del proyecto UniversiaG10, la plataforma en la web social del II Encuentro Internacional de Rectores Universia (EIRU), en este artículo se formulan algunas innovaciones y elementos que justifican la necesidad de avanzar hacia una auténtica gobernanza electrónica de las universidades.*

*A partir del diseño y los resultados de dicho proyecto, se revisan las bases de la sociabilidad en la web partiendo del enfoque de los movimientos grassroot (de base) y los nuevos modelos de interacción híbrida en redes sociales dentro-fuera de internet. Apoyándonos en esas experiencias y en su análisis crítico, se plantearán formas de «empujar» (to nudge) hacia procesos de innovación abierta en las instituciones de educación superior, tomando como referencia las dinámicas de participación en la web social. En concreto, se conceptualizan dos casos de innovación socioeducativa que parten de las acciones aplicadas durante el desarrollo del proyecto: la institucionalización de las lógicas participativas y las dinámicas basadas en la comunidad. En las conclusiones se pone de manifiesto la oportunidad de avanzar hacia modelos de e-gobernanza en las universidades, con el objetivo de integrar la innovación abierta y las dinámicas de participación de la comunidad universitaria apoyadas por tecnologías sociales.*

## *Palabras clave*

*conocimiento distribuido, educación superior, redes sociales, innovación abierta, movimientos* grassroot, nudge, *e-gobernanza*

# Introduction

The two meetings of Ibero-American university rectors organised by the Universia network (Seville 2006 and Guadalajara 2010) allowed the heads of those institutions to contrast their views of higher education and to jointly identify the challenges faced by the tertiary education system as a whole.[2] The latter was held in Guadalajara (Mexico) from 30 May to 1 June 2010, under the title "Universia International Meeting of Rectors".

From the early stages of preparing for the meeting, and in order to bring innovation to its organisational model, those in charge of the Universia International Meeting of Rectors considered that the debate on the meeting's thematic content should be opened up to the university community. This content, initially proposed by the rectors and institutional managers, was taken as the basis for articulating the reflections and agreements stemming from the event. The idea behind the new model was to strengthen participation and openness. Indeed, it led to an open, expanded event (living meeting) that allowed the potential of online socialisation spaces to be used to the full; the actions promoted at the meetings of rectors were basically aimed at the university community, and this new model allowed that community's interests to be integrated more directly.

In order to progress towards the goal of expanding participation, a series of Internet-based projects were implemented. We had the opportunity to coordinate one of those projects, UniversiaG10, which is the object of study and the source of the analysis performed in this article.[3] Regarding the goals of the UniversiaG10 project, three areas were considered:

- Instrumental area: To develop an online conversation open to audiences belonging to Ibero-American society that might be interested in higher education.
- With the data obtained from participation: To manage the knowledge acquired and to transfer it to the debates articulated by the meeting of rectors.
- Strategic area: To try and drive innovations in the use of technologies in order to strengthen and improve the governance of the higher education institutions belonging to the Universia network.

2. The official documents generated by the two meetings of rectors are available at: *Declaración de Sevilla* (2005), http://encuentro2005.universia.net/declaracionsevilla.htm; *Agenda de Guadalajara* (2010), http://www.universiag10.org/wp-content/uploads/guadalajara.pdf.

3. In short, the UniversiaG10 action consisted in seeking out and motivating, on social networks, the type of audience that would be interested in reflecting on the present and future of the Ibero-American university system. Once in contact with the audience, and in order to create a discourse and develop a conversation around it, an information flow was generated on social networks with the aim of contributing ideas on and fostering exchanges about the Universia International Meeting of Rectors 2010. The Social Web conversation took place in the following environments: Twitter, Facebook, YouTube, LinkedIn and Delicious. In addition, in order to manage the content, a project-specific platform was designed, www.universiag10.org, which acted as a point of convergence for anyone to follow the open conversations on the Social Web.
The focus, milestones and main results can be found in the final report of the UniversiaG10 project (Alvárez & Domínguez, 2010). The final report gives a detailed account of the project's most significant data, so the reader is strongly encouraged to read it in order to validate and contrast the information contained in this work. We refer to the data contained in the report when considering the reflections and the analytical frameworks stemming from this practical intervention.

The results generated in these areas are interpreted in a theoretical and conceptual framework where the tensions arising from the expansion of new forms of sociability on the Internet are examined. In the university sphere, these tensions arise in the particular relationship between grassroots social practices,[4] which spontaneously emerge among university-community participants, and institutional stances, which normally tend in the opposite direction due to the creation of online contexts that are constrained and limited to certain types of practices (Pando, 2010).

From the experience of the UniversiaG10 project, in which these tensions are identifiable, we endeavour to reflect on how a suitable consideration of the associative potential of the Internet can serve as a basis for driving institutional actions that generate advances (Thaler & Sunstein, 2008) that, in this case, can be applied in order to improve the model of relationships between universities and their audiences, as well as their joint knowledge production.

## Theoretical and conceptual framework: hybrid sociability and grassroots movements

The growing phenomenon of new citizen practices associated with the innovative power of information technology[5] is still far from reaching its full impact on the sphere of higher education. Universities have incorporated technologies in a generalised manner, driven by advances in the information technology and telecommunications sectors.[6] Generally speaking, however, this proliferation of tools and systems does not appear to have taken place in a policy and institutional management context that has surpassed the scope of the specific actions of technology units and services to reach the entire range of strategic lines of an organisation.

From its initial conceptualisation, the UniversiaG10 project endeavoured to avoid these biases towards an aseptic version of technology by including the social components of interaction as the main element. In order to do that, attention was focused on expanding social participation in various web-based environments, which meant that it was necessary to learn about the traits that

4. Grassroots movements are citizen groups that spontaneously emerge. They have a specific goal that justifies their existence and gives them meaning. Here, these groups are not considered in all of their sociological breadth. They will be used specifically as an interpretational approach to the ethos and configuration of those virtual communities that shaped the earliest expressions of cyberculture. An extensive analysis of these movements and of their connection with the Internet's evolution can be found in Castells (2000 and 2001). For a study applied to the capacity of online grassroots groups to take action in various contexts and with varying goals, see Norris (2001), Juris (2006) and Castells (2009).

5. Although the term 'information technology' usually has a highly technological meaning, with specific approaches in the fields of engineering and economics (see Sáez (2004)), it is used in this article to express the material component of information in the context of the network society (Castells, 2001).

6. There are many studies on the role of information technology in higher education. Taking the Spanish context as a point of reference, the most representative image is provided by a series of UNIVERSITIC studies by the Conference of Spanish University Rectors. The latest of these studies (Uceda & Barro, 2009) provides a clearly technocentric snapshot of the socio-educational potential of information technology. As a complement to that view, a critical approach to models of technology appropriation for pedagogical purposes in higher education can be found in Domínguez (2007). This perspective has been developed further in the joint study entitled "Gobierno electrónico y gobernanza en el Sistema Universitario Español (GEGOSUE)" (Álvarez et al., 2011).

characterise human behaviour in the new socio-technical contexts, paying equal attention to the individual level (which determines online 'presence') and to the group level (in the form of 'virtual communities'). That analysis allowed the main dimensions that shape online sociability to be put into context, and to introduce a conceptual basis on which to plan socio-educational uses of and practices with technologies in various institutional settings.

## Hybrid social 'presence'

Online 'presence' comprises a set of social practices that define the action and stance of individuals in the information society. Knowing their defining traits provides an essential basis on which to design effective social promotion actions. Of the many elements that shape online presence, worthy of analysis – from a theoretical and conceptual perspective – are two relevant aspects for the design of extended social actions such as those that took place at the 2nd Universia International Meeting of Rectors: (i) the techno-social structure of the environments in which practices take place; and (ii) aspects connected with people's engagement in participatory networks.

From a structural viewpoint, the Web is a public space that complements the physical environment where day-to-day sociability is shaped. The structure of this public space is not static. Rather, it evolves as a result of the complex interactions that take place between its two essential components: the technological component and the social component. In the context of that evolution and for analytical purposes, the most noteworthy trait of the Web is currently the hybridisation of on- and offline sociability. The online-offline hybridisation factor has a direct impact on the structure of sociability, since it gives rise to significant changes in people's behaviour. As a consequence of that component, the practices that take place on the most popular social networking sites (Facebook and Twitter for example) are noticeably very different from the ethos and purposes of early virtual communities. In the early years of the Web, social relationships were characterised by several clear forms of constraint, especially with regard to the topics of conversation (content connected with the development of protocols and software that made the advent of the Internet possible, civilian protests and role-playing games)[7] and to the structure of such conversation (limited by the characteristics of the communication tools).[8] Over time, those highly specific practices have led to forms of relationship that are more open, where technologies are directly present and embedded in people's physical lives, and the content shared covers the whole spectrum of daily life.[9] For its part, the ubiquity of connected devices allows for forms of extended sociability that blur the boundaries between physical and virtual reality (Monge & Contractor, 2003; Benkler, 2006; Echeverría, 2009).

7. For an initial approach to the logic of virtual communities prior to the advent of social networks, see Rheingold (1993), Turkle (1995), Jones (1998), Castells (2001), Di Maggio et al. (2001) and Katz et al. (2001). A generic analysis of social movement topics on the first generation Web can be found in Diani (2000).
8. An analysis of how technological architecture impacts on social practices on the Web can be found in Mayans (2001) and Estalella (2005a and 2005b). The former deals with IRC Chat channels and the latter deals with blogger communities.
9. To this range of generic topics, a particular aspect that needs to be added is the banal and fake backdrop that predominates in accounts and conversations on social networks constituting the mainstream (Mayans, 2006; Lara, 2010).

The resultant model is a web in which relationships are distributed in the form of a network; platforms that mediate between physical and virtual reality act as communication interfaces, and online interactions constitute the 'glue' that assures the bond between actors, ultimately driving the necessary innovations to keep the system active (Freire, 2010). To a certain extent, these interactions constitute the fluid in which human individualities are expressed, the behaviour of which is equivalent to semipermeable membranes that filter contextually dependent information (Álvarez, 2001 & 2002).

## (Grassroots) participation in the Social Web

The UniversiaG10 project sought to foster the presence of the Ibero-American university community in the 2nd Universia International Meeting of Rectors. In order to achieve that, a Social Web promotion strategy was designed with three objectives in mind: (i) to give the university community access to the entire content of the meeting of rectors; (ii) to activate and maintain online participation in the meeting; and (iii) to establish resources to allow the content of online debates to be reused in order to enhance the reflections made by the rectors. Generally speaking, these objectives do not differ greatly from those of other similar projects for online group management.

In order to achieve those objectives, the project design took account of the constraints on classic virtual-community promotion theories (Rheingold, 1993) arising from new forms of expanded sociability involving on- and offline practices and participants from many cultural backgrounds. The most significant innovation was a distributed communication system based on multiple open conversations. The aim was to get participants themselves to mould the development of the discourse so that it would generate a feeling of belonging. Under the UniversiaG10 brand, new sharing and socialisation spaces were also created to allow the university community's initiatives to be disseminated. Online conversation was considered to be an integrative component, and attempts were made to group conversations around pre-meeting activities, debates among participants in Guadalajara and post-meeting contributions. These innovative actions represented a step forward in the model of relationships between an institution like Universia and its audience, which was this time based on bidirectional processes and greater horizontality.

Likewise, to go beyond the classic models of interaction in virtual communities, a community participation strategy was designed. This strategy was based on the way grassroots movements operate in cyberspace. The organisational forms of grassroots movements are an important focus of analysis in terms of understanding today's online social dynamics and, by extension, they allow the organisation of online-offline group action to be elucidated.[10]

In the stages prior to the Social Web, online grassroots movements were articulated as 'intelligent crowds' and, with diverse goals, they used the potential of the Internet to strengthen their role and exert influence over the environment (Rheingold, 2002). Later, the capacity of any kind of group

10. See Castells (2009) for an in-depth analysis of information technology-based social movements and their impact on cultural change in the information society context.

to take action expanded significantly as a consequence of two major techno-social factors: (i) the proliferation of mobile devices; and (ii) the emergence of new open-innovation platforms, which operate and feed back on each other through social practices that take place both inside and outside the Internet space. The interplay of these two factors has led to new organisational capacities at social movements' and communities' disposal that are substantially different from those available in the pre-2.0 era. Today, information technology serves as a powerful catalyst to empower social actors and provide them with the necessary resources to implement their action in the information society.[11]

Within its limited scope of action, the UniversiaG10 project aimed to serve as an agent that made indirect use of grassroots forms of organisation. The analytical interest resides in the precise ways of carrying out grassroots action from an institutional platform like Universia, and in how to prevent the corporate approach from negatively altering the objectives of openness and horizontality. Both aspects form part of the socio-technical innovations examined in the next section.

## Focal points of socio-educational innovation

Linked to the general objectives of the project, the main innovations stemming from this experience were: the expansion of the Ibero-American university community's organisational capacity and the management of knowledge arising in that context.

To better analyse these innovations and their potential transfer to higher education institutions, we considered the utility of the nudge approach proposed by Thaler and Sunstein (2008) in the context of 'libertarian paternalism'.[12] The innovations and novel proposals arising from the UniversiaG10 project may serve as nudges to get higher education institutions to improve their open management and participation dynamics for the benefit of the university community.

## Inverse socio-technical appropriation: institutionalisation of grassroots methods

From a conceptual viewpoint, it is a matter of reflecting on two intertwined approaches: (i) social action proposals based on generative communities that are inherent to online culture; and (ii)

11. The new reality facilitated by Web 2.0 tools and other types of technology, such as augmented reality, dynamic contextual information and geolocation, has been conceptualised by George Siemens under the term 'xWeb'. For Siemens (2010), the "xWeb is the utilization of smart, structured data drawn from our physical and virtual interactions and identities to extend our capacity to be known by others and by systems". In the context of this work, individuals and communities are understood to be operating in an environment thus defined.
12. Nudges are based on evidence of the fact that people do not take decisions in a void. They take them in an environment influenced by many determining factors. The person/body that creates the environment in which these decisions are taken is a choice architect (Thaler, Sunstein & Balz, 2010). This architecture is used to nudge people to help them take better decisions, without forcing any final outcome on them, while retaining the individual's choice. This approach to indirect, choice-based intervention is called 'libertarian paternalism'.

institutional initiatives that use Web 2.0 resources as a marketing strategy to access and exert influence over their target audience. The practices included in this second dimension are called 'astroturfing'. 'Astroturfing', a term derived from AstroTurf (a brand of artificial turf), is used in opposition to the term 'grassroots' (used here with the meaning of a spontaneous popular movement) and aims to pass off an advertising campaign, festival, demonstration or protest as something popular, spontaneous and independent from an organisation or company (Pando, 2010). It is about institutions or official agents using forms of action drawn from online grassroots movements in order to further their mission or strategic objectives. While UniversiaG10 was not entirely an astroturfing initiative, it did have several comparable components, in that it was a project promoted by an organisation (Universia)[13] and that one of its goals was to enhance the impact of the 2nd Universia International Meeting of Rectors on the Social Web.

There is an obvious risk of mixing practices from opposing models of online mobilisation. Among these is the drift of institutional practices towards actions inherent to grassroots movements. This is a form of inverse appropriation that gives rise to numerous negative effects, such as a loss of credibility in the corporate discourse, the desertion of the critical mass, the unidirectionality of the conversation, the deterioration of content and the inability to generate novel arguments on the basis of a group's interests. Taken as a whole, these jeopardise the efficacy of communications that a social network is trying to promote and, therefore, of its potential as an expanded debate platform.

Ensuring that universities avoid these negative effects is key, since they are institutions whose prestige is based on the credibility and reliability of the proposals they make to and in society. Generally speaking, social network users expect their university-based interlocutors to establish sincere, non-commercial relationships that offer the chance to interact and learn about a variety of initiatives over and above those available in the physical world.

In order to correct the tendency existing in universities to inversely appropriate grassroots dynamics, the mechanisms used in UniversiaG10 suggest two possible initiatives: (i) the generation of multiple conversational environments, which expand the possibilities of topic development and provide participants with a varied offering that matches their interests; and (ii) the action's continuity over time, which is key for consolidating an institution's online digital identity, making it recognisable and generating the required level of trust to elicit fruitful interventions from its audiences.

## Community-based dynamics

Higher education institutions are social networks (although they are not necessarily structured in the form of a grid) that bring together a series of actors with whom they share common interests in educational environments for the purpose of professional and research inclusion. For its part, the university community forms another network that, directly connected with the institutional web, has

13. Indeed, to quote from Wikipedia, "Astroturfing may be undertaken by an individual promoting a personal agenda, or highly organized professional groups with money from large corporations, unions, non-profits, or activist organizations." http://en.wikipedia.org/wiki/Astroturfing [Accessed: 10 October 2010].

its own agenda or action programme, which the actors forming part of it define. The relationship capacity of both networks is directly dependent on the capacity for both systems to share communication protocols. As both networks begin to roll out common protocols, the inside-outside dynamics will become more fluid. In this regard, the practices carried out on social networks may act as either facilitators (semi-open interfaces) or inhibitors of the development of such protocols. For its part, as noted earlier, the content of these online exchanges in the information society constitutes the social 'glue' that bonds socio-technical innovations applicable to the system.

In an environment thus defined, the articulation of filtering processes and communication protocols that relate institutions with their communities of reference (and, by extension, with other core social actors and networks) is key to the success of organisations and their managing agents (Castells, 2000, 2001 and 2009). The UniversiaG10 project pointed to two possible ways of improving that connection. Both are linked to the objectives of obtaining knowledge from group interaction and of generating innovations that support continuous improvement processes in the university environment.

The first way that became apparent – albeit indirectly – was that online institutional openness strategies can facilitate the generation of valid knowledge to bring innovation and improvement to the system, in this instance the Ibero-American university system. This is based on the role of the individual as an active user of the Web. In the UniversiaG10 project report, this figure is identified as the 'prosumer' (Álvarez et al., 2010: 15). The term, which derives from the fusion of the words *PROducer* and *conSUMER*, has a long history in the field of economic thinking.[14] With the rise of social networks, it has been imbued with a new meaning and is now also used to refer to a type of user who interacts with Web content. Carried over to the educational environment, this phenomenon has led to student-as-producer theories (Neary, 2008; McCulloch, 2009; Neary & Winn, 2009; Taylor & Wilding, 2009), which situate teachers and lecturers in the role of people who provide accompaniment and guidance throughout the teaching-learning process, and who develop their expertise in a specific subject, just like curators of cultural exhibitions (Graham & Cook, 2010). A university community consisting of actors capable of producing content and articulated in a network, together with the necessary interface platforms to channel that participation, is the structural prerequisite for managing knowledge in the system formed by higher education institutions on local (geographical and identity-related) and global (society as a whole) scales.

The second way refers to community dynamics, understood as the capacity to generate institutional innovations based on the articulation of individuals' and interest groups' open participation. This process, which is directly associated with the prosumer phenomenon, has been conceptualised in various manners depending on where the focal point of interest lies. For example, it could be defined as 'crowdsourcing' if the objective is to reduce an organisation's costs and speed up its processes. It could also be called 'Open Innovation OUT' if the aim is to improve creativity (Freire, 2007).

In any event, all social open-innovation models have three fundamental components: networks, collaboration and shared assets. That is the reason why, on the UniversiaG10 open platform, we

14. For example, it was already used in 1980 by Alvin Toffler in his bestseller *The Third Wave*. Though it can also be traced back to classical social thinking. In this regard, it suffices to recall Marx's *Grundrisse*.

aimed to develop a knowledge management model that took account of those three components while proposing three articulated processes in order to: (i) design a basis for *collaboration*, taking the Social Web as the environment; (ii) integrate the actors into a *network* of shared interests by means of a discursive thread that would serve as a common denominator; and (iii) associate the result of the exchanges with a *shared* cause like the 2nd Universia International Meeting of Rectors.

## Conclusions: towards e-governance in higher education

We have endeavoured to document a case in which institutions relate to their audiences through an intensive use of mediating technologies by their organisational bodies. The new forms of relationship inspired by this type of experience point to the intensive use of the potential of social media and of devices that facilitate ubiquity in order to expand capacities to generate exchanges and to create and share new knowledge. Likewise, they introduce certain innovations that are in keeping with the methodology and objectives of organisational e-governance.

In this regard, it is in the context of e-governance systems that, through the integration of digital technologies and their socio-technical derivatives, these innovations could be implemented in a way that is useful to such institutions. All of this opens up new lines of research that may be very significant for the inevitable transformation that is taking place in higher education and in its educational, organisational and management models. Such transformation is a result of the deep-seated impact of the consolidation of a new socio-technical context; a context characterised by the massive expansion of information and communication technologies.

## References

ÁLVAREZ, J. F. (2001). "Filtros, membranas y redes: vínculos entre ética y economía". In: Mª. I. Lafuente (coord.). *Los valores en la ciencia y la cultura: Actas del Congreso "Los valores en la ciencia y la cultura"*. León: Universidad de León, Servicio de Publicaciones. Pages 159-176.

ÁLVAREZ, J. F. (2002). "El tejido de la racionalidad acotada y expresiva". In: M. B. Wrigley (ed.). *Dialogue, language, rationality*. Campinas. Brazil: Universidad de Campinas.

ÁLVAREZ, J. F.; DOMÍNGUEZ, D. [et al.] (2010). *UniversiaG10: Gestión en la nube del II Encuentro de Rectores Universia*. Madrid. [Accessed: 10 December 2010]. <http://www.slideshare.net/universiag10/informe-universiag10-30062010>

ÁLVAREZ, J. F.; ÁLVAREZ, L.; DOMÍNGUEZ, D.; KICZKOWSKI, A. (2011). "Gobierno electrónico y gobernanza en el Sistema Universitario Español". Informe de investigación. Ministerio de Educación. Programa de Estudios y Análisis (EA-2010-0147). Gobierno de España.

BENKLER, Y. (2006). *The Wealth of Networks, How Social Production Transforms Markets and Freedom*. New Haven: Yale University Press.

CASTELLS, M. (2000). *La era de la información. Vol. I. La sociedad red*. Madrid: Alianza Editorial.

CASTELLS, M. (2001). *La galaxia Internet. Reflexiones sobre Internet, empresa y sociedad*. Barcelona: Plaza & Janés.

CASTELLS, M. (2009). *Communication Power*. New York: Oxford University Press.

Di MAGGIO, P.; HARGITTAI, E.; NEUMAN, W. R.; ROBINSON, J. P. (2001). "The Internet's Effects on Society". *Annual Reviews of Sociology*. No 27, pages 307-336.

DIANI, M. (2000). "Social Movement Networks Virtual and Real". *Information Communication & Society*. Vol. 3, No 3, pages 386-401.

DOMÍNGUEZ, D. (2007). "Devenir histórico de mitos y usos tecnológicos en educación a distancia: de la lectoescritura al e-learning". *TEXTOS de la CiberSociedad*. [Accessed: 20 November 2010]. <http://cibersociedad.net/textos/articulo.php?art=136>

ECHEVERRÍA, J. (2009). "Cultura digital y memoria en red". *Arbor: Ciencia, pensamiento y cultura*. No 737, pages 559-567.

ESTALELLA, A. (2005a). "Anatomía de los blogs. La jerarquía de lo visible". *TELOS, Revista de Comunicación e Innovación*. No 65. [Accessed: 20 November 2010]. <http://sociedadinformacion.fundacion.telefonica.com/telos/articulocuaderno.asp@idarticulo=9&rev=65.htm>

ESTALELLA, A. (2005b). "Filtrado colaborativo: la dimensión sociotécnica de una comunidad virtual". *UOC Papers*. No 1. UOC. [Accessed: 30 November 2010]. <http://www.uoc.edu/uocpapers/1/dt/esp/estalella.pdf>

FREIRE, J. (2007). "Rutas para la innovación abierta: costes, aceleración y creatividad". *Nómada*. [Accessed: 30 November 2010]. <http://nomada.blogs.com/jfreire/2007/03/rutas_para_la_i.html>

FREIRE, J. (2010). "Cultura postdigital: pegamento, emergencia e innovación" [online paper]. In: *Primer Maratón del Pensamiento sobre Internet y Nuevas Tecnologías de Fundación Telefónica* (9 July: Madrid). [Accessed: 15 December 2010]. <http://mediateca.fundacion.telefonica.com/vod-publico3/show.asp?numero=000-thinkparty-326>

GRAHAM, B.; COOK, S. (2010). *Rethinking Curating. Art after New Media*. Cambridge (MA): MIT Press.

JONES, S. G. (ed.) (1998). *Cybersociety 2.0: Revising Computer-Mediated Communication and Society*. Thousand Oaks: Sage.

JURIS, J. S. (2006). "Movimientos sociales en red: movimientos sociales por una justifica global". In: M. Castells (ed.). *La sociedad red: una visión global*. Madrid: Alianza Editorial. Pages 415-439.

KATZ, J. E.; RICE, R. E.; ASPDEN, P. (2001). "The Internet 1995-2000: Access, Civic Involvement, and Social Interaction". *American Behavioral Scientist*. Vol. 45, No 3, pages 405-419.

LARA, T. (2010). "Miénteme, pero con arte". *Tiscar.com*. [Accessed: 10 January 2011]. <http://tiscar.com/2010/06/21/mienteme-pero-con-arte/>

MAYANS, J. (2001). "Género confuso: género Chat". *TEXTOS de la CiberSociedad*. No 1. [Accessed: 10 January 2011]. <http://www.cibersociedad.net/textos/articulo.php?art=22>

MAYANS, J. (2006). "Etnografía virtual, etnografía banal. La relevancia de lo intranscendente en

la investigación y la comprensión de lo cibersocial" [online paper]. In: *III Congreso Online del Observatorio para la Cibersociedad*. [Accessed: 10 January 2011]. <http://www.cibersociedad.net/congres2006/gts/comunicacio.php?id=772>

McCULLOCH, A. (2009). "The Student as Co-Producer: Learning from Public Administration about the Student-University Relationship". *Studies in Higher Education*. No 34, pages 171-183.

MONGE, P.; CONTRACTOR, N. (2003). *Theories of Communication Networks*. Oxford: Oxford University Press.

NEARY, M. (2008). "Student as producer – risk, responsibility and rich learning environments in higher education. Social purpose and creativity – integrating learning in the real World". In: J. Barlow, G. Louw, M. Price (eds). *Proceedings of Learning and Teaching Conference 2008*. Brighton: University of Brighton Press.

NEARY, M.; WINN, J. (2009). "The student as producer: reinventing the student experience in higher education". *The future of higher education: policy, pedagogy and the student experience*. London: Continuum.

NORRIS, P. (2001). *Digital Divide: Civic Engagement, Information Poverty, and the Internet Worldwide*. Cambridge: Cambridge University Press.

OECD (2001). *E-government: Analysis Framework and Methodology*. OECD Public Management Service, Public Management Committee. [Accessed: 20 November 2010]. <http://www.olis.oecd.org/olis/2001doc.nsf/LinkTo/PUMA(2001)16-ANN-REV1>

PANDO, F. (2010). "Guerra de césped: natural o artificial". *Yorokobu*. [Accessed: 15 January 2011]. <http://www.yorokobu.es/2010/05/04/guerra-de-cesped-natural-o-artificial/>

RHEINGOLD, H. (1993). *The Virtual Community. Homesteading on the Electronic Frontier*. New York: Harper Perennial.

RHEINGOLD, H. (2002). *Smart Mobs: The Next Social Revolution*. Cambridge, MA: Basic Books.

SÁEZ, F. (2004). *Más allá de Internet: la Red Universal Digital.* Madrid: Ramón Areces.

SIEMENS, G. (2010). xWeb. *Connectivism. Networked and Social Learning*. [Accessed: 15 January 2011]. <http://www.connectivism.ca/?p=264>

TAYLOR, P.; WILDING, D. (2009). *Rethinking the values of higher education – the student as collaborator and producer? Undergraduate research as a case study*. Southgate (UK): The Quality Assurance Agency for Higher Education. [Accessed: 15 January 2011]. <http://www.qaa.ac.uk/students/studentEngagement/Rethinking.pdf>

THALER, R.; SUNSTEIN, C.; BALZ, J. (2010). "Choice Architecture". *Social Science Research Network*. [Accessed: 15 January 2011]. <http://ssrn.com/abstract=1583509>

THALER, R. H.; SUNSTEIN, C. R. (2008). *Nudge: Improving Decisions about Health, Wealth, and Happiness*. New Haven, CT: Yale University Press.

TURKLE, S. (1995). *Life on the Screen. Identity in the Age of the Internet*. New York: Simon and Schuster.

UCEDA, J.; Barro, S. (2009). *Las TIC en el sistema universitario español. UNIVERSITIC 2009*. Madrid: CRUE. [Accessed: 15 January 2011]. <http://www.crue.org/export/sites/Crue/Publicaciones/Documentos/Universitic/UNIVERSITIC_2009.pdf>

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ARTICLE

# Wikis in Teaching: An Experiment with WikiHaskell and StatMediaWiki

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## Abstract

This article presents WikiHaskell, a project based on wiki technologies developed on the Computer Engineering degree course at the University of Cadiz. WikiHaskell is a wiki for which students, organised into groups of three, create complementary materials on Haskell programming language libraries. The main objective of this project is to introduce open knowledge creation into the classroom, thus turning the students into the true protagonists of the course subject. To assess the wiki and, therefore, the work done by the students, StatMediaWiki was developed. This is a statistical analysis system for MediaWiki wikis that allows such assessments to be performed both easily and

transparently. StatMediaWiki generates an overall report of the wiki and individual analyses of the work done by user, by page and by category. In the experiment described, StatMediaWiki's analysis of the time distribution of the students' contributions allowed a range of user profiles to be identified. Likewise, by-category analysis allowed certain situations within a group to be detected, such as the identification of the lead students or the less active ones. Both the wiki content and the StatMediaWiki code are open source and publicly accessible.

**Keywords**
computer-assisted collaborative learning, wikis, e-learning assessment, open-source software

## *Wikis en docencia: una experiencia con WikiHaskell y StatMediaWiki*

***Resumen***
*En este artículo se presenta WikiHaskell, un proyecto basado en tecnologías wiki que se ha desarrollado en la titulación de Ingeniero en Informática de la Universidad de Cádiz. WikiHaskell es un wiki en el que los alumnos, organizados en grupos de tres, crean material complementario sobre bibliotecas del lenguaje de programación Haskell. El principal objetivo de este proyecto es incorporar al aula la creación de conocimiento libre, de manera que se consiga que los alumnos se conviertan en los verdaderos protagonistas de la asignatura. Para evaluar el wiki y, por tanto, el trabajo realizado por el alumnado se ha desarrollado StatMediaWiki, un sistema de análisis estadístico para wikis MediaWiki que permite hacerlo de manera sencilla y transparente. StatMediaWiki genera un informe general del wiki y análisis individuales del trabajo desarrollado por cada usuario, por cada página y por cada categoría. Gracias al análisis de contribuciones de esta herramienta se han podido identificar varios perfiles de usuario según su distribución temporal en el curso. Del mismo modo, el análisis por categorías facilita la detección de determinadas situaciones dentro de un grupo, como por ejemplo, la ubicación de los alumnos líderes o la de los menos activos. Tanto el contenido del wiki como el código de StatMediaWiki son libres y accesibles públicamente.*

***Palabras clave***
*aprendizaje colaborativo asistido por computador, wikis, medición en aprendizaje electrónico, software libre*

# 1. Introduction

Just a few years ago, there was a clear, insurmountable divide between information creators and information consumers. However, Web 2.0 technologies have revolutionised that scheme of things. Among them is the MediaWiki technology (Wikimedia Foundation, 2010), which allows knowledge to be created collaboratively and more simply than ever before: just by pressing a key, it is possible to go from being a straightforward consumer of information to an author of content with a vast potential audience. An excellent example of this is Wikipedia, a project developed by volunteers that has recently led to Microsoft abandoning the commercialisation of its pay-to-use encyclopaedia *Encarta* (20 Minutos, 2010).

On the Computer Engineering degree courses at the University of Cadiz (UCA), several education projects using wiki technologies are being developed (Palomo et al., 2009). Other similar initiatives also exist, such as the one described by Chao et al. (2007), though their level of automation is still somewhat limited (Dodero et al., 2009). This article focuses on WikiHaskell, a wiki developed by the students taking Functional Programming, an optional subject in the fourth/fifth year of the Computer Engineering degree course at the UCA. This project is publicly accessible under an open-source licence (OSLUCA, 2010b) and is supported by the UCA's Open-Source Software and Open Knowledge Office (the Spanish acronym of which is OSLUCA) (OSLUCA, 2010a).

In the context of this project, the students documented Haskell programming language libraries as class work. To assess the wiki and, therefore, the work done by the students, StatMediaWiki was developed. This is statistical analysis software for wikis that is available under an open-source licence (Rodríguez et al., 2010). Version 1.05 of this program offers an overall analysis of the wiki and individual analyses of the work done by user, by page and by category.

The rest of this article is structured as follows: the second section expounds the objectives of the experiment carried out. The third section presents StatMediaWiki, the statistical analysis system developed to assess MediaWiki wikis. The fourth section gives a detailed account of the experiment carried out with WikiHaskell. The final section gives the conclusions drawn from our experiment and lists the reference works used.

## 2. Objectives

The main objective of this project was to introduce open knowledge creation into the classroom, so that the students could become active participants in the course subject, both inside and outside class (Ebner et al., 2008). To that end, and in randomly selected groups of three, the students created materials that complemented those provided in class for Functional Programming, an optional subject in the fourth/fifth year of the Computer Engineering degree course at the UCA.

This subject introduces functional programming, a paradigm that is new to students, who will have previously studied imperative and object-oriented programming. It involves learning about a new way of approaching and solving problems, which generates general, elegant and easy-to-verify solutions. We believe that the activities contained in the project presented in this article facilitated the acquisition of that new way of approaching and solving problems.

In our experience, this approach fosters the acquisition of certain competencies, such as written expression, self-directed learning, group work and critical analysis, while boosting motivation, which is something that other authors have also found (Wheeler et al., 2008; Cole, 2009). Students get a better understanding of the difficulties involved in writing high-quality technical documentation and lecturers have a valuable tool at their disposal to observe the students' progress and, in particular, to ascertain which course subjects the students find hardest and where any uncertainties or gaps occur in the concepts and techniques that they should be able to master.

Among the competencies developed in this project are:

- **Adaptation to change.** The use of the latest generation technology.
- **Learning.** The students' use of new tools and the assessment of such use.
- **Innovation.** Publication of the knowledge generated. This means that the students' work is not just a class practical. Instead, it is something that can be reviewed and used by their fellow students.
- **Teamwork.** To do their work, the students must reach agreement on what to include in the wiki. In addition, they know that this work may be reviewed by their peers (their fellow students).

Furthermore, we believe that this experiment has several interesting features and certain aspects that have a very positive effect on the dissemination of the actions developed:

- **Knowledge construction.** With wiki technologies, notes in Spanish are created on libraries available in Haskell, thus filling a gap in Spanish-language open resources in this area. In fact, one of the main objectives is that these notes should serve as a complement to the Spanish-language wiki now available on Haskell, which hardly has any content connected with the handling of the many existing libraries that can be used with that programming language.
- **Visibility.** Systems that can be accessed via the Internet are used. This allows the knowledge generated to extend beyond the classroom environment, since it is available anytime to the whole community interested in it (mainly computer engineers in our case).
- **Student collaboration.** After a short period of learning how to use the tools, these technologies allow the students to collaborate in an asynchronous, distributed manner. Every student can work wherever and whenever they want (something that students value highly).

In addition, when working with open-source technologies, it is easy to keep up with the latest advances and results of the project by using specific tools specially designed for that purpose. For this experiment, MediaWiki open-source wiki software and the StatMediaWiki analysis system were used.

## 3. Analysing wikis with StatMediaWiki

MediaWiki open-source technology is the one currently used by the majority of open-source wikis. It is based on PHP and allows connections to be made with MySQL and PostgreSQL databases. Among the wikis that use MediaWiki are Wikipedia and its sister products (such as Wiktionary, Wikibooks, Wikisource, etc.), for which it was originally designed. This technology was created by Lee Daniel Crocker (Bo & Ward, 2001) and is currently maintained by Wikimedia Foundation employees and some volunteers. Given the dissemination of this project, the interface is totally or partially translated into more than 200 languages (Various authors, 2010a). In addition, as the use of the software becomes more widespread, there are more and more extensions that add new functions to the system, such as Semantic Web features, user access management, etc. (Various authors, 2010b).

Moreover, the open philosophy and the community that develop around the use of this technology have given rise to many studies and to the development of new tools. For example, in his doctoral thesis *Wikipedia: A quantitative analysis* (Ortega, 2009), Felipe Ortega presents an analysis of the 10 biggest versions of Wikipedia. Tools that revert vandalism on MediaWiki also exist (Potthast et al., 2010), such as AVBOT (Rodríguez, 2010), an anti-vandalism system for the Spanish version of Wikipedia that won the "Best Community Project" award at the 3rd Open-Source Software University Competition held in Spain (Various authors, 2010c).

To facilitate the monitoring and assessment of the students' work on WikiHaskell, a statistical analysis tool was developed for MediaWiki-based wikis: StatMediaWiki. This system is available for download free of charge under an open-source licence (Rodríguez et al., 2010). Similar to applications like StatSVN and CVSAnalY (Robles et al., 2004), though adapted to wikis, it allows user activity and generated content progress to be monitored. Likewise, it facilitates the design of metrics to ascertain who contributes to the wiki and to what extent. The use of wikis for assessment and the design of such wikis have been dealt with in recent works (Judd et al., 2010; Wang, 2009), although the approaches taken by De Pedro (2007) and Trentin (2008) are also worthy of note.

The analysis generated by StatMediaWiki 1.05 first of all shows an overall summary of the number of pages, total edits and the number of users and uploaded files. Then it provides detailed information about the wiki's evolution over time, with charts showing the number of bytes added (Fig. 1) and the general activity by time of day and day of the week.

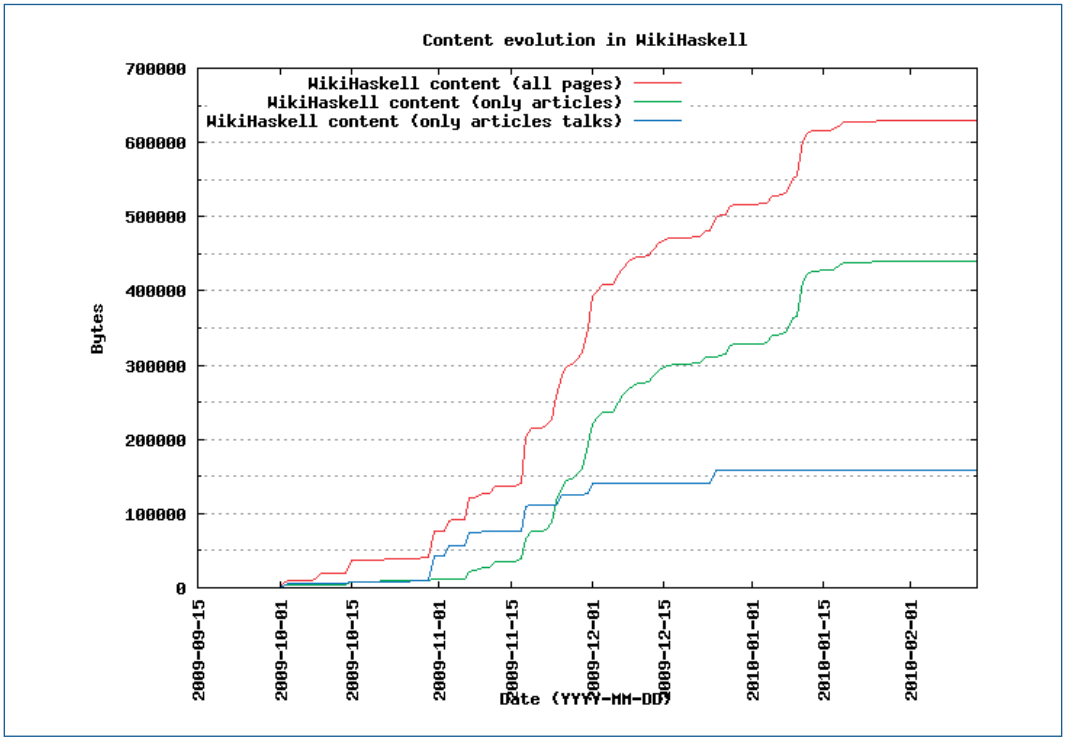


**Chart 1.** Evolution of WikiHaskell size.

After that, several tables provide a list of users that have worked on the wiki, ordered by changes made, by number of bytes added and by number of files uploaded. A ranking of the most heavily edited pages shows the content that has undergone the most changes and revisions (Table 1). It also shows the number of keywords that have been used most during wiki editing sessions (tag clouds).

In addition, the analysis that the tool provides offers not only an overall view, but also a by-user report where information is broken down by user progress over time, by content added, by the times and days of the week when most work was done, by pages to which changes have been made and by images added to the wiki (in the form of a gallery).

Finally, regarding by-page analysis, a by-page report is shown, similar to the by-user report, where information is broken down by page progress over time, by content added, by the times and days of the week when most work was done, by users that have made the most changes and, finally, the tag cloud. The information shown by pages grouped by category is identical to the latter, though with a ranking of pages belonging to it.

| No | User | Total edits | Edits in articles | Bytes added | Bytes added to articles | Files |
|---|---|---|---|---|---|---|
| 1 | Student 1 | 175 (11.78%) | 87 (7.75%) | 209,882 (30.31%) | 26,017 (5.51%) | 0 |
| 2 | Student 2 | 129 (8.68%) | 54 (4.81%) | 12,668 (1.83%) | 8,390 (1.78%) | 0 |
| 3 | Student 3 | 75 (5.05%) | 49 (4.37%) | 39,309 (5.68%) | 32,997 (6.99%) | 1 |
| 4 | Student 4 | 63 (4.24%) | 54 (4.81%) | 28,478 (4.11%) | 27,219 (5.76%) | 2 |
| 5 | Student 5 | 62 (4.17%) | 61 (5.44%) | 15,185 (2.19%) | 14,851 (3.14%) | 0 |
| 6 | Student 6 | 54 (3.63%) | 27 (2.41%) | 31,382 (4.53%) | 26,789 (5.67%) | 0 |
| 7 | Student 7 | 51 (3.43%) | 41 (3.65%) | 19,058 (2.75%) | 18,683 (3.96%) | 9 |
| 8 | Student 8 | 50 (3.36%) | 49 (4.37%) | 23,145 (3.34%) | 23,109 (4.89%) | 0 |
| 9 | Student 9 | 49 (3.30%) | 47 (4.19%) | 5,614 (0.81%) | 5,525 (1.17%) | 0 |
| 10 | Student 10 | 38 (2.56%) | 37 (3.30%) | 11,854 (1.71%) | 11,292 (2.39%) | 0 |
| | Subtotal | 746 (50.20%) | 506 (45.10%) | 396,575 (57.27%) | 194,872 (41.27%) | 12 |

Table 1. WikiHaskell user ranking.

StatMediaWiki was used for the WikiHaskell analysis, as a support for the students' assessments. Fairly good results were obtained and these are detailed in the next section. Given the good results obtained from the application of StatMediaWiki to WikiHaskell, we also believe that it would be interesting to extend its use to other fields, such as the analysis of public wikis or the assessment of competencies (Dodero et al., 2009).

# 4. WikiHaskell

The WikiHaskell project was developed as part of the university education innovation project for teaching and research staff called "Using Web 2.0 Collaborative Technologies to Foster Student Teamwork" at the UCA (Universidad de Cádiz, 2009).

## 4.1. Method and development

While the course subject was being taken, the students were subject to continuous assessment in relation to doing and successfully completing the following compulsory tasks and activities:

1. Individual written tests (face-to-face). These accounted for 30% of the final assessment grade.
2. Exercise solving: development of functions (programming exercises, on computers and on paper). These accounted for 25% of the final assessment grade.
3. Doing assignments: developing materials that complement those provided in class on WikiHaskell, and producing critiques and summaries of articles and lectures. Together, these accounted for 35% of the final assessment grade (25% for the development of complementary materials on WikiHaskell).
4. Generating frequently asked questions (FAQs). These FAQs were also for WikiHaskell and accounted for 10% of the final assessment grade.

In order to develop WikiHaskell, the students were divided into randomly selected groups of three to simulate, within our constraints, what would normally happen in real-life work situations: it is necessary to work in groups formed by people with whom an individual cannot normally choose to work.

From the libraries available in Haskell, each group selected one to use for the generation of complementary materials. While taking the course subject, the students generated documentation for the GHC6-Network, the Gtk2Hs chart library, the astar library, HOMMAGE, the IO library, the libSDL library, the gnuplot package, the Cabal packaging library, Haskell unit testing, the HPDF library, the HDBC library, the C Math library and RSA-Haskell.

In addition, each group had to give regular presentations in class to inform the groups about the current status of their work on WikiHaskell, as well as their latest advances and the problems encountered. This allowed each group to find out about the students' opinions on the work techniques used and about their progress on the project. For a positive assessment, it was essential for the members of each group to take turns, thus allowing a different member to give a periodical update.

The following were also essential requirements:

- Systematic attendance at WikiHaskell sessions.
- Individual and group work. Each student had to make individual and group contributions to WikiHaskell, in relation to both the FAQs and the complementary materials.

- Continuous and planned monitoring. Contributions made continuously to WikiHaskell were assessed positively. The aim of this was to encourage students to work continuously and not to leave everything to the last minute.
- Peer review. The students were asked to monitor and review the work done by their fellow students.
- Doing and delivering activities within the deadlines.

Regarding the assessment criteria, account was taken of the following:

- Suitability to the principles of the functional programming paradigm.
- Suitability to standards and specifications.
- Efficiency in the execution of the programs made.
- Organisation, clarity, elegance and accuracy of the solutions presented.
- Participation and engagement.
- Spelling and grammatical accuracy..

## 4.2. Analysis of WikiHaskell data

In the research carried out, the following analysis was performed on WikiHaskell data:

- User activity: who contributed to the wiki and to what extent, by the changes they made, by the bytes they added and by the number of files they uploaded over time.
- Progress on wiki content: the most heavily edited pages, showing what content underwent the most changes and revisions, the total number of pages generated, edits and uploaded files and images.
- General activity on the wiki by time of day and day of the week.
- The keywords that were used most during wiki editing sessions (tag clouds).

The whole analysis was performed using StatMediaWiki, which automatically provided the results presented in the next section. The data used were those obtained from October 2009 to February 2010, which was the period when the Functional Programming subject was imparted.

StatMediaWiki was used while the subject was being taken, and not just to obtain the final results at the end of the course. These data are presented further below. This allowed the progress of the wiki and of the students to be monitored in some detail, and corrective actions to be taken to ensure that both the course subject and the experiment ran smoothly.

## 4.3 Results

This project was developed in the first semester of the 2009/2010 academic year. The results were very positive. Despite the significant number of students (46 to be precise, of whom 40 became involved in the project), all of them performed at a fairly high level, especially in relation to their work on WikiHaskell. In fact, of the initial 46 students, the 40 who became involved in the project passed (four did not attend and two failed).

By applying StatMediaWiki, the charts obtained show a total of 1,486 changes (a total of 695,745 bytes), 1,122 of which were made on 44 pages (the rest were mainly on Haskell library discussion pages). The percentages indicate that each student made a mean of just over 32 contributions to the wiki (a total of 15,124 bytes per student). It is interesting to note that the 10 most active students (just over 20% of the total students in the class) together made around 50% of the total contributions to the wiki, which shows that, in general terms, participation was fairly well distributed (StatMediaWiki, 2009).

In addition, the charts generated by StatMediaWiki allowed five student profiles to be identified:

- *Continuous* profile: we consider this to be the optimum profile. The student makes continuous contributions throughout the course of the work. Only three students matched this profile (the student in Chart 2 for example).
- *Stepped* profile: this profile is also good. The student makes continuous contributions, albeit intermittently. Sixteen students matched this profile (the student in Chart 3 for example).
- *Early peak* profile: this is the abandonment profile. Students made contributions at the beginning but then abandoned the work and gave up the subject. Only four students matched this profile (the student in Chart 4 for example).
- *Middle peak* profile: similar to the stepped profile in terms of numbers. Seventeen students – the highest number – matched this profile. In this case, most of the work is done halfway through (the student in Chart 5 for example).
- *Late peak* profile: this is the profile of the student who leaves everything to the last minute. Only six students matched this profile.

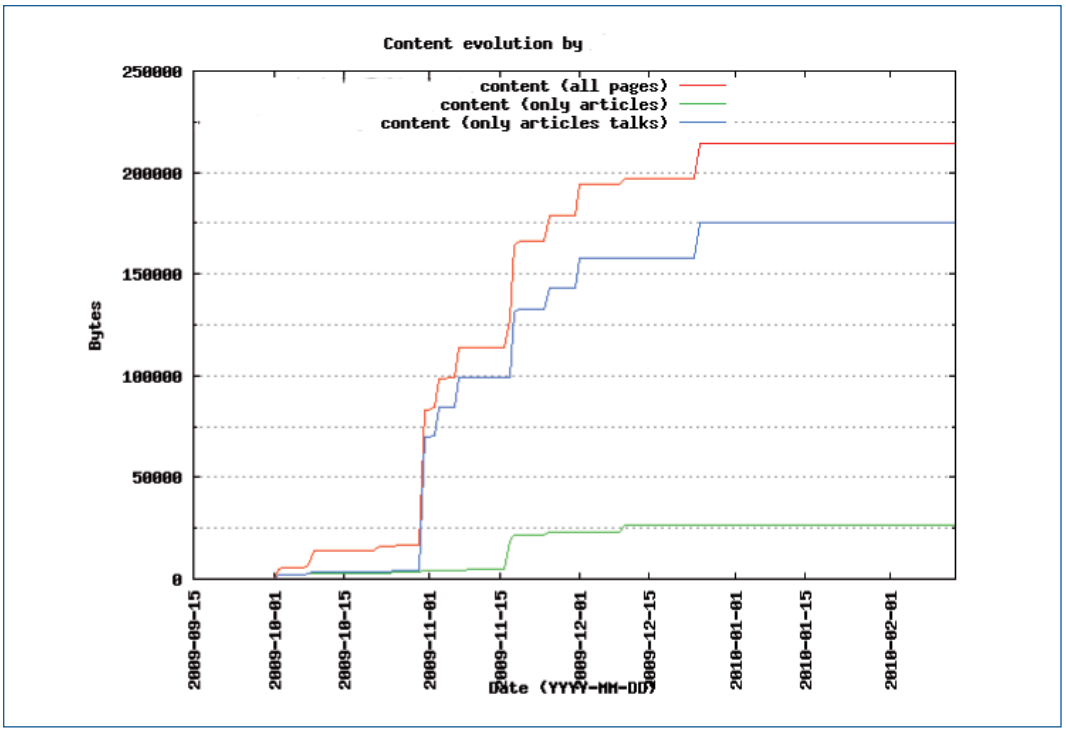


**Chart 2.** Example of a continuous profile.

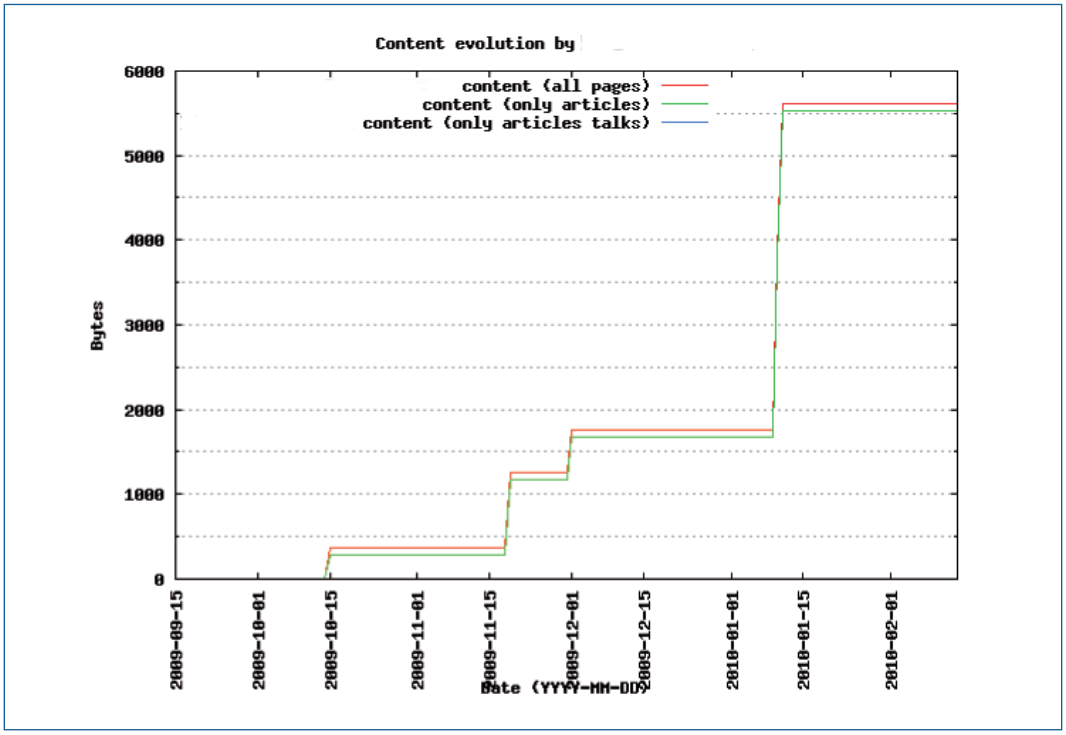


**Chart 3.** Example of a stepped profile.

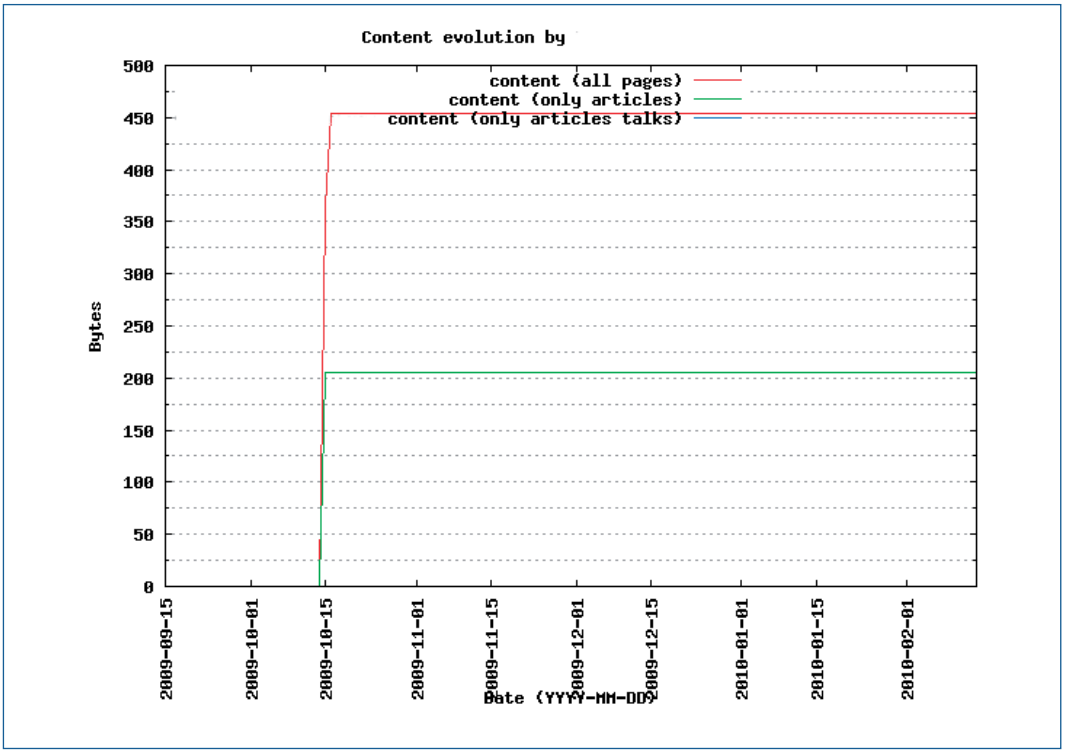


**Chart 4.** Example of an early peak profile.

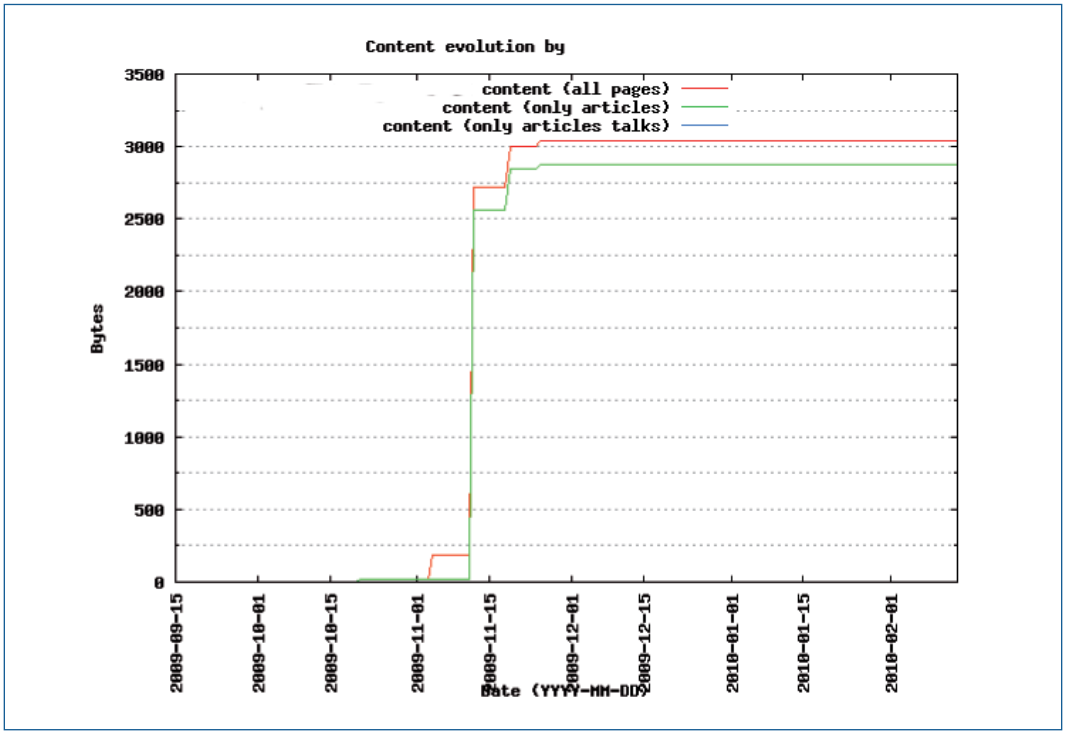


**Chart 5.** Example of a middle peak profile.

In addition, data were obtained for the times and days of the week when most work was done. Generally speaking, the students worked most midweek, with hardly any contributions at weekends. The times when students worked varied considerably, though they usually worked in the morning (obviously, because their face-to-face lectures were in the afternoon).

Given that this activity was assessed in class and that it counted towards the final grade, the wiki only allowed students taking this course subject to make changes. However, the content was publicly accessible in Medina.

An anonymous survey of the students was carried out on completion of the course subject. Twenty-four students responded and the following results were obtained (Table 2). The scale used was from 0 (Low) to 5 (High):

| *Question* | *Mean* |
|---|---|
| Opinion on the use of the publicly accessible open-source wiki in teaching | 4.5 |
| Method and development of work on the wiki (groups of three students, organisation and revisions, etc.) | 3.83 |
| Difficulty using the wiki | 2.54 |
| Weight of work on the wiki in the final grade for the course subject | 3.67 |
| Overall assessment of the course subject | 4.13 |

Table 2. End-of-course survey.

As shown, the students' satisfaction with the use of the publicly accessible open-source wiki in teaching was very high (4.5 on a scale from 0 to 5). In fact, they remained motivated and engaged in the project throughout the course of the experiment. In terms of the method and development of work on the wiki, the students were also satisfied, though at times they felt the additional workload was excessive. Using the wiki did not present any difficulties for most of the students, though a small group of them did have problems to begin with due to a lack of familiarity with this technology. Regarding the weight of work on the wiki in the final grade for the course subject, most of the students agreed with it. Finally, the overall assessment of the course subject was very positive (4.13 on a scale from 0 to 5).

In addition, in the satisfaction survey carried out by the UCA's quality unit, the course subject obtained a score of 4.2 on a scale from 0 to 5, positioning it above the mean obtained for the department's course subjects, for the degree course and for the university.

## 4.4. By-category analysis

Since the experiment, StatMediaWiki has been extended to include by-category analysis, a feature that users of version 1.05 desired (Rodríguez et al., 2010). Analysis by page groups is therefore facilitated. Such pages groups will form part of the student group's projects next year.

In MediaWiki, a category is a group of related articles on the same topic. An article can form part of as many categories as is considered appropriate. For example, an entry in Wikipedia on "primary education" can be included in the *child education* and *Spanish education system* categories. Likewise, a category can form part of other categories, thus becoming one of their subcategories. Continuing with the same example, *Spanish education system* can become a subcategory of *European education systems*.

By-category reports allow the work done by a user group on a set of the wiki's pages to be followed in accordance with the interrelated nature of the information. In particular, these reports begin with various statistics on the category: number of pages, number of edits, number of users taking part in them, number of bytes, etc. Then the same content and activity evolution charts as those in a normal page report are included, but this time aggregating information from all of the category's pages. Finally, lists appear for the most active users and for the most visited pages, as well as the tag cloud.

In WikiHaskell, each student group had to work on a specific topic of functional programming. Consequently, they were able to divide their work into different pages of the wiki, all of which belonged to the same category. Their work can therefore be analysed more easily by using StatMediaWiki by-category charts. Specifically, five of the 14 groups divided their work into more than one page.

Among other things, the use of StatMediaWiki's by-category analysis helps to identify the leaders of each group. For example, this is shown clearly in the content evolution charts for the various students of the *libSDL* category (Chart 6). Chart 7 shows the evolution of content generated by its leader. When compared with the other two members of the group (Charts 8 and 9), it is possible to see that the leader started working before the other two. On the vertical axis of the charts (or on the classification of users in the category), what is noticeable is that the total amount of bytes of the leader's contributions is greater than the other contributors'.

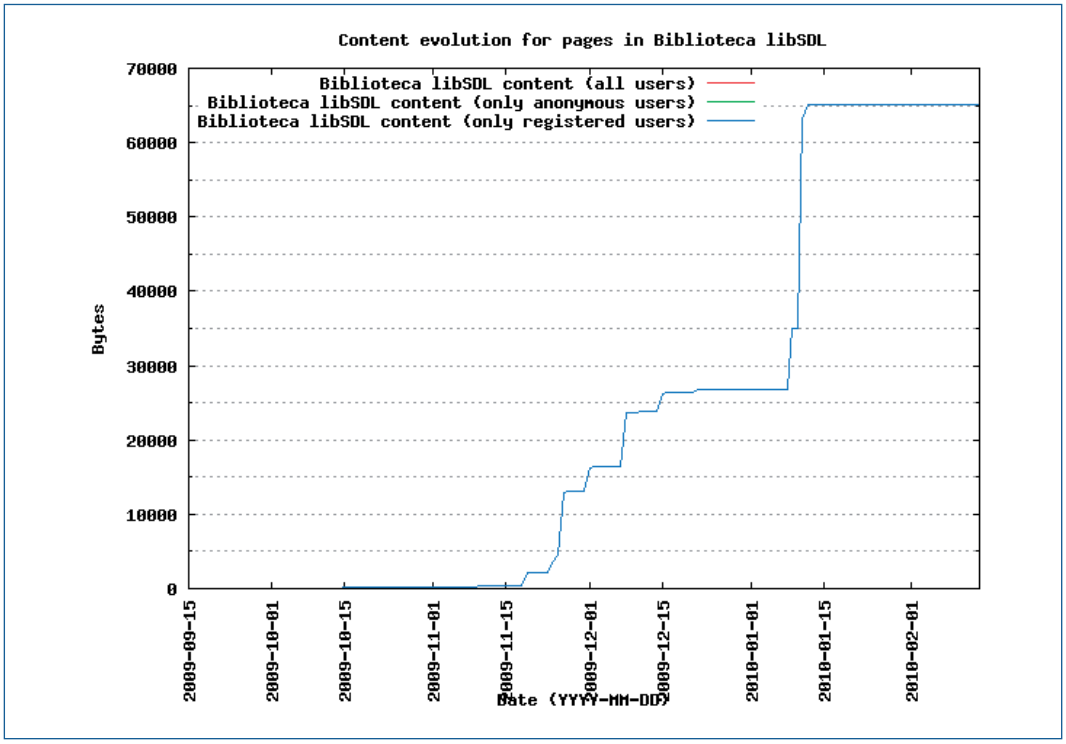


**Chart 6.** Content evolution of the libSDL category.

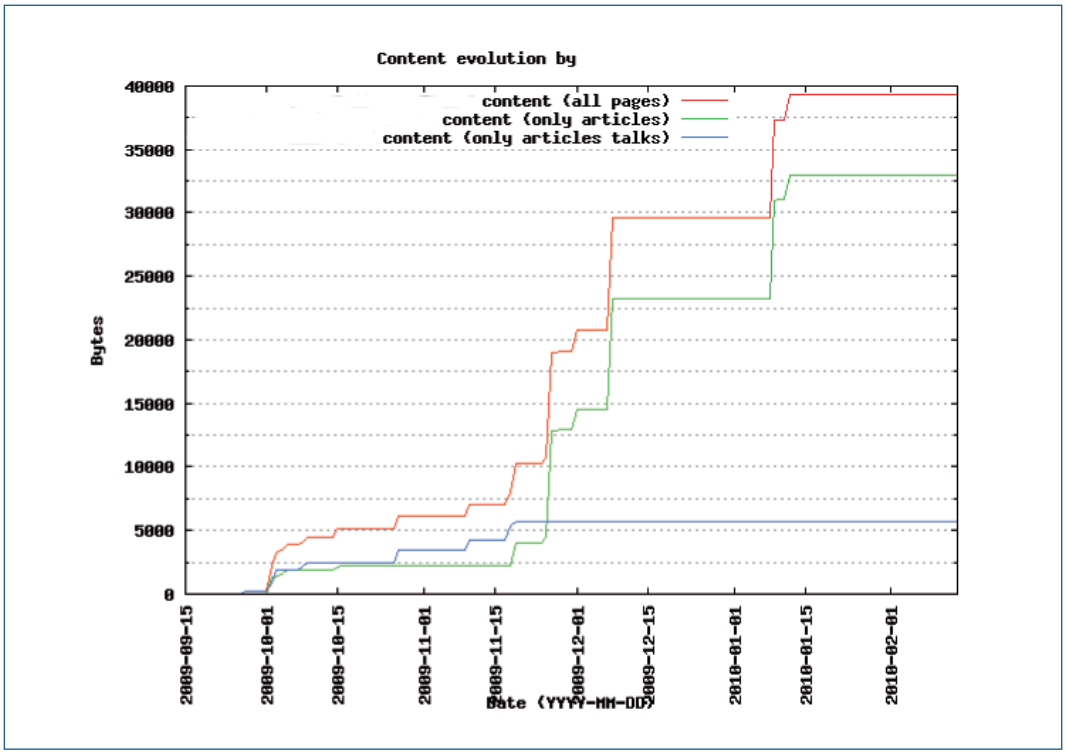


**Chart 7.** Evolution of content generated by the leader.

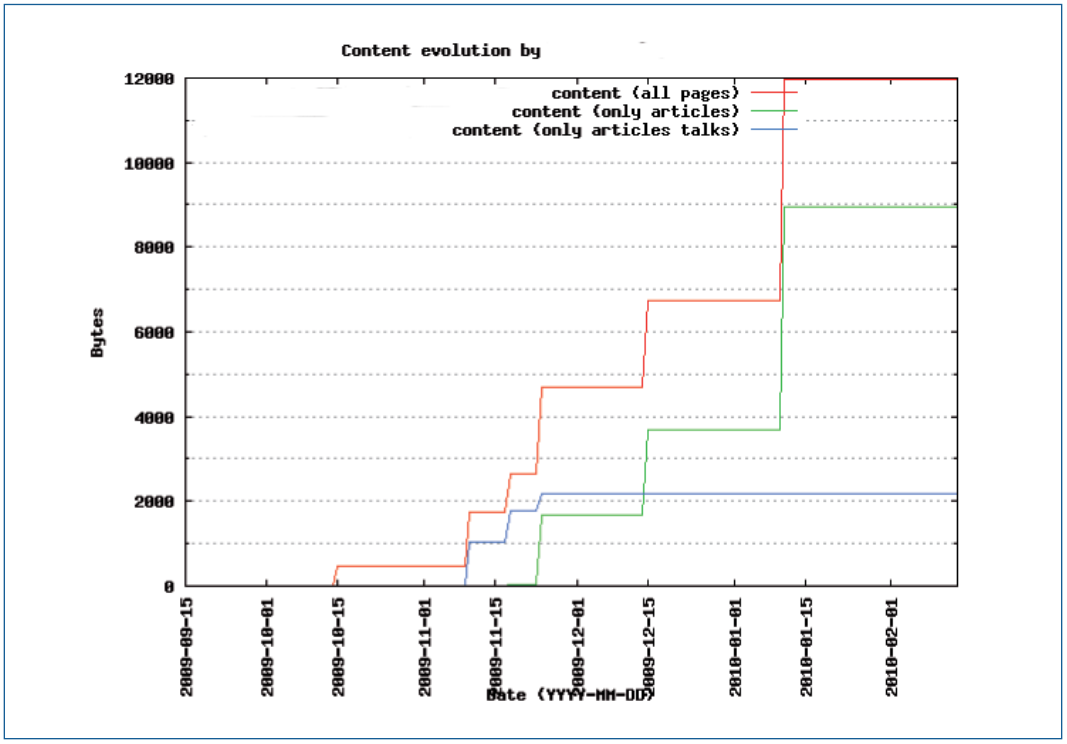


**Chart 8.** Evolution of content generated by user 1.

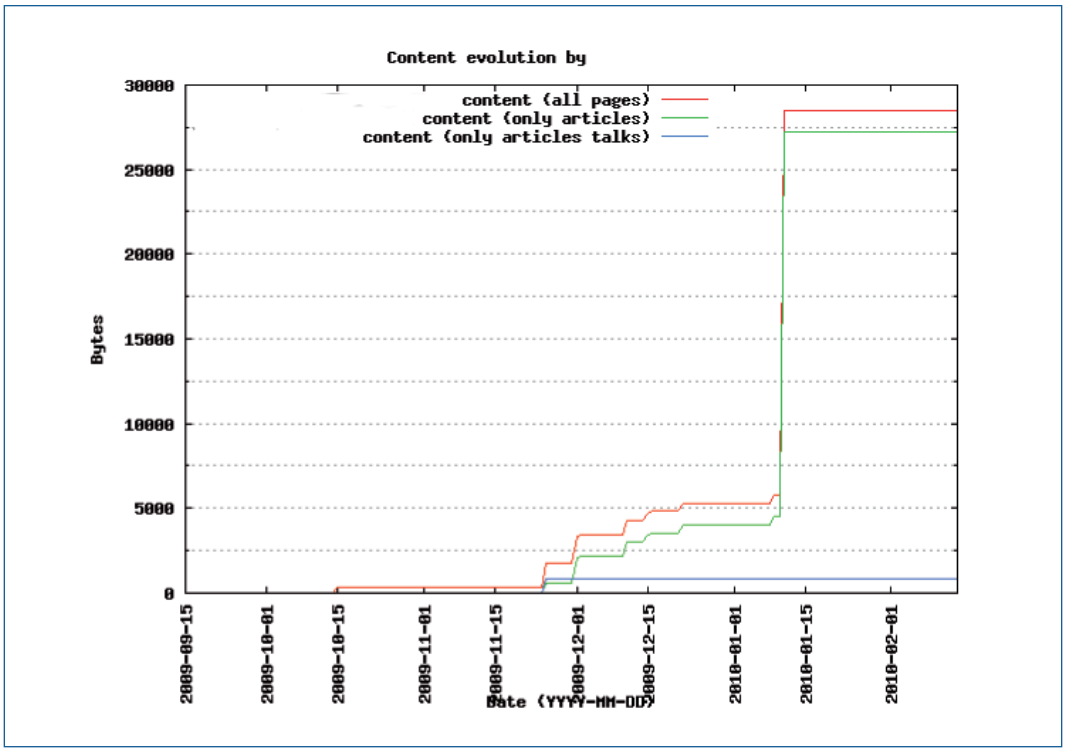


**Chart 9.** Evolution of content generated by user 2.

Given that MediaWiki software does not store the pages that have belonged to a category over time, the report is generated with the pages currently belonging to each category. This may lead one to think that a student could falsify the data for a group's effort by adding pages to its category. However, while it is true that the size of a category's content significantly increases if an average-sized page is added to that category, it is also true that the authors' contributions to the bigger category proportionately decrease as a percentage. That said, it should be pointed out that such a situation did not occur during this experiment.

## 5. Conclusions and future work

This article has presented WikiHaskell, a project based on wiki technologies and developed in the Functional programming subject on the Computer Engineering degree course at the UCA. Although the experiment focused on computer engineering, we believe that the initiative could be adapted to other branches of knowledge, as discussed at the 2009 Open Knowledge and Web 2.0 Conference organised by OSLUCA at the Cadiz Engineering School (OSLUCA, 2009).

Our experiment showed that these technologies help to identify problems in the students' learning, in group work, etc. Thanks to the use of an automatic tool like StatMediaWiki, many repetitive tasks are avoided while light is thrown on the work done by the students, thus allowing them to be assessed both easily and transparently. By using it, we were able to identify several student profiles related to the work they did while taking the course subject. By cross-matching this information with data on their academic performance, in upcoming academic years we will be able to identify which students are prone to giving up the course subject, thus allowing us to focus our efforts on them. Similarly, other interesting data are obtained, such as the times and days of the week that students work most, the distribution of work by student or by page (individual or aggregated by category), etc.

In general, students are very happy to participate in initiatives of this type, where they are the protagonists (Álvarez et al., 2009; Recio-Quijano et al., 2010). By using straightforward, convenient technologies and establishing a work system that is flexible yet forces students to be accountable, we believe that their engagement, satisfaction and academic performance can be very high.

On the Computer Engineering degree courses at the UCA, several education projects using wiki technologies are being developed (Palomo et al., 2010). The use of wikis for assessment and the design of such wikis have been dealt with in earlier works (De Pedro, 2007; Trentin, 2008). However, while other similar initiatives exist (Judd et al., 2010; Wang, 2009), and not just in technical teaching (Chao et al., 2007; Various authors, 2009a; Various authors, 2009b), their level of automation is still somewhat limited (Dodero et al., 2009). The Wikimedia Foundation itself is developing (2010/2011) a programme to get university students in the United States to improve Wikipedia articles in English as part of the curriculum, though it is still too early to draw any conclusions from the preliminary results (Various authors, 2011).

Finally, we would underscore the importance of this type of initiative in terms of making high-quality documentation in Spanish freely available to the Spanish-speaking WikiHaskell community.

## Acknowledgments

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## References

*20 Minutos (2010)*. "La Encarta sucumbe ante la Wikipedia" [online]. [Accessed: 27 October 2010]. <http://www.20minutos.es/noticia/460388/0/wikipedia/encarta/enciclopedia>

ÁLVAREZ, Alejandro; PALOMO, Manuel; RODRÍGUEZ, Rafael (2009). "Experiencias en la aplicación de técnicas y herramientas de desarrollo colaborativo de software en una asignatura basada en proyectos". *Actas del XVII Congreso de Innovación Educativa en las Enseñanzas Técnicas*, pages 1-11.

BO, Leuf; WARD, Cunningham (2001). *The Wiki Way: Quick Collaboration on the Web*. Addison-Wesley Professional. 1st edition.

CHAO, Joseph T.; PARKER, Kevin R. (2007). "Wiki as a teaching tool". *Interdisciplinary Journal of Knowledge and Learning Objects*. Vol. 3, pages 57-72.

COLE, Melissa (2009). "Using wiki technology to support student engagement: Lessons from the trenches". *Journal of Computers & Education*. Vol. 52, pages 141-146.

DE PEDRO, Xavier (2007). "New method using Wikis and forums to evaluate individual contributions in cooperative work while promoting experiential learning: Results from preliminary experience". *Proceedings of the International Symposium on Wikis*. ACM. Pages 87-92.

DODERO, Juan Manuel; RODRÍGUEZ, Gregorio; IBARRA, María Soledad (2009). "Análisis de las contribuciones a un wiki para la evaluación web de competencias". *Actas de la Conferencia Conjunta Iberoamericana sobre Tecnologías de Aprendizaje*. Pages 268-277.

EBNER, Martin; KICKMEIER-RUST, Michael; HOLZINGER, Andreas (2008). "Utilizing wiki-systems in higher education classes: A chance for universal access?". *Universal Access in the Information Society*. Vol. 7, pages 199-207.

JUDD, Terry; KENNEDY, Gregor; CROPPER, Simon (2010). "Using wikis for collaborative learning: Assessing collaboration through contribution". *Australasian Journal of Educational Technology*. Vol. 26, No 3, pages 341-354.

MEDINA, Inmaculada et al. *WikiHaskell*. <http://wikis.uca.es/wikihaskell>

ORTEGA, Felipe (2009). *Wikipedia: A quantitative analysis* [online thesis]. URJC. [Accessed: October 2010]. <http://libresoft.es/Members/jfelipe/phd-thesis>

OSLUCA (2009). *Jornadas de conocimiento libre y web 2.0* [online]. [Accessed: 27 October 2010]. <http://softwarelibre.uca.es/jornadasweb>

OSLUCA (2010a). *Web de la Oficina de Software Libre y Conocimiento Abierto de la Universidad de Cádiz* [online]. [Accessed: 27 October 2010]. <http://www.uca.es/softwarelibre>

OSLUCA (2010b). *Wikis libres con apoyo de la OSLUCA* [online]. UCA. [Accessed: 27 October 2010]. <http://osl.uca.es/wikis>

PALOMO, Manuel; MEDINA, Inmaculada; RODRÍGUEZ, Emilio José; SALES, Noelia (2009). "Tecnologías wiki y conocimiento abierto en la universidad". *Actas de la V Conferencia Internacional en Software Libre*, pages 16-19.

PALOMO, Manuel; MEDINA Inmaculada; RODRÍGUEZ, Emilio José; PALOMO, Francisco (2010). "Wikis en docencia: una experiencia con WikiHaskell y StatMediaWiki". *Actas del Simposio Pluridisciplinar sobre Diseño y Evaluación de Contenidos Digitales Educativos SPDECE*. Conferencia Conjunta Iberoamericana sobre Tecnologías de Aprendizaje (CcITA 2010), pages 127-134.

POTTHAST, Martin; STEIN, Benno; HOLFELD, Teresa (2010). "Overview of the 1st International Competition on Wikipedia Vandalism Detection". *Notebook Papers of CLEF 2010 LABs and Workshops*.

RECIO-QUIJANO, Pablo; SALES-MONTES, Noelia; GARCÍA-DOMÍNGUEZ, Antonio; PALOMO-DUARTE, Manuel (2010). "Collaboration and competitiveness in project-based learning". *Proceedings of the ACM SIGCSE Methods and Cases in Computing Education Workshop (MCCE)*, pages 8-14.

ROBLES, Gregorio; KOCH, Stefan; GONZÁLEZ-BARAHONA, Jesús M. (2004). "Remote analysis and measurement of libre software systems by means of the CVSAnalY tool". *Proceedings of the 2nd ICSE Workshop on Remote Analysis and Measurement of Software Systems (RAMSS),* pages 51-55.

RODRÍGUEZ, Emilio José (2010). "*AVBOT: detección y corrección de vandalismos en Wikipedia*". *Novática*, No 203, pages 51-53.

RODRÍGUEZ, Emilio José et al. (2010). *StatMediaWiki* [online]. [Accessed: 27 October 2010]. <http://statmediawiki.forja.rediris.es>

STATMEDIAWIKI (2009). *Estadísticas de StatMediaWiki sobre WikiHaskell* [online]. [Accessed: 27 October 2010]. <http://osl.uca.es/statmediawiki>

TRENTIN, Guglielmo (2008). "Using a wiki to evaluate individual contribution to a collaborative learning project". *Journal of Computer Assisted Learning*. Vol. 25, pages 43-55.

UNIVERSIDAD DE CÁDIZ (2009). "Convocatoria de Proyectos de Innovación Educativa Universitaria del Programa de Innovación Educativa de la Universidad de Cádiz". [Accessed: 27 October 2010]. <http://www.uca.es/web/estudios/proyecto_europa>

VARIOUS AUTHORS (2009a). *Número Monográfico IV: WIKI y educación superior en España* (part 1). <http://www.um.es/ead/Red_U/m4/>

VARIOUS AUTHORS (2009b). *Número Monográfico V: WIKI y educación superior en España* (part 2). <http://www.um.es/ead/Red_U/m5/>

VARIOUS AUTHORS (2010a). "Translatewiki. Statistics for mediawiki translation development" [online]. *Translatewiki.* [Accessed: 27 October 2010]. <http://translatewiki.net/wiki/Translating:Statistics>

VARIOUS AUTHORS (2010b). "Mediawiki extensions" [online]. *Mediawiki.* [Accessed: 27 October 2010]. <http://www.mediawiki.org/wiki/Category:Extensions/es>

VARIOUS AUTHORS (2010c). *III concurso universitario de software libre* [online]. [Accessed: 27 October 2010]. <http://www.concursosoftwarelibre.org/0809/premios-iii-concurso-universitario-software-libre>

VARIOUS AUTHORS (2011). *Public Policy Initiative. Wikimedia Outreach Project*. [Accessed: 2 June 2011]. <http://outreach.wikimedia.org/w/index.php?title=Public_Policy_Initiative&oldid=14089>

WANG, Qiyun (2009). "Design and evaluation of a collaborative learning environment". *Journal of Computers & Education*. Vol. 53, No 4, pages 1138-1146.

WHEELER, Steven; YEOMANS, Peter; WHEELER, Dawn (2008). "The good, the bad and the wiki: Evaluating student-generated content for collaborative learning". *British Journal of Educational Technology*. Vol. 39, No 6, pages 987-995.

WIKIMEDIA FOUNDATION (2010). "MediaWiki" [online]. [Accessed: 27 October 2010]. <http://www.mediawiki.org>

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DOSSIER

# Mathematical e-Learning

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Educational technologies are changing the way in which higher education is delivered. These technologies include, but are not limited to, e-learning environments or learning management systems for individual and collaborative learning, Internet resources for teaching and learning, academic materials in electronic format, specific subject-related software, groupware and social networking software. With ubiquitous access to technology and technological innovation, over the last decades not only have we seen the establishment and growth of purely online universities, but we are also now witnessing a transformation in how instruction is being delivered in most traditional face-to-face universities. This transformation is affecting the nature of the courses as well as the degree programs offered by higher-education systems in a global world. These technological innovations have driven the growth of distance-learning opportunities, as students who are time bound – due to job or travel difficulties – or place bound – due to geographic location or physical disabilities – now have the flexibility to access courses and degree programs at their convenience.

e-Learning models are extensively used all over the world. Within mathematics and statistics teaching, educational reforms are widespread both in purely online and in face-to-face education. Many instructors have been encouraged to try new teaching strategies such as online support, interdisciplinary collaborative learning and integration of mathematical and statistical software in their courses. University departments worldwide have been leveraging technological capabilities by creating new engaging curricula that promote conceptual understanding instead of procedural knowledge. Nevertheless, as implementation is not at all easy, especially in mathematics, we are confronted with numerous challenges. Some of these challenges are due to the intrinsic demographic characteristics of so-called 'Internet-generation' students, while others are due to the intrinsic disciplinary nature of mathematics and statistics. In fact, most innovative teaching approaches documented so far have been developed by individuals or by small teams of instructors. These experiences are rarely generalized outside the institution or even maintained over time. Thus, when referring to online mathematics courses, generalization and sustainability of innovative approaches are issues that need to be investigated and promoted by researchers and teaching academics.

In a broad sense, Mathematical e-Learning refers to the use of mathematical software and the Internet to deliver and facilitate instruction of mathematics-related courses. Established technologies (e.g., virtual learning environments and specialized software) enable emerging instructional strategies based on computer-supported collaborative learning. These Web-based strategies are being used in both new and traditional universities to completely teach (either following a synchronous or an asynchronous online mode), partially replace (blended or hybrid learning models) or supplement course offerings in mathematics to a new generation of students. There is little doubt that this new way of teaching mathematics is here to stay and, in fact, its use continues to grow year on year.

With e-learning experiencing what has been characterized as 'explosive growth', there is an urgent need to undertake more research to inform best practices specific to the disciplinary particularities of mathematics e-learning in higher education. While a growing number of publications generically cover e-learning, computer-supported collaborative learning or mathematics education from a more theoretical point of view, few – if any – put emphasis on the practical implementation of mathematical e-learning in higher education. This special issue tries to fill this gap in the literature

by identifying and publishing worldwide best practices in the aforementioned field, sharing not only theoretical but also applied pedagogical models and systems. Among others, the goals of the special issue are: (a) to describe experiences on the use of computer-supported collaborative e-learning in mathematical education; (b) to forecast emerging technologies and tendencies regarding mathematical software and its integration into online courses and materials; (c) to explore how learning management systems are contributing to mathematics education online; and (d) to highlight current-edge research in the area.

This *RUSC* special issue contains five articles, selected after a blind peer-review process from almost thirty submitted papers. The selected articles are briefly introduced below:

In "The Role of Digital, Formative Testing in e-Learning for Mathematics: A Case Study in the Netherlands" by D. Tempelaar et al., the authors discuss the importance of formative assessment, in terms of the feedback it provides both to students and instructors of mathematics-related courses, and describe their own experiences while integrating this type of assessment into e-learning platforms.

The article "A Knowledge-Skill-Competencies e-Learning Model in Mathematics" by G. Albano addresses the emergent issue of how to successfully model mathematics-related competencies in an e-learning environment. The author presents a model, based on knowledge and skills representations, which defines a personalized learning experience to promote students' competencies in mathematics.

In "Activity Theory and e-Course Design: An Experience in Discrete Mathematics for Computer Science", J. L. Ramírez et al. present an interesting e-learning experience involving a higher-education course on mathematics. The course design is based on two theoretical approaches: while the content-related design is supported by different concepts of Activity Theory, interaction between participants is designed following Slavin's Team Accelerated Instruction model.

The article "Distance Training of Mathematics Teachers: The *EarlyStatistics* Experience" by M. Meletiou-Mavrotheris and A. Serradó analyzes how information and communication tools could be employed to improve the quality and efficiency of teacher training in statistics education. The authors also point out lessons learned from their own experience with *EarlyStatistics*, an online course in statistics education which was offered to European elementary and middle school teachers.

In "On How Moodle Quizzes Can Contribute to the Formative e-Assessment of First-Year Engineering Students in Mathematics Courses", M. Blanco and M. Ginovart describe their experience with the use of Moodle's quiz module, and discuss the utility of this tool for the formative assessment of students.

This special issue also contains a review, written by H. Cuypers, of the book *Teaching Mathematics Online: Emergent Technologies and Methodologies*, which has recently been published by IGI Global.

Finally, we would like to thank the authors and reviewers of this special issue for their collaboration and prompt responses to our enquiries, which enabled completion of this manuscript in a timely manner. We gratefully acknowledge the editor at *RUSC*, Ms Elsa Corominas, for her help and encouragement during the entire editing process of this *RUSC* special issue.

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**Dossier "Mathematical e-learning"**

ARTICLE

# The Role of Digital, Formative Testing in e-Learning for Mathematics: A Case Study in the Netherlands

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## Abstract

Repeated formative, diagnostic assessment lies at the heart of student-centred learning, providing students with a continuous stream of information on the mastery of different topics and making suggestions to optimize the choice of subsequent learning activities. When integrated into a system of e-learning, formative assessment can make that steering information instantaneous, which is a crucial aspect for feedback in student-centred learning. This empirical study of the role of formative assessment in mathematics e-learning focuses on the important merit of integrating these assessments into a system of state or national testing. Such tests provide individual students with crucial feedback for their personal learning, teachers with information for instructional planning, and curriculum designers with information on the strengths and weaknesses in the mastery states of students in the program and the need to accommodate any shortcomings. Lastly, they provide information on the quality of education at state or national level and a means to monitor its development over time. We shall provide examples of these merits based on data from the national project ONBETWIST, part of the Dutch e-learning program Testing and Test-Driven Learning.

## Keywords

interim assessment, bridging education, mathematics, heterogeneous international education, mathematics program reforms

# *El papel de los exámenes formativos digitales en el aprendizaje virtual de matemáticas: un estudio de caso en los Países Bajos*

## *Resumen*

*La repetida evaluación diagnóstica y formativa es uno de los elementos clave del aprendizaje centrado en el alumno, ya que ofrece a los estudiantes un flujo continuo de información sobre su nivel de conocimientos en distintas materias y permite optimizar la posterior elección de actividades de aprendizaje. Cuando se integra en un sistema de aprendizaje virtual, la evaluación formativa puede convertir esta información en instantánea, lo que constituye un aspecto crucial para el retorno de información en un aprendizaje centrado en el alumno. Este estudio empírico sobre el papel de la evaluación formativa en el aprendizaje virtual de matemáticas se centra en la ventaja de integrar estas evaluaciones en un sistema nacional o estatal de exámenes. Estos exámenes proporcionan a los estudiantes una información crucial para su aprendizaje personal; suministran a los profesores los datos necesarios para llevar a cabo la planificación docente; y ofrecen a los encargados de elaborar los planes de estudio la información necesaria sobre las fortalezas y las debilidades de los estudiantes de cada programa y la necesidad de solucionar cualquier deficiencia. En último lugar, ofrecen información sobre la calidad de la enseñanza a escala nacional o estatal y son un*

*medio para controlar su desarrollo a través del tiempo. Daremos ejemplos de todas estas ventajas según los datos del proyecto nacional ONBETWIST, que forma parte del programa de aprendizaje virtual holandés «Los exámenes y el aprendizaje basado en exámenes».*

***Palabras clave***
*evaluación intermedia, cursos puente, matemáticas, educación internacional heterogénea, reforma de los programas de matemáticas*

# Introduction

According to a recent, domain overarching meta-analysis of empirical educational studies (Hattie, 2008), feedback is the most effective instructional mechanism. Feedback can have many different sources, and in student-centred learning, students' mastery or lack of mastery to perform a specific task is an important part of that feedback. Formative assessment is a means to repeatedly assess a student's mastery in order to establish the subsequent learning step, and its importance is extensively documented, in the context of both traditional learning (Donovan et al., 2005; Pellegrino, et al., 2001) and e-learning (Juan et al., 2011). Recently, there has been some interest in systematically combining formative assessment with the use of state or national tests. In the U.S., this is termed 'interim assessment' (Beatty, 2010). According to the U.S. National Research Council, interim assessments "are assessments that measure students' knowledge of the same broad curricular goals that are measured in annual large-scale assessments, but they are given more frequently and are designed to give teachers more data on student performance to use for instructional planning. Interim assessments are often explicitly designed to mimic the format and coverage of state tests and may be used not only to guide instruction, but also to predict student performance on state assessments, to provide data on a program or approach, or to provide diagnostic information about a particular student. Researchers stress the distinction between interim assessments and formative assessments, however, because the latter are typically embedded in instructional activities and may not even be recognizable as assessments by students …" (Beatty, 2010, p. 6).

Continuous evaluation processes are at least as crucial in mathematics education as they are in other disciplines (Donovan et al., 2005; Taylor, 2008; Trenholm et al., 2011). Beyond assessment for development and assessment for achievement, both of which are generally recognized as important assessment functions, formative assessment in mathematics education functions as 'transition' or 'placement' assessment, particularly in the first year of university education (Taylor, 2008). In their comparative study of long-term online mathematics teaching experiences, Trenholm et al. (2011) provide four major case studies, all of which point to continuous assessment as a key factor of success. However, empirical studies into the effect of formative assessment in mathematics education remain scarce (Wang et al., 2006).

In the Netherlands, SURF, the Dutch collaborative organisation for higher education institutions and research institutes aimed at innovations in ICT, initiated the nationwide program Testing and

Test-Driven Learning to stimulate the design and use of such interim assessments, among other things. Part of this program is the ONBETWIST project (http://www.onbetwist.org/), focusing on mathematics learning, both in the transition from high school to university, and in the first year of university, using e-learning with the support of these interim assessments. The ONBETWIST project builds on earlier projects, such as SURF projects NKBW (http://www.nkbw.nl/) and TELMME (www.telmme.tue.nl), and EU projects S.T.E.P. (www.transitionalstep.eu/) and MathBridge (http://www.mathbridge.org/). All these projects focus primarily on the design and use of mathematics e-learning tools to facilitate the transfer from high school to university, e.g., for international students who have been educated in school systems whose premises differ considerably from those on which the university curriculum is built. Offering flexible bridging courses in mathematics when the inflow of students is too heterogeneous in terms of prior mathematics mastery to start immediately with class-based regular university teaching is, in short, the main aim of all these initiatives. Reviews of some of these endeavours can be found in Brants et al. (2009), Rienties et al. (2011) and Tempelaar et al. (2008). In our companion paper, Tempelaar et al. (2011), we report on the outcomes of bridging education in the context of the NKBW project for one Dutch university. This university is a typical exponent of European internationalisation of higher education, where international students account for more than 70% of the total. Although most of these students are not very international in terms of the geographical distance they have to bridge, there is huge diversity with respect to the high school education they have received. Secondary school systems, even in neighbouring countries like the Netherlands, Germany and Belgium, are very different, producing major heterogeneity in mathematical knowledge and skills that prospective students have. Such heterogeneity means that there is a considerable need for bridging education in the transfer from secondary to university education, and it offers an outstanding case to demonstrate the advantages of interim assessment. While the companion paper focuses on the remedial education component, designed as a voluntary mathematics summer course, this paper investigates the use of digital, formative tests for diagnostic aims in the same population of international students. The empirical context of this study refers to the use of entry tests generated within the national NKBW and ONBETWIST projects (full versions of the tests can be found in the open-access ONBETWIST question database, available at http://moodle.onbetwist.org/), where subjects for the empirical study are selected from one university, which is characterized by a strong international orientation and large year classes.

The aim of this study is to add to the limited body of empirical studies into the effects of formative assessment in mathematics education, thereby focusing on its role in the first year of university education, where assessment, beyond development and achievement functions, plays an additional and important transition or placement role.

## The UM mathematics summer course

Since bridging education takes place before students participate in the interim assessments, a short introduction to the summer course is required in order to understand its impact on performance in

the assessments. The voluntary mathematics summer course is constructed around the test-steered, adaptive, e-tutorial: ALEKS (Assessment and LEarning in Knowledge Spaces) College Algebra module. The tool makes use of server-based computing and can be characterised as supporting individual distance learning. The ALEKS system (see also Doignon & Falmagne, 1999; Falmange et al., 2004; Tempelaar et al., 2006) combines adaptive, diagnostic testing with an e-learning and practice tutorial in several domains relevant to higher education. In addition, it provides lecturers with an instructor module, where students' progress can be monitored in both learning and assessment modes.

The ALEKS assessment module starts with an entry assessment in order to evaluate a student's knowledge of the domain. Following this assessment, ALEKS delivers a graphic report analyzing the student's knowledge within all curricular areas of the course. The report also recommends concepts on which the student can begin working; by clicking on any of these concepts or items, the student gains immediate access to the learning module. See Figure 1 for a sample of the learning report.

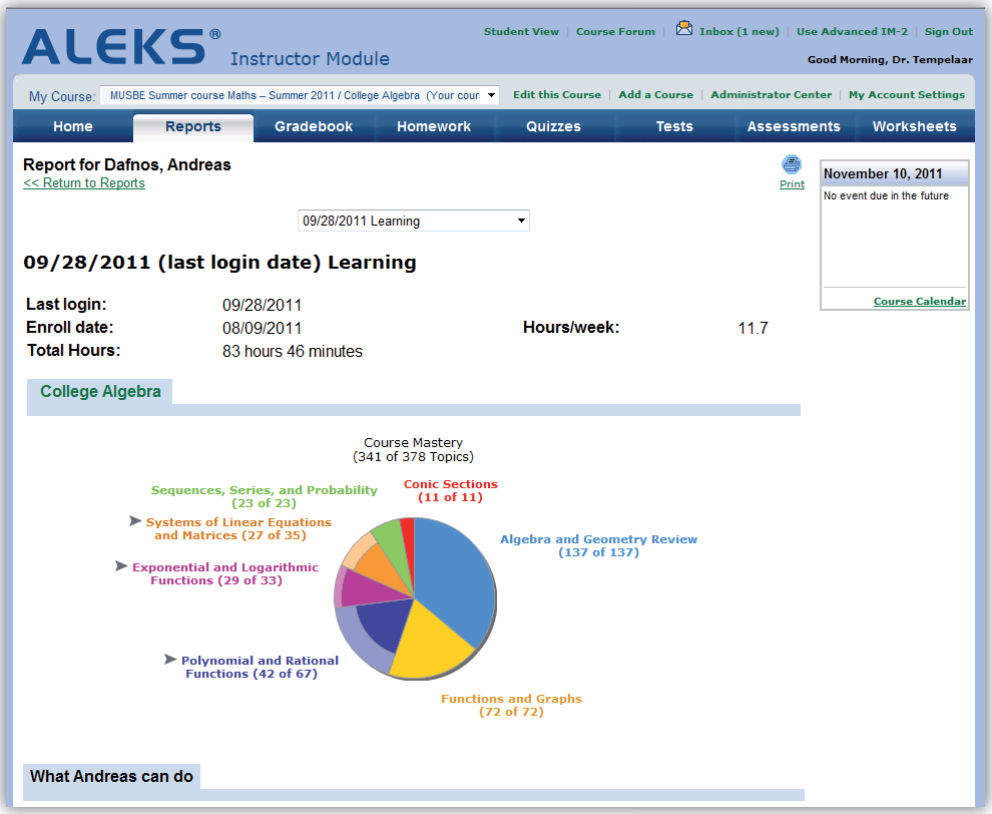


**Figure 1.** Partial sample of an ALEKS learning report

Some key features of the assessment module are that all problems require the student to produce authentic input, all problems are algorithmically generated, and assessment questions are generated from a carefully designed repertoire of items, thus ensuring comprehensive coverage of the domain. The assessment is adaptive: the choice of each new question is based on the aggregate of responses to all previous questions. As a result, the student's knowledge state can be found by asking only a small subset of the possible questions (typically 15-25). Both the principles of the UM summer course, and the use of the e-tutorial ALEKS, are described in more detail in Tempelaar et al. (2011). An important

aspect for this study is that the summer course is extra-curricular; offered before the regular program starts, participation can only be voluntary. As a consequence, three different groups of students can be distinguished: those not participating in the summer course (*NoSC*), those successfully participating in the summer course (*SCPass*), and those enrolling the summer course but not reaching a sufficient level of achievement (*SCFail*). To distinguish between passing and failing summer course participants, a mastery level of 55% of the lessons contained in the ALEKS module was used.

## Participants

This study is based on the investigation of five cohorts, of about equal size, of first-year students at a Business and Economics School in the south of the Netherlands (academic years 07/08, 08/09, 09/10, 10/11 and 11/12). Programs offered by this school deviate from mainstream European university education in two important ways: the student-centred learning approach of problem-based learning and a strong international orientation (the programs are offered in the English language and mainly attract international students). Of the 3,900 students in these five cohorts, 71% have an international background (mostly European, and just over 50% from German-speaking European countries) and 29% are Dutch. Of these students, 36.7% are female and 63.3% are male. The mean age of the students was 20.12 years, with a range of 17-31 years, though most students were in their teens: the median age was 19.82 years. They were all enrolled on a business and economics program.

A large majority of these students took part in the administration of at least one diagnostic entry test: 3,014. A small minority of the students took part in the voluntary summer course: 622, of which 267 passed and 335 failed (did not achieve a 55% mastery level in ALEKS).

After finishing the summer course in late August, the regular program of bachelor's degree studies in International Business and International Economics started in early September. Both programs begin with two eight-week (half semester) integrated, problem-based learning designed courses, each having a 50% study load. The first course is an introduction to organizational theory and marketing. The second course, called Quantitative Methods I or QM1, is an introduction to mathematics and statistics. The very first activity in the QM1 course is to administer the mathematics entry test. The coverage of the QM1 course mirrors the circumstance that strong heterogeneity in mathematics mastery, due to students being educated in different national systems and at different mathematics levels, necessitates a fair amount of repetition. Most of the topics covered are repeats of those taught in grades 11 and 12 of Dutch secondary schooling, basic mathematics level (the last two years of high school), with some time devoted to new topics. There is no overlap between QM1 and the content of the summer course, since that content covers those topics taught in grades 7-10 of secondary schooling (middle school and first year of high school).

The major component of heterogeneity in mathematics mastery is caused by the level of mathematics schooling in high school. European countries generally distinguish between two different levels of high school mathematics: basic and advanced. Of the students in this study, 28.1% did their high school education under the Dutch national system, called VWO (pre-university

education), and were taught mathematics at one of two different basic levels (A1 or A1,2) or one of two advanced levels (B1 or B1,2). The lowest level, A1, prepares students for studies in arts and humanities, but does not qualify them to take social sciences studies such as business or economics, so what remains is only the higher basic level: DutchA12 (18.6%). Another two tracks are at advanced levels: DutchB1 (4.5%, preparing for life sciences studies) and DutchB12 (2.3%, preparing for technical studies). Due to a reform in mathematics education in the Netherlands, students taking the advanced track in high school from the last two cohorts (10/11 and 11/12) were educated in an undifferentiated advanced track: DutchB (5.4%). A majority of students (53.1%) was educated in a German-speaking high school system. That system again has two different levels of prior mathematics education, the advanced level or *Leistungskurs*, and the basic level or *Grundkurs*. Students taking the basic track have a further choice to select mathematics as one of their four subjects in the final examination or *Abitur* (students in the advanced track always do so). As a consequence, there is one advanced track: GermanLK (13.9%), and two basic tracks: GermanGKA (25.0%) and GermanGKnA (13.8%), where the last category has opted out with regard to final examination. Again, in the last two cohorts, a new but very small category of students can be distinguished owing to a reform in mathematics education in some of the German states: the merger of basic and advanced tracks into one single, undifferentiated level of mathematics education: GermanUndif (0.8%). In comparison to other European universities, there is a rather large share of students having an International Baccalaureate (IB) diploma (6.9%). IB again allows one advanced level (HL) to be distinguished from two basic levels (SL and StudiesSL), generating the categories IBMathHL (1.5%), IBMathSL (5.1%) and IBMathSSL (0.3%, but excluded from this study due to its small size). The remaining students (11.9%) are educated within a national system outside the Dutch or German-speaking part of Europe. For this last category, students were asked to classify their own prior mathematics education at the level of either mathematics major or mathematics minor. This results in the categories OthMathMajor (6.2%) and OthMathMinor (5.7%).

## Interim assessments

In this study, we investigate the role of two different interim assessments. Both are designed for use in the transfer from high school to university and, for that reason, are labelled as entry assessments in the two projects for which they were designed. We shall adhere to that convention.

The first entry test is called the NKBW entry test, designed within the SURF NKBW project. In that project, secondary education and tertiary education representatives cooperated on the design of these entry tests, giving the entry tests the unique characteristic of being based on a shared opinion of what prospective students should master when graduating from high school and entering university. That is, the NKBW tests are both entry and exit tests. Tests were developed for different tracks of high school mathematics education; since mastery of mathematics at higher basic track level is required, we applied that type of entry test. That 16-item test comprises four topics: algebraic skills (*AlgebraicSkills*), logarithms and exponentials (*Log&power*), equations (*Equations*), and differentiation (*Differentiation*). In this study, we focus mostly on the topic of algebraic skills, since deficiencies in the

mastery of these skills appear to have a great impact on study success in the first year of university, and the topic is beyond the scope of most forms of refreshment education provided at the start of regular university education in many programs. Such refreshment topics typically include more advanced topics from senior high school, whereas algebraic skills are taught in junior high school, if not in primary education. Algebraic skills constitute a main part of the summer course program. NKBW entry tests have been available since 2009, and the two cohorts 09/10 and 10/11 of students investigated here have participated in this test.

The other entry test applied is the one designed by the TELMME project partners: the three Dutch technical universities. For that reason, the entry test is called the 3TU test. Since the test is based on the mastery of the advanced track of high school mathematics education, items belonging to the topic differentiation and integration were deleted from the test. The remaining categories are algebraic skills, logarithms and exponentials, and equations, and total 14 items. Written for a more advanced target audience, items have a somewhat higher level of difficulty than items in the NKBW entry test. They also have a stronger focus on skills mastery, whereas the conceptual understanding of mathematics is somewhat more prominent in the NKBW test. The 3TU test was administered in all five cohorts of UM freshmen, and thus provides a better basis for analysing developments over time.

# Results

## Prior education and the 3TU and NKBW entry tests

Figure 2 demonstrates the development over the years of diagnostic entry test scores in the topic *AlgebraicSkills* of the main prior mathematics education groups in our study. We shall focus on the component algebraic skills in most of this section, since it is at the heart of the project. However, the analysis of total scores in the entry test results in rather similar outcomes, with identical patterns, but at a slightly lower level.

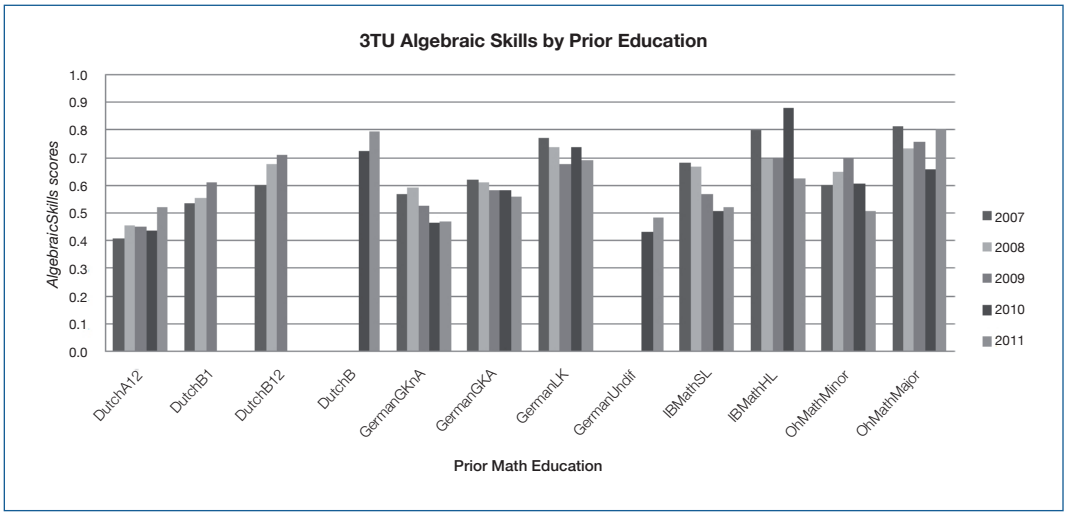


**Figure 2**. *AlgebraicSkills* scores from the 3TU entry test, by prior mathematics education

When the entry tests were administered for the very first time in 2007, we were surprised to find such a major underperformance of national (Dutch) students compared to international students. For example, national students with the most advanced prior mathematics education, DutchB12, scored no more than 60%, against a 62% score for German students educated at basic level (GermanGKA) and a 77% score for German students educated at advanced level (GermanLK). Needless to say, the scores of Dutch students from the less advanced tracks were even lower: 41% for DutchA12 and 53% for DutchB1. Indeed, they were the lowest of all other types of prior education. However, given the raison d'être of our national bridging project, this outcome was not that surprising. In fact, it did provide justification for the project, since Dutch secondary education proved to lack in preparing students for university, especially in the area of algebraic skills, not only in an absolute sense, but also in a relative sense, when comparing Dutch students to international students.

Since 2007, several remarkable developments have occurred. School reforms in Dutch secondary mathematics education have improved the performance of advanced track students year after year, for both the B1 and B12 tracks. The merger of both of these tracks into one DutchB track was another successful step in terms of mastery of algebraic skills: students from that broad track achieved 72% and 79% scores, higher than ever before. And by doing so, they approached the score of German advanced track students (74%, GermanLK). Scores of Dutch basic track students, however, remained at the very lowest level.

Amongst the three different types of international prior education, radically different developments can be observed. Mastery levels of the advanced tracks are relatively stable and high (greater variability present in the scores of IBMathHL, though that may simply be due to sampling variability, given the smaller size of this group, 15 on average). The OthMathMajor category seems to demonstrate decreasing scores, but, being a residual category, this is not easy to interpret. Mastery levels among basic track students do, however, signal a decline over the years for both German and IB students, with very marked developments for the GermanGKnA and IBMathSL groups. As a consequence, mastery levels among all tracks of basic mathematics education (except OthMathMinor) converge to worryingly low levels – ranging between 40% and 50% – that have been present in the Netherlands for some time. In contrast to the success of the Dutch educational reform, the reform in Germany of removing different tracks to create an undifferentiated system seems to be less successful: the score is certainly not higher – and is more likely to be lower – than that of the basic track still in existence in other states. However, this group is somewhat small to place a lot of trust in this outcome.

The assessment of the German educational reform also depends on the type of entry test applied: changing to the NKBW entry test, which is based rather more on conceptual understanding and somewhat less purely on skills, German undifferentiated system students score midway between the basic and advanced tracks (60% versus 59% and 69%). In addition, the other educational reform is assessed differently: the new DutchB group scores similarly to, or even slightly lower than, students from the advanced track the year before. Besides being more conceptually oriented, the NKBW entry test is clearly less difficult (scores are uniformly higher) and less discriminative between the basic and advanced tracks than the 3TU entry test: see Figure 3.

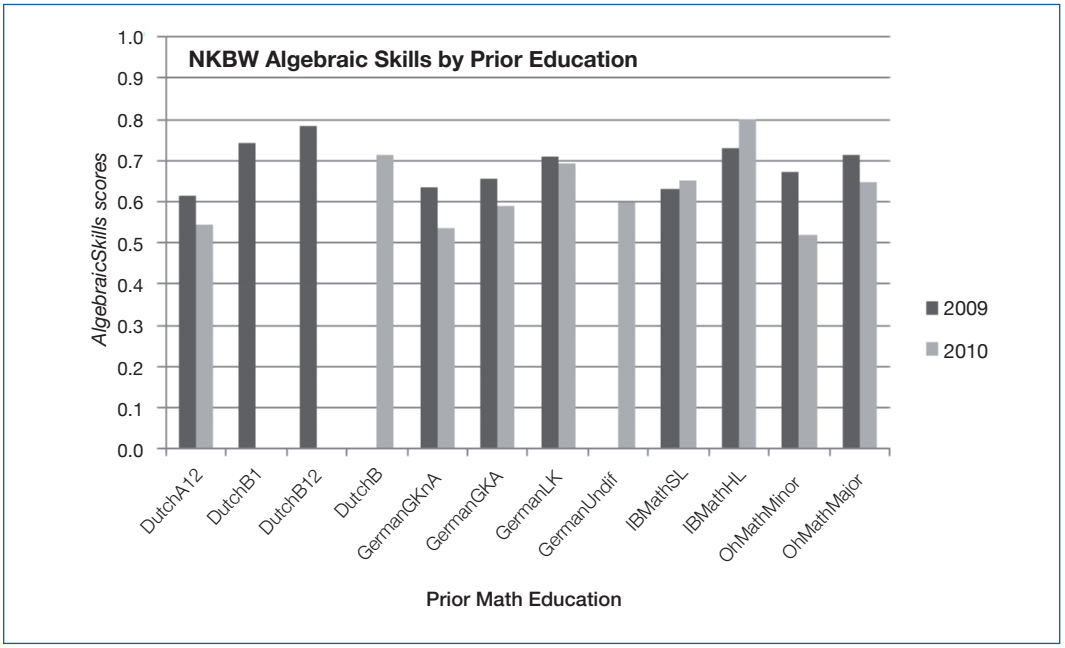


**Figure 3**. *AlgebraicSkills* cores from the NKBW entry test, by prior mathematics education

How large the differences between international mathematics educations can be with regard to the mastery of very basic algebraic skills is illustrated by the scores of two entry test items from this category in the 3TU entry test. The items themselves are provided too: see Figures 4 and 5.

*AlgebraicSkillsNo2*: $\frac{x^2-x}{x^2-2x+1}$ equals: a. $\frac{x}{1-x}$ b. $\frac{1}{2x-1}$ c. $\frac{-x}{-2x+1}$ d. $\frac{x}{x-1}$

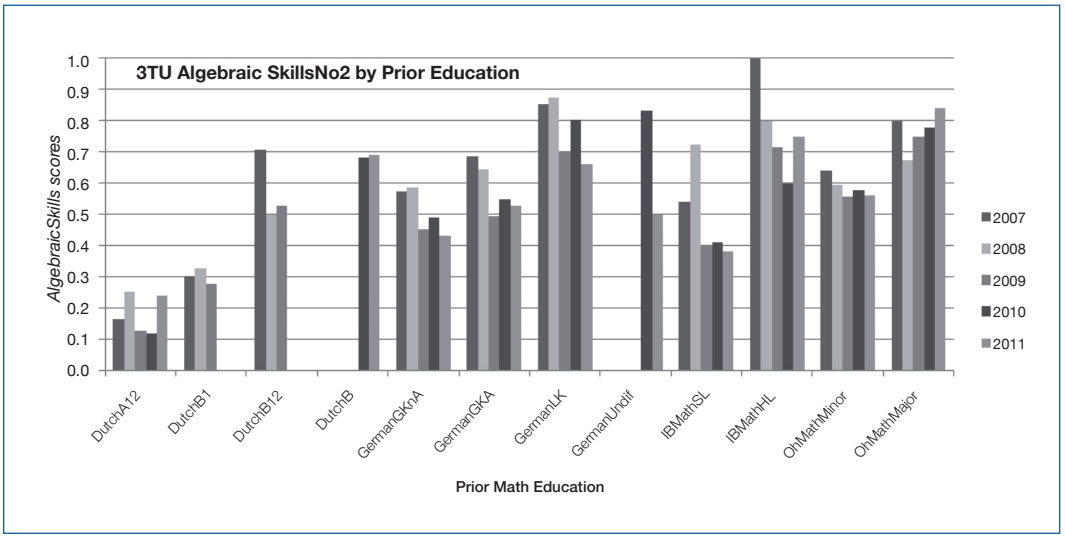


**Figure 4**. *AlgebraicSkillsNo2* scores from the 3TU entry test, by prior mathematics education

*AlgebraicSkillsNo3*: $\frac{x}{x+1}+\frac{x}{x-1}$ equals: a. $\frac{2x}{2x-2}$ b. $\frac{2x^2}{x^2-1}$ c. $\frac{2x^2}{1-x^2}$ d. $\frac{2x}{x^2-1}$

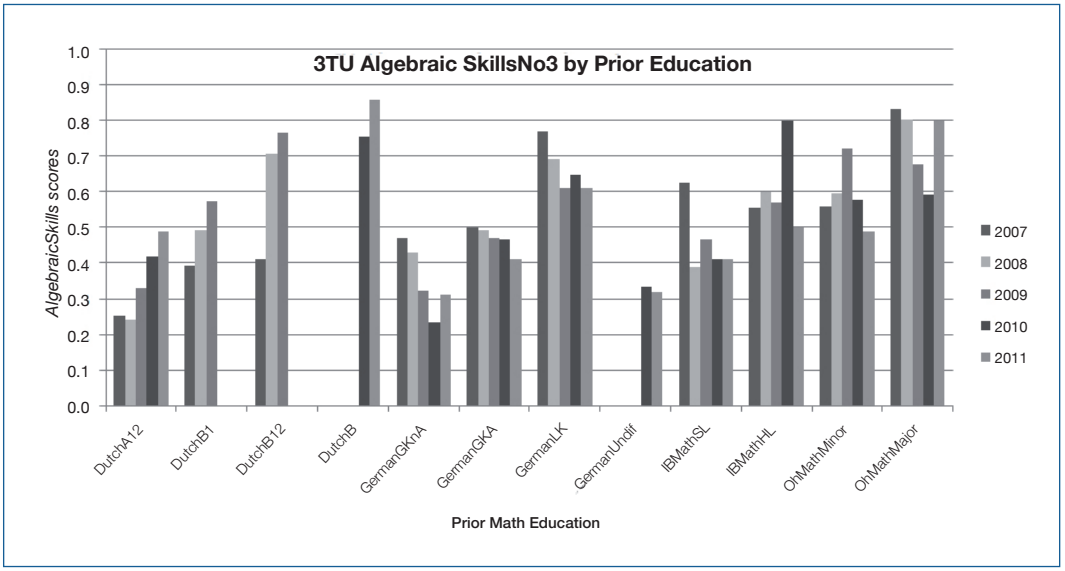


**Figure 5**. *AlgebraicSkillsNo3* scores from the 3TU entry test, by prior mathematics education

Where the *AlgebraicSkillsNo3* scores are not beyond guessing level in some group and year combinations, we at least observe improved mastery over time, especially for the Dutch students, who were the weakest in 2007. In contrast, scores for *AlgebraicSkillsNo2* in the Dutch basic track are even lower than guessing rate, and do not indicate any sign of improvement over time: students continue to become strongly attracted to the third answer option, apparently following the strategy of eliminating equal quadratic terms in numerator and denominator. Beyond very strong differences between outcomes for the Dutch and other European educational systems, both items, but especially the first one, also demonstrate considerable mastery differences between basic and advanced track students. This is remarkable in its own, since algebraic skills are typically taught in junior high school, to students in both the advanced and basic tracks.

## Summer course participation and the 3TU and NKBW entry tests

Since the mathematics bridging course offered by the program runs in the summer, participation is voluntary, which allows student performance in the entry tests to be compared for three different groups of students: successful summer course participants, unsuccessful summer course participants and non-participants. Figure 6 and 7 contain student performance scores in both types of entry test in the *AlgebraicSkills* section and, as reference material, in two other topics in the NKBW entry test. Figure 6 makes clear that there is a strong effect of successful participation in the summer course. The true effect is even greater than the figure suggests, since students educated at the basic level are overrepresented in the group of summer course participants, whereas students educated at the advanced level are overrepresented in the group of non-participants (according to the aim of the summer course). Part of this overrepresentation is visible in the scores of unsuccessful summer course

participants: in three of five cohorts, their mastery level is significantly lower than the mastery level of the non-participants, indicating that these students initially made the right decision to register for the bridging course, but failed to materialize that decision.

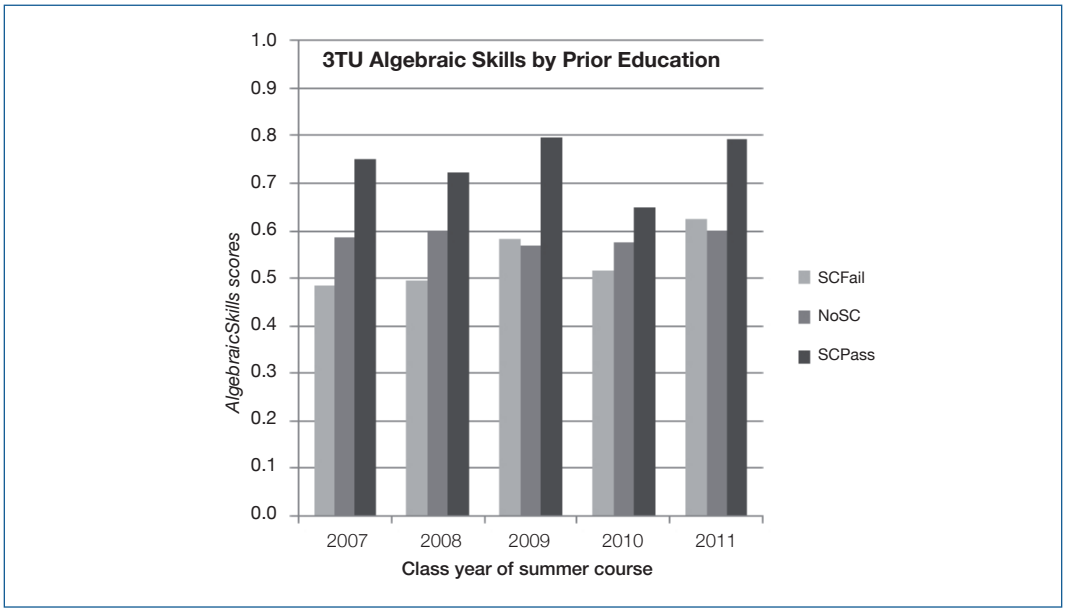


**Figure 6**. *AlgebraicSkills* mastery in the 3TU entry test, by summer course participation

The first panel of Figure 7 confirms that impression, be it that effects are much weaker when measured with the NKBW entry test *AlgebraicSkills* section. The second panel indicates that items in the *Logs&Powers* section contain a stronger effect of bridging education. And the third panel is added to check the adequacy of comparisons of this type. The third panel contains the items of the *Differentiation* section, not part of the summer course. For comparisons between the three groups to be valid, no effect of bridging education is to be expected in this third panel, which is indeed the case.

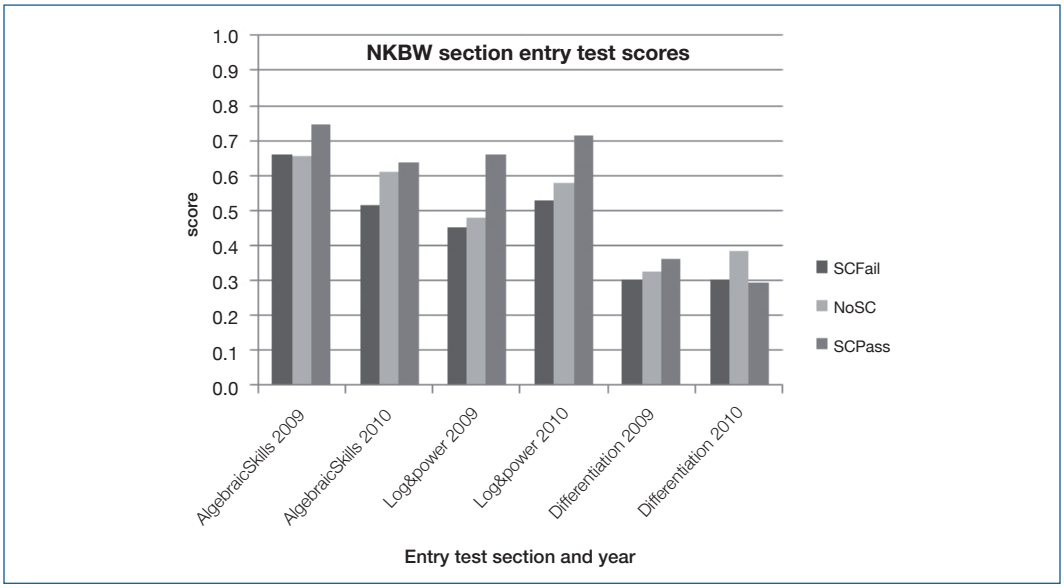


**Figure 7**. *AlgebraicSkills, Logs&Powers & Differentiation mastery* in the NKBW entry test, by summer course participation

Does participation in the summer course help students achieve academic success, beyond getting higher scores in purely formative tests like the two types of entry test? The answer is clearly affirmative, as visible in Figures 8 and 9. Figure 8 contains the scores in the final exam for both sections of that exam: mathematics and statistics (maximum score being 20). The effects of successful summer course participation are substantial, in both sections, where the true effects are again expected to be stronger than the visible effects, given that weaker students are overrepresented in the summer course. Differences in final mathematics exam scores between successful summer course participants and non-participants are statistically significant at 1% level in all class years, except for 2008 and 2011. Differences in final statistics exam scores are statistically significant at 1% level in class years 2007 and 2009.

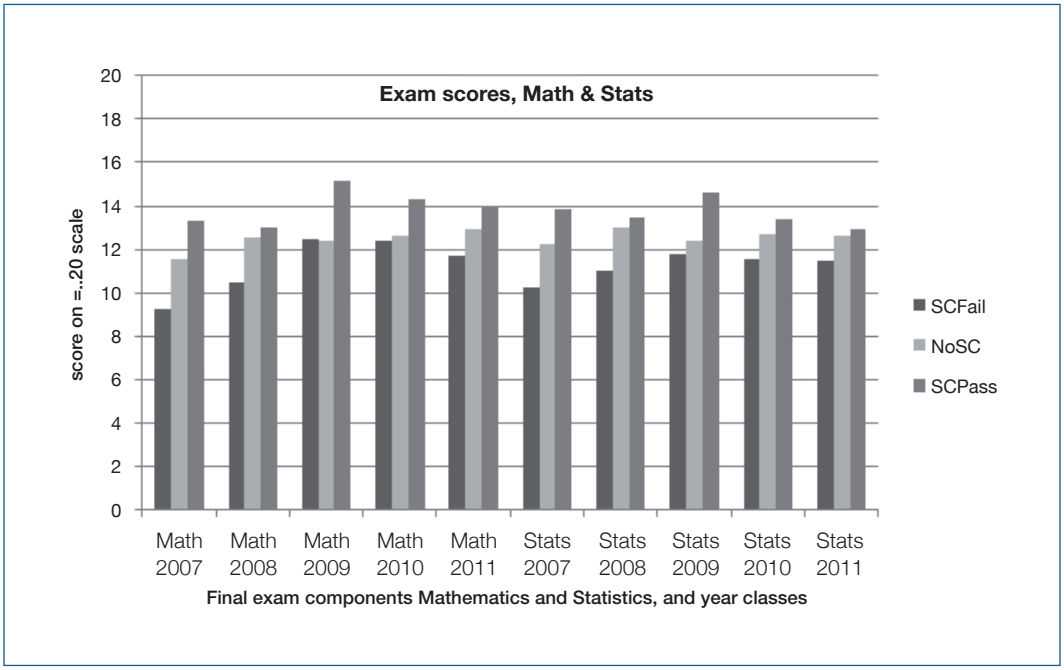


**Figure 8**. Score in final mathematics exam and final statistics exam, by summer course participation

The strongest effects are visible in Figure 9, containing the passing rates for the QM course. Since most students score in the region of 55% (required to pass), the effects of summer course participation are stronger on passing rates than on absolute score. Differences in passing rates between successful summer course participants and non-participants are statistically significant at 1% level in all class years except for 2008, where significance is at the 10% level.

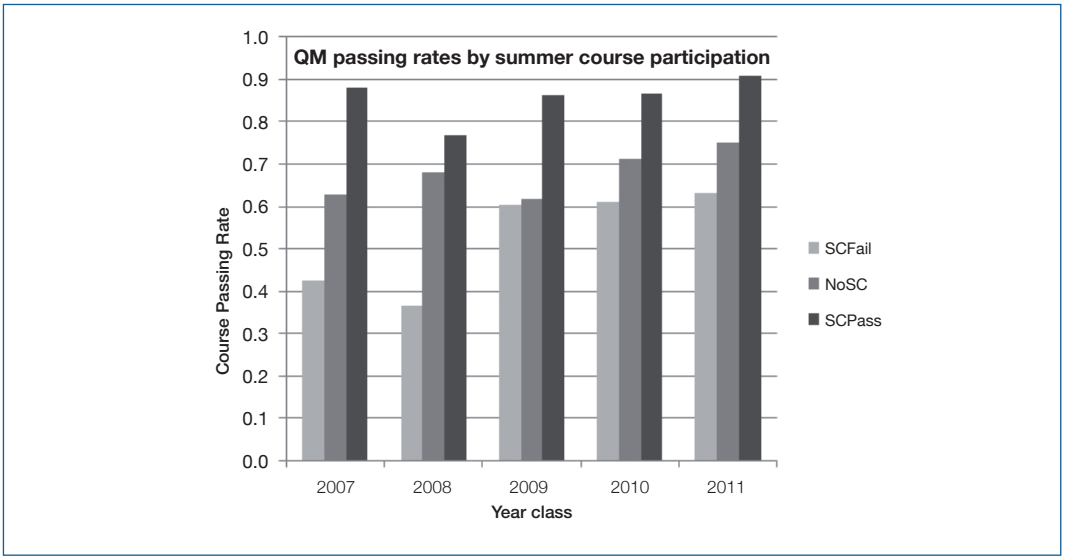


**Figure 9**. QM passing rate, by summer course participation

## Prior education and summer course participation, and the 3TU entry test

In order to properly disentangle the combined effects of prior mathematics education and summer course participation, it is necessary to analyse the effect of bridging education separately for students of each of the different types of prior education. Figure 10 provides the outcomes of one sample of such an analysis.

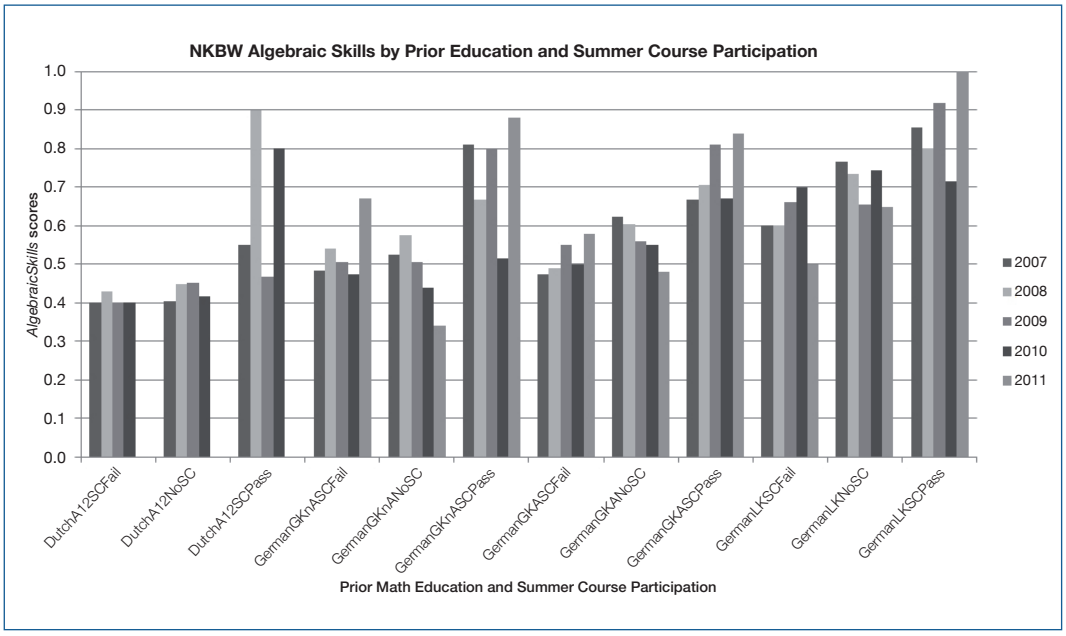


**Figure 10**. *AlgebraicSkills* scores in the 3TU entry test, by prior education and summer course participation

Since only a minority of students participated in bridging education, comparison is restricted to those prior education categories that had a sufficient number of students (five) in each of the three categories *NoSC*, *SCFail* and *SCPass*. Prior education categories that satisfy that constraint are DutchA12, GermanGKnA, GermanGKA and GermanLK. With the exception of the last category, these are all categories of basic tracks of mathematics education. German students are overrepresented, partly because many German students interrupt their studies after finishing high school and go to university only after a break of often two or more years. These students, even if educated at advanced level, regard the summer course as an effective refresher of their mathematics mastery. For all four prior education categories, Figure 10 contains three panels, corresponding to failing, non-participation and passing the summer course. As expected, we observe that entry test scores demonstrate both a prior education effect and a summer course participation effect. The summer course effect seems to be weakest among advanced track students, which is no surprise: beyond some refreshment, these students cannot gain much from participating in the bridging course. Stronger effects are to be found for students educated at the basic level. But beyond the systematic differences, there is more sampling variability present, due to smaller samples, which makes interpretations from these decomposed data less easy.

## Cluster analysis of 3TU entry test scores

A very different approach to analysing data derived from entry test takes is to look at groups of students with similar score patterns for the different items in the test. We did this by applying cluster analysis; Figure 11 contains a graphical representation of the outcomes of such a cluster analysis.

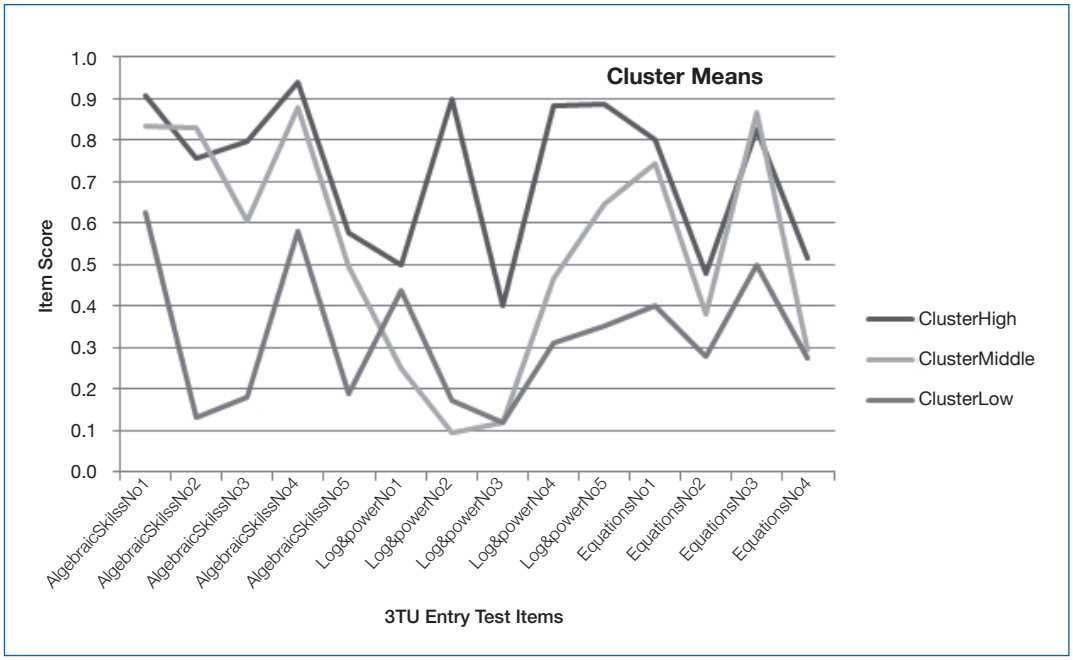


**Figure 11**. Clustering of students in high, middle and low clusters based on five years of 3TU test takes

The analysis is performed on all test takes together, by adding all five cohorts. In the analysis, each student is allocated to one of three clusters, where the clusters are calculated to maximize variation between clusters and to minimize variation within clusters. Such cluster analysis can be repeated within each of the prior education groups; in this contribution, we shall limit ourselves to the outcomes of cluster analysis applied to all groups together. In most of these cluster analyses, distinguishing three clusters works quite well and, in most cases, these clusters are easily interpretable. As one can see from Figure 11, the clusters represent high scoring students, low scoring students, and a group of students whose performance is between the two. The latter middle group is by far the most interesting one, especially since the students perform similarly to the high scoring students for some items, and similarly to the low scoring students for other items. In Figure 11, students in the middle cluster score similarly to those of the high cluster for items belonging to the *AlgebraicSkills* section, with the third item (discussed earlier) as a potential exception. In contrast, students in the middle cluster score similarly to students in the low cluster, or even lower, in items in the *Log&power* section. They score highly again in the *Equations* section, especially on the third item, which requires them to find the zeros of a standard quadratic equation. Deviant patterns are here for the second question, which acts as a kind of trick questions: it asks for the number of different zeros of a third order polynomial, in which two zeros coincide. And the last question, where beyond solving an equation, students need to know how to find a tangent line. In short, middle cluster students act on the same level as high cluster students when items can be solved by the straightforward application of regular solution strategies taught in high school, but fall back to the level of low cluster students when items deviate from the regular pattern of class exercises.

## Conclusions and discussion

The repeated use of formative, diagnostic tests is a crucial component of any mathematics e-learning program, providing the feedback required for the optimal steering of individual learning. The use of broad 'interim' assessments for these purposes brings many additional advantages. First, it allows the strengths and weaknesses of different prior education tracks to be distinguished for programs attracting large numbers of international students educated in very different high school programs. Second, when the heterogeneous inflow is accommodated by implementing bridging education, it allows the effects of prior education and of remedial education to be properly disentangled. Finally, it allows different clusters of students with very different patterns of mathematics mastery to be distinguished. Doing so provides important information – beyond that for the individual students – for instructional planning, for regular curriculum design, for the implementation of bridging programs, for the streaming of education and even for admission regulations. Inferential statistical analyses indicate that first-year students using these formative assessments and participating in the summer course (based on such a formative assessment strategy) are substantially more successful (in the sense of statistical significance) than students who do not.

Both students and instructors evaluate the facilities of online formative assessment as highly positive. However, it is difficult to assess the evaluation of the developmental and placement functions of formative assessment separately from the evaluation of the achievement functions. As in many other programs, online formative assessment is introduced together with online low-stakes testing in the form of quizzes. Positive evaluation of formative assessment is therefore not to separate from the appreciation of low-stakes testing and the availability of online tools to prepare these quizzes.

Future research will have a dual focus. First, formative tests, specifically entry tests, provide crucial feedback with regard to the mathematics proficiency of students from different backgrounds. Given the recent major reform in Dutch secondary mathematics education, longitudinal monitoring of the mathematics proficiency of prospective students from different secondary education systems will continue to serve an important function. Second, future research will focus on the role formative tests can play in both providing continuous and instantaneous feedback to students, and in making education itself more adaptive, with the aim – in both instances – of optimising the learning process.

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## References

BEATTY, A. (Rapporteur) (2010). *Best Practices for State Assessment Systems Part I: Summary of a Workshop*. Washington, D. C.: National Academy Press.

BRANTS, L.; STRUYVEN, K. (2009). "Literature review on online remedial education: A European perspective". *Industry and Higher Education*. Vol. 23, No 4, 269-276.

DOIGNON, J. P.; FALMAGNE J. C. (1999). *Knowledge spaces*. Berlin: Springer.

DONOVAN, M. S.; BRANSFORD, J. D. (eds) (2005). *How Students Learn: Mathematics in the Classroom*. Washington, D. C.: National Academy Press.

FALMANGE, J.; COSYN, E.; DOIGNON, J.; THIÉRY, N. (2004). *The assessment of knowledge, in theory and in practice*. [Accessed: 1 December 2010]. <http://www.aleks.com/about_aleks/Science_Behind_ALEKS.pdf>

HATTIE, J. (2008). *Visible Learning. A synthesis of over 800 meta-analyses relating to achievement*. London: Routledge.

JUAN, A. [et al.]. (2011). "Teaching Mathematics Online in the European Area of Higher Education: An instructors' point of view". *International Journal of Mathematical Education in Science and Technology*. Vol. 42, No 2, pages 141-153.

PELLEGRINO, W.; CHUDOWSKY, N.; GLASER, R. (eds) (2001). *Knowing What Students Know: The Science and Design of Educational Assessment*. Washington, D. C.: National Academy Press.

RIENTIES, B. [et al.] (2011). "Describing the current transitional educational practices in Europe" [submitted article]. *Interactive Learning Environments*.

TAYLOR, J. A. (2008). "Assessment in First year university: A model to manage transition". *Journal of University Teaching & Learning Practice*. Vol. 5, No 1.

TEMPELAAR, D. T.; RIENTIES, B. (2008). "Remediating summer classes and diagnostic entry assessment in mathematics to ease the transition from high school to university". In: *Proceedings of Student Mobility and ICT: Can E-LEARNING overcome barriers of Life-Long Learning*. Maastricht: FEBA ERD Press. Pages 9-17.

TEMPELAAR, D. T. [et al.] (2006). "An online summer course for prospective international students to remediate deficiencies in math prior knowledge: The case of ALEKS". In M. Seppällä; O. Xambo; O. Caprotti (eds). *Proceedings of WebALT2006*. Technical University of Eindhoven: Oy WebALT Inc. Pages 23-36.
<http://webalt.math.helsinki.fi/webalt2006/content/e31/e157/e161/6_zDR2j2uQcB.pdf>

TEMPELAAR, D. T. [et al.] (2011). "Mathematics bridging education using an online, adaptive e-tutorial: preparing international students for higher education". In: A. A. Juan; M. A. Huertas; S. Trenholm; C. Steegmann (eds). *Teaching Mathematics Online: Emergent Technologies and Methodologies*. IGI Global.

TRENHOLM, S. [et al.] (2011). "Long-Term Experiences in Mathematics E-Learning in Europe and the USA". In: A. A. Juan; M. A. Huertas; S. Trenholm; C. Steegmann (eds), *Teaching Mathematics Online: Emergent Technologies and Methodologies*. Hershey, PA: IGI Global. Pages 236-257.

WANG, K. H.; WANG, T. H.; WANG, W. L.; HUANG, S. C. (2006). "Learning styles and formative assessment strategy: enhancing student achievement in Web-based learning". *Journal of Computer Assisted Learning*. Vol. 22, No 3, pages 207-217.

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**Dossier "Mathematical e-learning"**

ARTICLE

# A Knowledge-Skill-Competencies e-Learning Model in Mathematics

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## Abstract

This paper concerns modelling competence in mathematics in an e-learning environment. Competence is something complex, which goes beyond the cognitive level, and involves meta-cognitive and non-cognitive factors. It requires students to master knowledge and skills and at least some measurable abilities, which Niss calls 'competencies'. We present a model that exploits the innovative technological features of the IWT platform to define a personalised learning experience allowing students to increase their competence in mathematics. It is based on knowledge and skills representations by means of a graph metaphor, and on a theoretical framework for modelling competence.

## Keywords

mathematics learning, knowledge, skill, competence, competency, e-learning

## *Conocimientos, destrezas y competencias: un modelo para aprender matemáticas en un entorno virtual*

**Resumen**

*Este trabajo se centra en la competencia matemática en un entorno de aprendizaje virtual. La competencia es algo complejo, que trasciende el nivel cognitivo, e implica factores metacognitivos y no cognitivos. Exige de los estudiantes su dominio sobre conocimientos y destrezas y, por lo menos, sobre algunas capacidades medibles, a las que Niss llama «competencias específicas» [competencies]. El modelo que presentamos utiliza las innovadoras características tecnológicas de la plataforma IWT para definir una experiencia de aprendizaje personalizado que permite a los estudiantes aumentar su competencia en matemáticas. Se basa en la representación de conocimientos y destrezas mediante metáforas gráficas y en un marco teórico para modelar la competencia.*

**Palabras clave**

*aprendizaje de matemáticas, conocimientos, destrezas, competencia, competencia específica, aprendizaje virtual*

# 1. Introduction

Competence in mathematics is something complex, hard to define, which requires students to master not only knowledge and skills, but at least some measurable abilities, which Niss calls 'competencies' (detailed in section 2). In this paper we face the problem of mathematics teaching-learning in an e-learning environment, with particular respect to competencies. The author has extensive experience in undergraduate blended courses supported by the e-learning platform IWT (Intelligent Web Teacher), which allows personalised Units of Learning (UoLs) for each learner to be created and delivered by means of an explicit knowledge representation (see section 3). The latter has been improved in order to make a clear distinction between knowledge and skills (Albano, 2011a). Competency modelling requires a different approach and further work, since it is based on knowledge and skills and goes beyond the cognitive and meta-cognitive levels of both. In this paper, starting from the assumption that the learning of competencies comes from the engagement of learners in suitable Learning Activities (LAs), we propose a model that is able to generate and update suitable *templates* associated with the learning of a certain competency. Moreover, we give a complete framework of how the knowledge-skill-competency model should work in the IWT context. In particular, the IWT learning personalisation features can be exploited to personalise the delivery of LAs, so as to engage learners in those activities that best match their individual cognitive states and learning preferences.

The paper is organised as follows: sections 2 and 3 give an overview of the theoretical and technological frameworks, respectively; section 4 describes a model for knowledge and skills in mathematics learning, based on a multi-level graph representation of the domain; section 5 describes a model for competencies, framed in Dubinsky research on undergraduate mathematics education (RUME); section 6 shows how the three models work and integrate; section 7 analyses

costs and benefits; section 8 explores the opportunities for future research; and section 9 draws some conclusions.

## 2. Theoretical framework

Many authors (Weinert, 2001; D'Amore, 2000; Godino, J.; Niss, 2003) have tried to explain competence in mathematics. According to Niss (2003), "possessing mathematical competence means having knowledge of, understanding, doing and using mathematics". All these authors agree that it is not something to be taught; rather, it is a long-term goal for the teaching-learning process. It is something complex and dynamic, which requires mathematics domain knowledge of a declarative-propositional type and of a procedural type, that is, knowledge (to know) and skill (to know how), but at the same time goes beyond cognitive factors. Table 1 shows a list of some basic requirements for the distinction between knowledge and skills:

Table 1. Classification of the main types of mathematical content.

| *Content type* | *Knowledge* | *Skill* |
|---|---|---|
| Definition | Statement | Procedure/computation |
| Theorem<br>Theorem | Statement<br>Proof | Procedure/computation<br>Procedure/computation |
| Algorithm<br>Example (counter) | Description | Performance of the algorithm |
| Exercise<br>Problems | | Computational skills<br>Solving standard problems |

In order to make the notion of mathematical competence more factual, we can consider a mathematical competency as a clearly recognizable distinct major constituent in mathematical competence (Niss, 2003). Niss has distinguished eight characteristic cognitive mathematical competencies, adopted by PISA 2009 (OECD, 2009). They correspond to relational mathematics (Skemp, 1976), which consists of reasoning, thinking, problems, and processes. This is reflected by 'relational comprehension', which means to know why. The following table lists them in two clusters (Niss, 2003):

Table 2. Clusters related to cognitive mathematical competencies.

| *The ability to ask and answer questions in and with mathematics* | *The ability to deal with mathematical language and tools* |
|---|---|
| Mathematical thinking competency | Representation competency |
| Problem handling competency | Symbols and formalism competency |
| Modelling competency | Communication competency |
| Reasoning competency | Tools and aids competency |

# 3. Technological framework

From a technological viewpoint, we refer to the IWT platform that we used in our practices. It is a software platform for distance learning, equipped with Learning Content Management System (LCMS) and adaptive learning system features. It allows teaching-learning experiences to be both personalized and collaborative by means of the explicit representation of knowledge and the use of Web 2.0 techniques and tools. Realized at the Italian Pole of Excellence on Learning & Knowledge and marketed by MOMA[1], this platform, which is not open source, has been adopted by various Italian universities and high schools.

## 3.1 The main features of IWT

Personalisation of the learning process is made possible in IWT by means of three models: Knowledge, Learner, Didactic.

The Knowledge Model (KM) is able to intelligibly represent the computer and the information associated with the available didactic material. It makes use of:

1) Ontologies, which allow the formalization of cognitive domains through the definition of concepts and relations between the concepts. They consist of graphs, whose nodes are the concepts of the cognitive domain and whose edges represent the relations HasPart, IsRequiredBy and SuggestedOrder, designed by domain experts using a specific editor available in IWT (Figure 1).

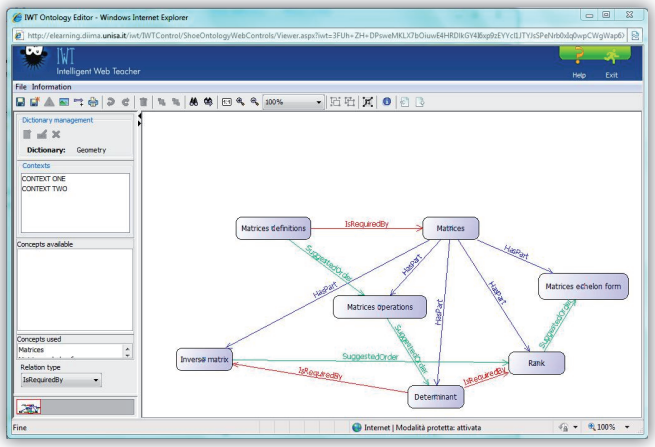


**Figure 1**. An example of an ontology for the topic Matrices.

2) Learning Objects (LOs), consisting of "any digital resource that can be reused to support learning" (Wiley, 2000).

3) Metadata, which are descriptive information tagged to each LO in order to associate it with one or more concepts in an ontology (Figure 2, red box). Further information refers to educational

1. http://www.momanet.it/index.php?lang=en

parameters such as LO typology (video, text, slide, etc.), context (high school, college, training, etc.), type of interaction (expositive, active, mixed) and its level, difficulty and semantic density.

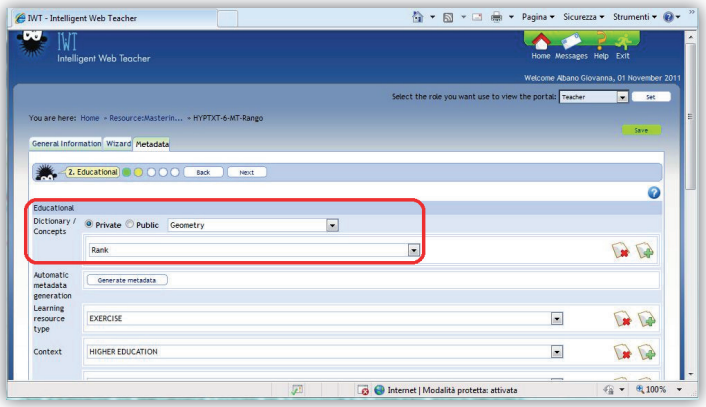


**Figure 2**. An example of metadata (zoom on Ontology/Concept association).

The Learner Model (LM) allows a user profile to be managed (Figure 3). The user profile automatically captures, stores and updates information on individual learners' preferences and needs (e.g., media, level of interactivity, level of difficulty, etc.) and their cognitive states (that is, concepts of a knowledge domain that have already been learnt).

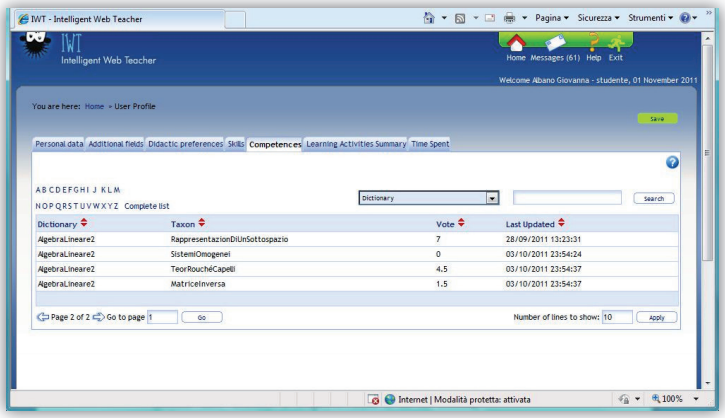


**Figure 3**. An example of a learner profile.

The Didactic Model (DM) refers to a pedagogical approach to learning (e.g., inductive, deductive, learning by doing, etc.). Currently, it is associated with specific LO typologies (for instance, a simulation refers to inductive didactic learning) and it is stored both in the LO metadata and in user profiles (as preferred LO typologies).

## 3.2. How IWT works

IWT allows both guided and self-regulated learning. The former consists of standard courses (e.g., Geometry, Calculus) and the latter allows learners to express their learning needs in natural language (e.g., learning to solve linear systems). In both cases, IWT gives rise to tailored UoLs, taking advantage

of the previous models (Albano, 2011b; Albano et al., 2007; Gaeta et al., 2009). Domain experts (i.e., teachers) first define a number of suitable specifications for courses or learning needs, choosing or editing a suitable ontology for the course topics. They then set suitable learning goals (e.g., one or more target concepts on the chosen ontology) and finally choose certain parameters for the teaching flow (e.g., pre-test, how many intermediate tests, educational context). The UoL is generated at run-time from IWT, when a student accesses it for the first time, through the following steps: the ontology is used to create the list of concepts needed to reach the target concepts of the course, then user profile information allows this list to be updated according to the cognitive state, and the LOs to be chosen. These LOs are those whose metadata best match the learner preferences. Further, the UoL is dynamically updated according to the outcomes of intermediate tests.

## 4. Multi-level graphs to model knowledge and skills learning

The current use of ontology in IWT corresponds to a rough version of teaching according to 'fundamental nodes'. With this term we refer to "those fundamental concepts which occur in various places of a discipline and then have structural and knowledge procreative value" (Arzarello et al., 2002). In mathematics education, teaching by fundamental nodes means "to weave a conceptual map, strategic and logic, fine and smart" (e.g., Figure 4), where each concept is the goal of a complex meshed system, where no concept stands completely alone and each of them is part of a relational web rather than a single "conceptual object" (D'Amore, 2000).

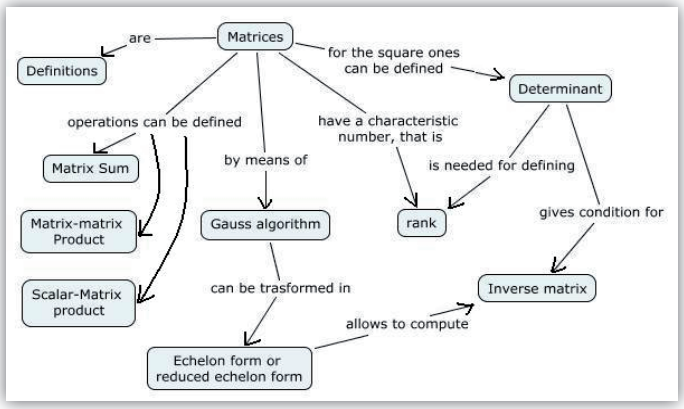


**Figure 4**. An example of a conceptual map for the topic Matrices.

As we can see, the distinction between the knowledge and the skill levels is made clear by the relations between the nodes (i.e., the edges). Edges in IWT ontologies cannot do the same. So the two levels are flattened onto the nodes, thus associating LOs for both of them.

In order to overcome this restraint, we propose the use of a multi-level graph representation (Albano, 2011a). At the first level, the fundamental nodes are seen as 'roots' of a further two graphs (ontologies), where the levels of knowledge and skill are made explicit.

- Knowledge level (Figure 5), where the nodes correspond to definitions, theorems, examples, etc. (Table 1), and the possible relations, mandatory (continuous lines) or not (discontinuous lines).

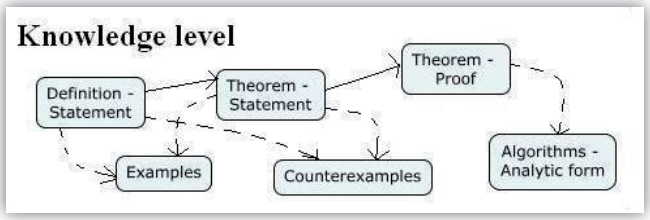


**Figure 5.** Generic ontology at the knowledge level.

- Skill level (Figure 6): where the nodes correspond basically to computational methods and standard problem-solving capabilities (Table 1).

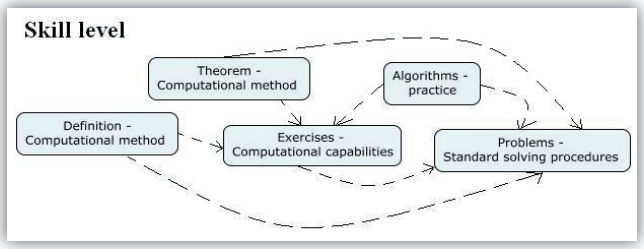


**Figure 6**. Generic ontology at the skill level.

Moreover, a third level related to competencies can be devised:

- Competency level: where the nodes correspond to those competencies for the fundamental node 'root' (Table 2).

In the following section, we shall take the competency level and its modelling into consideration.

## 5. Dubinsky's cycle to model competency learning

According to the theoretical framework, we assume that competencies develop from students' engagement in LAs. This is why, in order to model competencies, we refer to Dubinsky's RUME framework (Asiala et al., 1996). It consists of a cycle of three interrelated elements, which are theoretical analysis, instructional treatment and data collection/analysis.

Let us see what they mean in our context. Starting from a concept, we can single out one or more associated competencies. Then, we can implement a LA aimed at getting students to practice them. Thus, we can start the cycle described below:

## Theoretical analysis

The theoretical analysis aims to propose a competency learning model, that is, a description of mental construction processes used by learners in their understanding of the competency, called Genetic Decomposition (GD). Such GD is strictly dependent on the content to which the competency is applied (e.g., representation competency has a different meaning if it concerns a set of real numbers or the lines in a 2D space) and it is not necessarily unique with respect to fixed content (Figure 7).

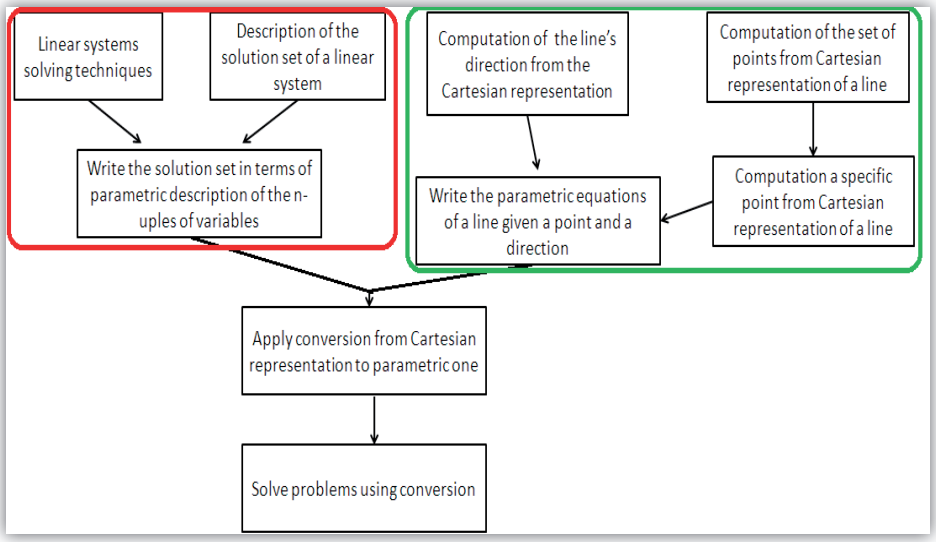


**Figure 7**. Example of algebraic (on the left) and geometric (on the right) genetic decomposition for a given competency.

Moving along a GD, the mechanism for practicing and constructing mathematical competency is described in terms of the following four elements (APOS):

- *Action*: a transformation generated as a reaction to external stimuli (physical or mental).
- *Process:* the interiorisation of the object, so that transformations can be mentally imagined.
- *Object:* the encapsulation of the process, due to reflections on operations applied to a particular process, making the individual aware of the process in its totality.
- *Schema:* objects and processes can be organized in a coherent collection, explicating the interconnections between them and giving rise to what is called a 'schema'. A schema represents an individual's knowledge of a competency and it is invoked in order to understand, deal with and face a perceived situation involving that competency.

Given a competency, its GD together with the related APOS give rise to a Learning Scenario (LS) suitable for a learner to practice and master such a competency.

### Instructional treatment

Theoretical analysis indicates a specific LS to be fostered by instruction. This means designing instruction for a LA associated with a LS, which enables students to construct the appropriate actions, processes, objects and schemata. Such instruction can be described using a specific language for learning design (for instance, IMS-LD 2003) allowing the description of an activity workflow associated with the LS. These workflows include the definition of actions, processes, pedagogical strategies and specific environments comprising sets of LOs and services (forum, chat, calendar, virtual classroom, access to maths engines, etc.). The outcome of this phase will be one or more *templates* for a LA associated with a fixed LS. The *templates* also contain descriptive information in order to associate a LA with both a competency and to one or more concepts in an ontology (at knowledge and/or skill level).

### Data collection/analysis

Once the instruction is implemented and experienced by students, observations and analysis of learning results in terms of theoretical expectations are needed. This means examining whether students have made the mental constructions predicted by the theoretical analysis or whether they have used alternative constructions. The data are used to validate the theoretical analysis and the consequent instruction treatment. Appropriate adjustments or a complete revision can be made.

## 6. How the new models work

From the above sections, we can sketch out the following Figure 8.

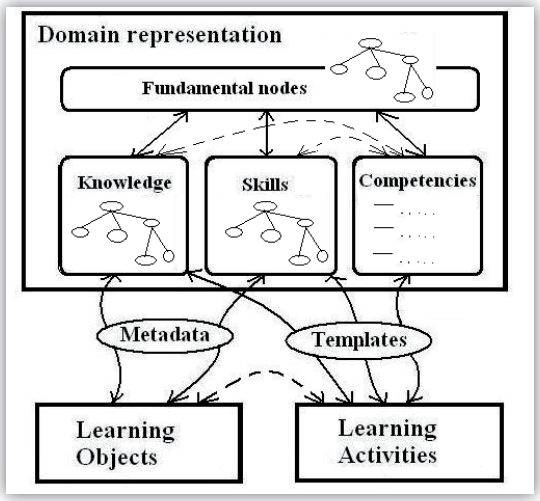


**Figure 8**. Model of learning experience generation.

Domain representation in the platform will consist first of all of an ontology on fundamental nodes, and then further levels of ontologies (knowledge and skills) and a database of competencies are devised.

Taking into consideration both guided and self-regulated learning, let us see how the new domain representation impacts on them. Concerning the former, the UoL corresponding to the standard course differs from the ones described in section 3.2 with respect to two aspects:

- The selection of target concepts can be specified at one or more ontology levels and the learning path will develop from the merging of the lists generated at each level; then the process continues as previously shown.
- The UoL will be enriched by engaging learners in LAs corresponding to selected competencies in the third level of domain representation (sections 4 and 5). The choice of LAs will be guided by the best match between a *template*'s descriptive information and a user profile.

Concerning self-regulated learning, the models are also able to meet learners' needs with respect to competencies (e.g., to learn proving statements). In this case, from among the available LAs, the platform selects the ones that best match the needs expressed by learners and, at the same time, that refer to concepts (in an ontology) already present in their cognitive states. In any event, a pre-test on such concepts can be done and a tailored UoL can be offered to each learner in order to bridge the gap if necessary.

## 7. Costs, benefits and feedback

In traditional teaching, teachers are, at one and the same time, the authors, tutors and evaluators of their courses. In an e-learning environment, we can explicitly distinguish the roles of author and tutor. Authors are collective subjects possessing all the skills required for the preparation of teaching materials in a digital context; they are not only experts with competencies in general and discipline-specific education, but also professionals with technical capabilities in ICTs, management and pedagogy. Tutors can be human or artificial agents to give students the right scaffolding needed to reach the desired educational goals. Teachers can assume one or more roles, including that of author, according to their expertise. For instance, in the case of our courses at the University of Salerno, teachers act as domain experts in Geometry or Calculus and have designed the related ontologies (by means of a user-friendly graphical tool, shown in Figure 2). They have also designed various LOs (from hypermedia to structured video and dynamic exercises with *Mathematica*[2]) and supervised their implementation by suitable technical staff.

While the work of an author in an e-learning context may seem tougher (since it also requires technical capabilities) than that of a teacher in traditional lectures, there are some considerable advantages, including:

2. www.wolfram.com

- Reusability: ontologies, LOs and *templates* constitute a repository available to all authors using the platform (not only to the owner).
- Continuous enrichment of the learning pool: this is a direct consequence of the previous item, as every teacher can take advantage of the others' work, thus benefitting from the chance to use much more material than they are individually capable of producing.
- Support for diversity in students' learning methods: the personalisation of teaching is not possible at undergraduate level, especially with large classes of freshers, but blended courses that combine face-to-face classes and distance mathematics instruction/learning can bridge the gap.
- Automatic learning tracking data: for both individuals and groups. Their analysis provides a great deal of information at the domain level (e.g., topics with intrinsic difficulty) and at learning level (e.g., basic shortcomings) so that adjustments can be made in the design/implementation of LOs and LAs.

Regarding students, we can make some considerations on the basis of our experience at the University of Salerno. Over the last few years, some mathematics courses at the University of Salerno have been IWT supported. Traditional classes have been supported by distance instruction, consisting of tailored UoLs (section 3.2) and teacher-driven cooperative or individual learning activities (whose formalisation, and the generalisation of the latter, has given rise to the model in section 5). Apart from the grades obtained in exams, we submitted questionnaires to students engaged in blended classes in order to investigate outcomes concerning meta-cognitive and non-cognitive levels. We essentially found that LAs have fostered a change in their working methods: going into depth as a standard practice, broadening perspectives, changing attitudes towards learning, focusing on relevant activities, organizing homework timetables and giving continuity to their work. Besides changing their working methods, they begin to grasp mathematical meanings and improve their ways to tackle problems, which were our main goals. Then their attitudes towards mathematics change (even those of individuals who are not usually successful at mathematics), thus initiating a productive learning process.

## 8. Future trends

We plan to continue our research on the knowledge-skill-competency model. Implementation on a platform requires details to be investigated, and integration with IWT algorithms for the automatic generation of personalised UoLs poses new open problems, such as:

- Investigation into tools useful for instructional treatment: it would be very interesting to have the chance to choose, at run-time, LOs involved in LAs, taking account of the assigned metadata.
- Investigation into the possibilities of LA interconnection with UoLs needed as prerequisites.

- Definition of competency assessment procedures according to the requirements of PISA (OECD, 2009), both in closed and open form (Albano, 2011b; Albano et al., 2008).
- Integration of the outcomes of competency open assessment to automatically update the UoLs and choose subsequent LAs.

## 9. Conclusions

In the context of mathematics e-learning, in this paper we have focused on competency learning. Assuming that competencies develop from learners' engagement in LAs, we have proposed a model apt to generate learning experiences, which can be further tailored to individual learners according to their user profiles. This model supplements the knowledge and skill models based on multi-graphs. All three models interact in order to generate a knowledge-skill-competencies model capable of creating and delivering personalised UoLs consisting of collections of LOs or LAs. The IWT platform has been used to validate the models in undergraduate courses. The outcomes show that students improve their ways of tackling mathematics problems or studying, while changing their attitudes towards mathematics.

## References

ALBANO, G. (2011a). "Knowledge, Skills, Competencies: a Model for Mathematics E-Learning". In: R. Kwan; C. McNaught; P. Tsang; F. L. Wang; K. C. Li (eds). *Enhancing Learning Through Technology: International Conference, ICT 2011, Hong Kong, July 11-13. Proceedings (Communications in Computer and Information Science)*. CCIS 177. ISBN: 978-3-642-22382-2. Springer Heidelberg. Pages 214-225.

ALBANO, G. (2011b). "Mathematics education: teaching and learning opportunities in blended learning". In: A. Juan; A. Huertas; S. Trenholm; C. Steegmann (eds). *Teaching Mathematics Online: Emergent Technologies and Methodologies* [in press].

ALBANO, G.; FERRARI, P. L. (2008). "Integrating technology and research in mathematics education: the case of e-learning". In: F. J. García-Peñalvo (ed.): *Advances in E-Learning: Experiences and Methodologies*. IGI Global. Pages 132-148.

ALBANO, G.; GAETA, M.; RITROVATO, P. (2007). "IWT: an innovative solution for AGS e-Learning model". *International Journal of Knowledge and Learning*. Vol. 3, No 2/3, pages 209-224.

ARZARELLO, F.; ROBUTTI, O. (2002). *Matematica*. Brescia: La Scuola.

ASIALA, M.; BROWN, A.; DEVRIES, D. [et al.] (1996). "A Framework for Research and Curriculum Development in Undergraduate Mathematics Education". *CBMS Issues in Mathematics Education*. Vol. 6.

D'AMORE, B. (2000) "La complessità dell'educazione e della costruzione dei saperi". *Riforma e didattica*. No 4, pages 35-40.

GAETA, M.; ORCIUOLI, F.; RITROVATO, P. (2009) "Advanced Ontology Management System for Personalised e-Learning". *Knowledge-Based Systems*. Special issue. Vol. 22, Iss. 4, pages 292-301.

GODINO, J. (2002). "Competencia y comprensión matemática: ¿Qué son y cómo se consiguen?". *Uno*. Vol. 8, No 29, pages 9-19.

NISS, M. (2003). "Mathematical competencies and the learning of mathematics: The Danish KOM project". In: A. Gagatsis; S. Papastavridis (eds). *Proceedings of the 3rd Mediterranean Conference on Mathematical Education*. Athens: Hellenic Mathematical Society. Pages 115-124.

OECD (2009). *PISA 2009 Assessment Framework - Key Competencies in Reading, Mathematics and Science*. [Accessed: 28 January 2011].
<http://www.oecd.org/dataoecd/11/40/44455820.pdf>

SKEMP, R. (1976). "Relational understanding and instrumental understanding". *Mathematics Teaching*. No 77, pages 20-26.

WEINERT, F. (2001). "Concept of competence: a conceptual clarification". In: D. Rychen; L. Salgenik (eds). *Defining and electing key competencies*. Seattle, Toronto, Bern, Göttingen: Hogrefe & Huber Publishers.

WILEY, D. A. (2000). "Connecting learning objects to instructional design theory: A definition, a metaphor, and a taxonomy". In: D.A. Wiley (ed.). *The Instructional Use of Learning Objects*. [Accessed: 18 February 2010].
<http://reusability.org/read/chapters/wiley>

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Dossier "Mathematical e-learning"

ARTICLE

# Activity Theory and e-Course Design: An Experience in Discrete Mathematics for Computer Science

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## Abstract

The aim of this article is to present a distance e-learning experience of mathematics in higher education. The course is offered as a remedial program for master's degree students of Computer Science. It was designed to meet the particular needs of the students entering the master's degree program, as a response to the lack of understanding of logical language which was identified in several previous cohorts of students at CENIDET. The course addresses mathematical abilities of comprehensive functional use of logical language as a basic ability to be developed for later successful participation in the Master of Computer Science and also for later use in professional contexts of Computer Engineering. Eighteen students distributed throughout Mexico volunteered to participate under the guidance of one instructor. The techno-pedagogical design of the course is grounded on two theoretical approaches. Content-related instructional decisions are supported by different concepts of the second generation of Activity Theory. The concept of Orienting Basis of an Action was particularly useful to define the skills the students were expected to develop. Instructional decisions related to the participants' interaction are underpinned by Slavin's Team Accelerated Instruction model. We present the course structure in detail and provide some student interaction excerpts in order to illustrate their learning progress.

## Keywords

e-learning, instructional design, higher education, discrete mathematics, activity theory, mathematical abilities

# *Teoría de la actividad y diseño de cursos virtuales: la enseñanza de matemáticas discretas en Ciencias de la Computación*

## *Resumen*

*El objetivo de este estudio es presentar una experiencia de aprendizaje virtual a distancia en el ámbito de la enseñanza de las matemáticas en educación superior. El curso se ofrece como programa de apoyo para alumnos de un máster de Ciencias de la Computación y está específicamente diseñado para satisfacer las necesidades de los estudiantes que iniciaban dicho programa, particularmente la falta de comprensión del lenguaje lógico detectada en varias promociones anteriores de los alumnos del CENIDET. El curso tiene como objetivo el desarrollo de la habilidad de uso del lenguaje lógico, la cual es básica para cursar con éxito el máster de Ciencias de la Computación, así como para su posterior aplicación en contextos profesionales relacionados con la Ingeniería computacional. Dieciocho estudiantes distribuidos por todo México participaron voluntariamente en el estudio bajo la dirección de un tutor. El diseño tecnopedagógico del curso se basa en dos premisas teóricas. Las decisiones didácticas relacionadas con el contenido se fundamentan en varios conceptos derivados de la segunda generación de la Teoría de la Actividad (TA). El concepto de «base de orientación para la acción» ha sido particularmente útil para definir las habilidades que se esperaba que desarrollaran los estudiantes. Las decisiones didácticas relacionadas con la interacción de los participantes se basan en el modelo de enseñanza acelerada en equipo de Slavin. A continuación se expone detalladamente la estructura del curso y se presentan algunos extractos de la interacción de los estudiantes para ilustrar su proceso de aprendizaje.*

## *Palabras clave*

*aprendizaje virtual, diseño didáctico, educación superior, matemática discreta, teoría de la actividad, habilidades matemáticas*

# 1. Introduction

Working with formalized or semi-formalized statements is often a challenge for many students of mathematics. A typical coping strategy is to read the statements informally, avoiding mathematical formalism. Unfortunately, an important loss of mathematical knowledge happens by using this strategy. Various researchers have linked these difficulties with: i) the negation of mathematical statements (Antonini, 2001; Durand-Guerrier, 2004); ii) the translation (formalization) of natural-language statements into the formal language of First Order Logic (FOL) (Barker-Plummer, Cox, Dale & Etchemendy, 2008); and iii) the identification of the logical structure of mathematical statements (Selden & Selden, 1996).

In the field of Computer Science (CS), there have been recent proposals to include Formal Methods in the curriculum. Students are now expected to develop skills to read and write formal specifications for professional practice (Boca, Bowen & Duce, 2006). However, although many of them first encounter formalized or semi-formalized mathematics in Discrete Mathematics (DM) courses, their instructors often expect them to master FOL already. Hence, the students face difficulties in understanding and communicating new and complex concepts in their discipline with semi-formalized texts. Consequently, they need specific help to develop the skills to read mathematical texts in different settings. A good presentation of content does not suffice; therefore, remedial courses in higher education must work towards the explicit development of this ability (Merisotis & Phipps, 2000).

This paper describes the use of some elements of the second generation of Activity Theory (AT) to design an online remedial course. Particularly, the concept of Orienting Basis of an Action (OBA) was helpful to provide master's degree students with the necessary support in their learning processes. The online remedial course covers DM Preliminary Concepts (Logic, Set, Relations and Functions) for students entering a Master of CS in Mexico. In the following sections, we shall present the contextual background in detail, the theoretical assumptions and the consequences for instructional design. Some excerpts of the interactions occurring during the course will illustrate the students' learning progress.

# 2. The institutional context: mathematics teaching in Computer Science

Most DM courses offered to CS students follow a traditional model of mathematics teaching, such as: (1) concept definition; (2) theorem presentation; (3) demonstration; and (4) exercising (see Meyer, 2005, for example). Alternative courses are still the exception. Furthermore, they usually lack the theoretical underpinning of mathematical education (see, for example, Sutner, 2005).

Whether traditional or problem-based, all of these instructional proposals emphasize the accuracy of mathematical definitions. They all establish the definitions of content by means of logical language. In contrast, previous evaluation of the Mexican context (Ramírez, 1996; 2005) has repeatedly pointed to two comprehension *lacunae* among CS students: (a) translating mathematical language into natural language (and vice versa); and (b) analysing mathematical definitions. Hence, instructional programs of mathematics for CS students should address both topics. Regarding the

latter topic in particular, students need to connect different representations of one concept, such as natural language, logical language, mathematical language and pictographic language.

## 3. Theoretical background: Activity Theory

AT allows mathematics educators to address all the above-mentioned deficiencies and requirements in DM online courses. Currently, there are three generations of AT (Engeström, 2000). The concepts defined by the first generation of AT – mediation, internalization and zone of proximal development (Vygotsky, 1988) – and those proposed by the third generation – learning by expanding, shared zone of proximal development (Engeström, 1987) and situated learning (Lave & Wenger, 1991) – are well established. In contrast, the development and applications of the second generation of AT are less recognised. Our instructional experience specifically draws on the second generation of AT. One of the basic elements of this approach is the accurate definition of the activity structure, through actions and operations (Leontiev, 1984). These concepts enable the study of human activity by facilitating the characterization of the notion of ability, which is a key element in our instructional proposal, both for the design of activities and learning materials, and for the analysis of advancements in learning. In the following subsections, we shall address the instructional decisions step by step, as guided by this theoretical framework.

### 3.1. The second generation of AT and mathematics teaching in higher education

Leontiev's concept of activity was used by Tallizina (1988), and later by Hernandez (1989) and Valverde (1990), among others, to describe mathematical abilities. For Leontiev, the activity appears as a refinement of the internalization concept and is a constituent element of the psychological subject in both its cognitive (awareness) and its affective and motivational aspects (personality). The activity orients the subject in the objective reality, transforming it into a form of subjectivity. That is, an activity is not just a reaction or a series of reactions; it is a system with structure, development, transitions and internal changes. An activity system produces actions and is, in turn, realized through actions. However, the activity is irreducible to particular actions. Each activity is always linked to a motive (either material or abstract), which responds to a need. The components of human activities are the actions performed by the individuals. The action has an operational aspect (how, by what means can we achieve the objective?), defined by the objective conditions required to achieve the goal of the activity. Activities, actions and operations are dynamic: they can change their 'level' within the macrostructure of the activity under certain conditions.

The design of a learning process departs from the psychological characterization of the activity in terms of its structural components: actions and operations. The educational interpretation of these components is expressed in terms of skills, and requires the mastery of a complex system of actions for self-regulation of the activity. The process of acquiring abilities involves the systematization of

the actions they comprise. In turn, this process requires a conscious execution by the subject. The successful execution of the actions indicates the degree of skill development to perform the task. Hence, the subject must master the system of actions in order to fully develop the skill. In other words, we could argue that, for the teaching of mathematical text comprehension, it is essential to characterise the ability and identify the skills it comprises.

## 3.2. Designing the Orienting Bases of Action

The development of higher mental functions has a social origin (Vygotsky, 1988). This development happens in two separated stages: interpsychological and intrapsychological. Thus, development results from internalized actions. Galperin's Theory of the Stage-by-Stage Formation of Mental Activity (Galperin, 1969) is grounded on Vygotsky's premises and applies them to the instructional context. First, there is the stage of material activity, in which the learner needs to manipulate real objects, and embodied activity, in which the individual can handle models, diagrams and drawings, depending on the learner's age. Second, there is verbalization, when the student needs to repeat the sequence of operations aloud. By rewording, the action moves from the outside to the inside. Finally, the activity can take place at a wholly inner level, which implies thinking.

These evolutionary events can be tailored through the performance of certain guided actions. It is precisely that set of actions which will allow the student and the instructor to monitor and, if necessary, to correct each stage of assimilation. Galperin introduced the term 'orienting basis of an action' (OBA) to refer to the whole set of orienting elements by which the student is guided towards the successful execution of an action (also conceptualized as 'scaffolding' (Samaras & Gismondi, 1998).

In our study, we assume that the ability to read and understand mathematical texts comprises the following actions: (a) the translation of a mathematical statement into natural language, or vice versa; (b) the translation of the statement into the FOL language in order to reveal its structure; and (c) the

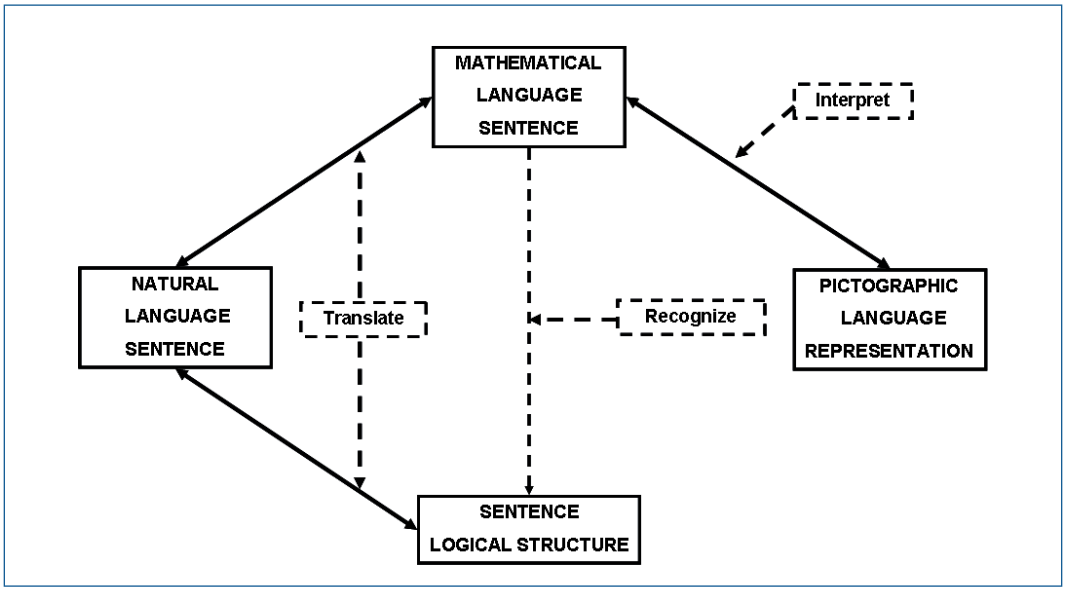



**Figure 1:** Ability system for the reading of mathematical texts.

representation of the statement in graphical language. To proceed with these steps and correctly interpret the mathematical statements, the students need to master both codes. This identification and characterization of the necessary skills for reading and comprehending mathematical texts provides a basis for designing and implementing online instructional processes (see Figure 1).

# 4. Addressing the challenges of instructional design

In line with AT, we took three axis elements for the instructional design: course objectives, contents and the scaffolds for the students (OBAs). We shall address each of these elements one by one further below. We shall then explain how these elements were implemented in a Learning Management System (LMS).

## 4.1. Course objectives

As a result of the problems identified in previous courses, we wanted the students to develop skills to identify and analyze the formal language (logical language and mathematical language itself) and thus represent mathematical concepts and their definitions. This main goal was divided into three objectives:

*Students should...*

a) Analyze and identify the FOL language in natural language.
b) Identify the mathematical language that is expressed through logical language, and the mathematical entities to which it relates.
c) Interpret definitions in mathematical language, both in formal and pictographic codes.

## 4.2. Content focus

The basic contents of DM traditional courses in higher education are *Propositional Logic, Predicate Logic, Sets, Relations and Functions*. Logic is usually taught on the basis of a deductive model of content presentation, aiming at demonstration, and using its own rules. In contrast, our course focused on the handling of FOL language and emphasized the process of translation of natural-language statements into logical and mathematical languages. The topic Reading Mathematical Texts was introduced after the Logic unit. For the translation from natural to mathematical language, students received a specific OBA.

The topics *Sets, Relations and Functions* had the following structure: first, the instructor presented a brief reading of the disciplinary area, where target mathematical concepts appeared in their usual contexts. After that, he presented the mathematical subject with standard texts. Thirdly, the students performed the exercise system for each topic, which included two main activities: (a) the analysis of definitions and (b) the use of the corresponding OBAs. Finally, the students received other additional readings of the disciplinary area, in which the target mathematical concepts appeared.

## 4.3. Orienting Bases of Action

We defined OBAs to help the students in their problem-solving processes. In this course, there were OBAs to translate statements: (a) from natural to propositional-logic language; (b) from natural to predicate language; (c) from natural to mathematical language, and vice versa. Finally, we proposed one OBA for (d) reading mathematical texts and for (e) analyzing the definition of mathematical concepts.

We offered the OBAs throughout the course, along with the material used by the students, introducing them by examples. In the unit Logic, OBAs were characterised and provided in order to develop the translation ability from natural language into FOL language. For the units *Sets, Relations and Functions*, an OBA was provided for the analysis of definitions. The following is an example of a partial implementation of an OBA for the analysis of definitions.

### 4.3.1. Example of an OBA

Initially, we offered the students step-by-step examples, performing the eight actions of the analysis: (1) differentiating between the expression of the definition in natural language and its expression in mathematical language; (2) identifying the mathematical entities in it; (3) giving examples of objects that both meet and do not meet the definition; (4) finding different ways to represent it; (5) identifying the underlying logical structure; (6) setting its negation; (7) finding the logical equivalence of the definition; and finally, (8) generalizing it.

The process presented to students as a model for using the OBA is outlined in Figures 2 and 3. In these Figures, the actions are listed in the left-hand column and possible responses are illustrated in the right-hand column.

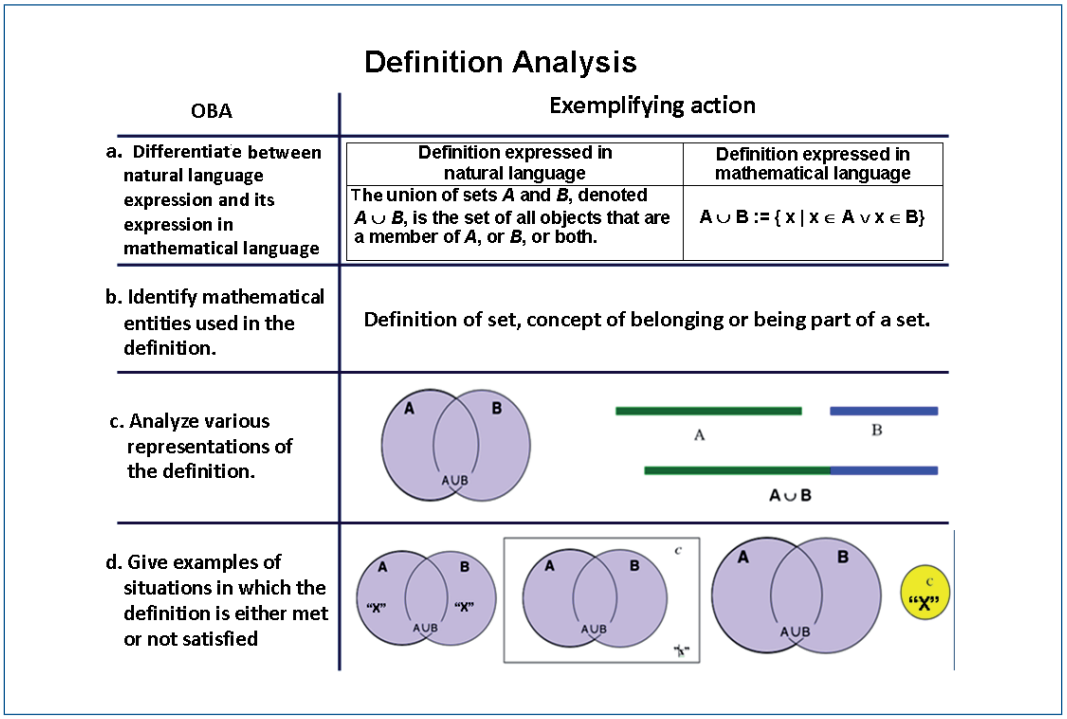



**Figure 2:** Actions #1 to #4 presented to students as an example for the analysis of a definition.

**Definition Analysis**

| OBA | Exemplifying action |
|---|---|
| e. Identify the definition's logical structure | If P(x) means that x belongs to A and Q(x) means that x belongs to B, the union definition of the logical structure of two sets is: $P(x) \vee Q(x)$. |
| f. Set the denial of the definition | From the definition's logical structure $P(x) \vee Q(x)$ we apply the logical negation $\neg(P(x) \vee Q(x))$, getting $\neg P(x) \wedge \neg Q(x)$. So the denial is $\neg(A \cup B)=\{x \mid x \notin A \wedge x \notin B\}$ |
| g. Find the logical equivalences of the definition | In this case an equivalent expression to $P(x) \vee Q(x)$ would be unnatural, we could use $\neg(\neg P(x) \wedge \neg Q(x))$. How can we read this expression in natural language? |
| h. Generalizing the definition | The union of a finite number of sets is given by "successive unions" $[((A \cup B) \cup C) \cup D) \ldots \cup W]:=\{x \mid x \in A \vee x \in B \vee x \in \ldots \vee x \in W\}$ That can be summarized $\bigcup_{\beta \in B} A_\beta = \{x \in U \mid \exists \beta \in B : x \in A_\beta\}$ |

**Figure 3:** Actions #5 to #8 presented to students as an example for the analysis of a definition.

This OBA assumes the partial development of the skills to translate statements from mathematical, pictorial and natural languages into each of the three codes. Performing the analysis of definitions provides students with fertile ground for developing the ability to read mathematical texts.

## 4.4. Techno-pedagogical design of the e-course

In e-learning, many drop-outs are caused by a lack of motivation (Juan, Huertas, Steegmann, Corcoles & Serrat, 2008); therefore, the instructional design of the courses is a key issue in the context of adult education. The term techno-pedagogical design refers to the instructional characteristics of a course as supported by technological devices (Mauri, Colomina & De Gispert, 2009). Indeed, the design of e-learning courses cannot be reduced to the traditional elements of the curriculum, i.e., objectives, content and learning activities and assessment. On the contrary, it must include a reasoned selection and planning of the technological tools that will be used throughout the course, together with a plan for the actual use of these tools and spaces by all participants. Hence, the techno-pedagogical design must include a careful planning of the interactions (instructor-students and among peers) that will be pursued throughout the course.

### 4.4.1. The LMS

For this course, we used Moodle (V.1.5.8) as the LMS. Moodle presents a flexible structure and leaves many choices open to the course designers and instructors. For example, it is possible to manage different spaces for diverse, flexible groups within the same course. This feature was particularly relevant in this course since it allowed for whole-class group interaction as well as small-group

private spaces. The course administrator/instructor takes these decisions, according to the techno-pedagogical design. Furthermore, it allows the management of the course content in individual modules. In this course, we presented each of the five topics separately, in 'week-mode', all of which had the same recursive structure to help the students assume the participation norms.

### 4.4.2. Interaction design

For the selection and planning of technological tools, it is necessary to determine the interaction among students, and between students and instructor. We adapted the collaborative technique called Team Accelerated Instruction (TAI) (Slavin, 1994) to the Virtual Learning Environment (VLE). In keeping with this technique, the students have to perform three kinds of activities. First, the students must work independently with the learning materials. They are expected to read the course materials and solve the exercises and problems. The second step is for them to work in pairs in order to share and discuss solutions and difficulties with exercises and problems. For this purpose, the students have access to both a synchronous (chat) and an asynchronous (forum) private room on the online platform. The third interaction level covers the whole group. Again, both chat and forum tools support group interaction. The use of each of these spaces and tools is regulated by means of specific participation norms. Figure 4 shows a scheme for the organization of participants and content-learning materials.

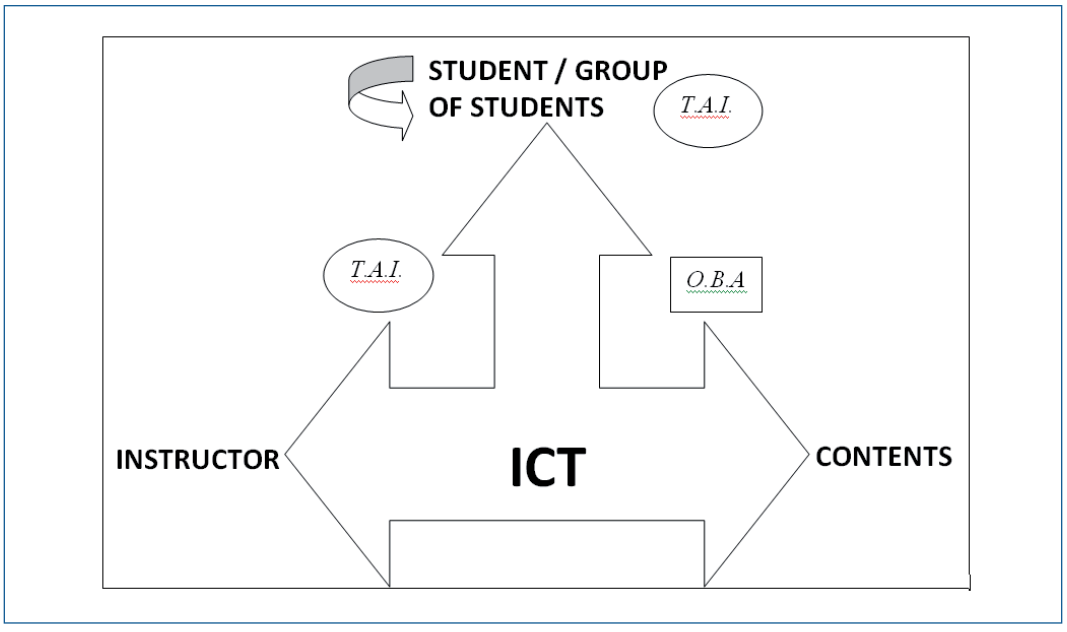



**Figure 4:** Techno-pedagogical course design.

*Student-content interaction*. Earlier editions of the course presented a technical difficulty while using chat and forum tools. The participants faced troubles when writing in logical and mathematical language. These problems had been reported previously in similar studies (Smith, Ferguson & Gupta, 2004). Thus, to facilitate mathematical communication, we added an HTML editor with a mathematical equation editor (WIRIS, V.2.1.26) to the chat device (Juárez & Ramírez, 2010). Figures 5 and 6 show the equation editor and some examples of how it can be used.

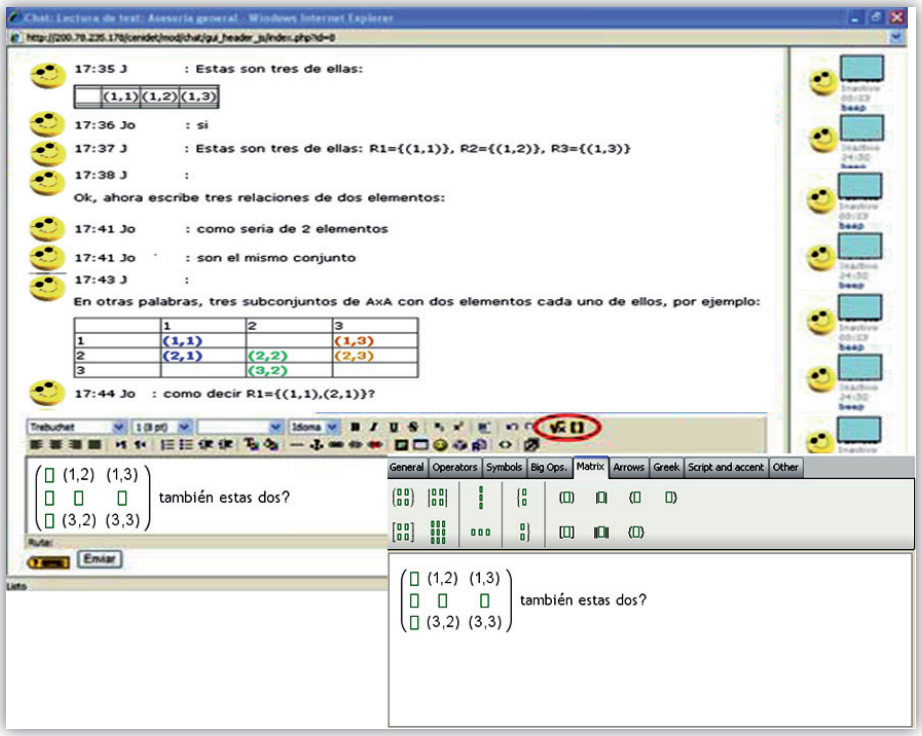



**Figure 5:** Example of the equation editor and its use in synchronous interaction.

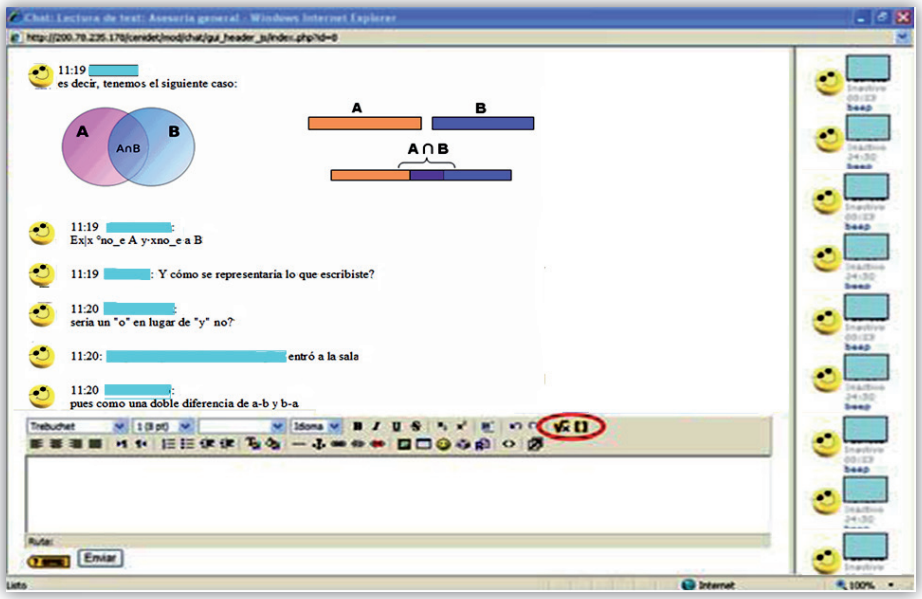



**Figure 6:** Using WIRIS for online pictorial representation.

*Student-instructor interaction*. The main area of the course had three communication spaces. First, there was a forum for small-group discussion. This forum provided an asynchronous space to facilitate continuity of discussions and feedback to students by the instructor. Second, there were two chat rooms for synchronous interaction, serving two purposes: there was a first chat room for organized whole-class discussion to resolve doubts under the instructor's guidance, and a second one for technical support.

*Student-student interaction*. Student-student interaction was designed to occur in pairs and was facilitated by means of different tools. First, there was a chat room for synchronous interaction; second, a wiki for joint resolution of mathematical problems; and third, a database to share results and reflections. Each pair of students could freely decide which tool to use. The group spaces were private to each pair of students; only the instructor could access all the small-group spaces. Hence, he was able to check or participate in the students' interaction, as would be the case in face-to-face TAI situations.

#### 4.4.3. Course structure

The course lasted five weeks, from July to August 2008. A group of 18 students voluntarily accepted to enrol on the master's degree course in CS at CENIDET. The students were CS Engineers from several states across Mexico. The instructor had experience in conventional courses on the subject; in addition, he was familiar with basic technological tools and had participated in the course design.

The course included five units (*Logic and Mathematical Language, Sets, Relations, Functions and Applications*), one per week. The students worked together in pairs, following the TAI model previously presented. If doubts remained after peer interaction, they were brought to the whole-class forum or the whole-class chat.

After each week, the students carried out a self-assessment using a feedback sheet provided by the instructor as a model of resolution. The students had to compare the model with their own resolution in order to identify deviations, strengths and weaknesses. This self-assessment was not graded. The instructor conducted weekly sessions of two hours to offer guidance and clarify doubts. He gave feedback and interacted with the students both synchronously (whole-class chat room) and asynchronously (whole-class forum). Strict turn-taking was established in order to facilitate synchronous interaction in the whole-class chat room. Each student pair had a particular interaction turn with the instructor for 20 minutes. The other participants attended the chat session as observers; they had the chance to 'listen' until the change of turn. This instructional design is presented in more detail in an earlier publication (Remesal, Juárez & Ramírez, 2011).

## 5. Results: evidence of ability development through the use of Orienting Bases of Action

In order to assess the development of the students' abilities, we performed an interpretive analysis of the following discursive aspects (Lacity & Janson, 1994; Willig, 2004):

1. The students' answers to the exercises.
2. The questions asked in the forum and chat.
3. The comments made in student-student interaction.
4. The results of the students' weekly self-assessment.

We shall now go on to present the specific results of the analysis of data sources #1 to #3, with the purpose of illustrating rather than providing an exhaustive account.

In the following sequence, we can observe an example of a student's development of abilities, that is, of her internalization process (translated from the original language, participants are quoted by pseudonyms). First, we can see how Lois begins the analysis of the definition by indicating what definition she used for inverse functions; then she indicates her doubts regarding its logical structure. She finally tells Mary how she interprets the mathematical definition in natural language. Her explanations and doubts show the acquisition of a skill to organize definitions according to the model shown in the OBA. In this asynchronous interaction, Mary's answer shows how she partially performs the definition analysis. She starts with the definition in natural language and then in mathematical language. Mary provides more elements about what she understands as the logical structure of the definition. She concludes by commenting on the types of properties that a function must satisfy in order to have an inverse function. Despite her analysis, she is unsure about the correctness of the logical structure she proposes:

[Small-group forum. Author *Lois*. 08/02 08:59]

"Hello Mary,
What definition in mathematical language did you use for an inverse function? I used the following one, but I'm not sure what its logical structure is:

$$f^{-1}:B[A \mid x = f^{-1}(y),$$

which in natural language is: a function is inverse is any rule or correspondence that allows us to get the values of

$$x \in A \text{ from the values of } y \in B$$

Do you have any other idea?"

[Small-group forum. Author *Mary*. 08/02 11:27]

"Hello Lois! Good morning,
Well, let's see if I can help you, OK? Look, my definition of natural language came out like this....
Be A in B and B in A an inverse function, if and only if the function is bijective, that is, a one to one correspondence and above the co-domain.

$$f \Leftrightarrow f^{-1}$$

in mathematical language...

It's an inverse or invertible function.

$$f = f^{-1} \text{ If,}$$
$$f: A \rightarrow B \text{ and } f^{-1}: B \rightarrow A \text{ if,}$$
$$f: A \rightarrow B\ (\forall x\, \exists y \wedge \forall y\, \exists x)$$

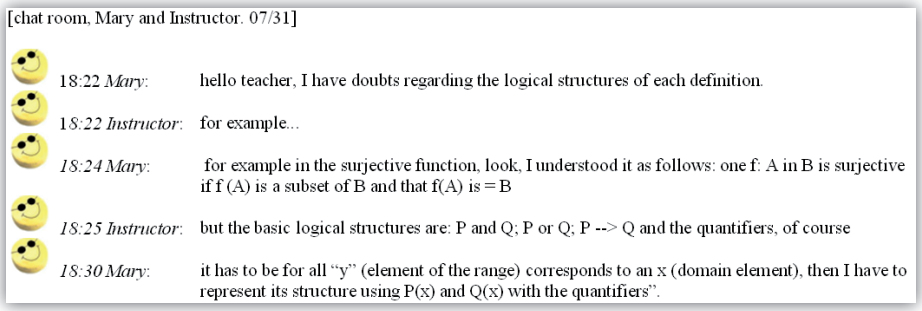
and in its logical structure, I'm not quite sure, but look at what I got…

$$P(x) \text{ ----> } Q(x) \text{ and } Q(x) \text{ ----> } P(x)$$

Well, that's what I think, look, because reading the definition, it says that in order for a function to be inverse, you first need to know that it's a function, secondly, check if it has the properties of injective and surjective in order to say that $f: A \rightarrow B$ and $f^{-1}: B \rightarrow A$.

Well, girl, I hope this was helpful,... if it wasn't, tell me and we can talk, I may be wrong and that way we can clear things up, OK?"

Through peer interaction, by sharing doubts and efforts to grasp the OBA in order to handle mathematical content in the multiple communication spaces of the course, the students proved to be progressively internalizing these abilities. In the last units of this course, most students formed definitions according to the OBA through the following actions: first, negating the function; second, translating the function from mathematical language to natural language and vice versa; third, representing the different forms of the function; and finally, representing the logical structure.


[chat room, Mary and Instructor. 07/31]

18:22 *Mary*: hello teacher, I have doubts regarding the logical structures of each definition.

18:22 *Instructor*: for example...

18:24 *Mary*: for example in the surjective function, look, I understood it as follows: one f: A in B is surjective if f (A) is a subset of B and that f(A) is = B

18:25 *Instructor*: but the basic logical structures are: P and Q; P or Q; P --> Q and the quantifiers, of course

18:30 *Mary*: it has to be for all "y" (element of the range) corresponds to an x (domain element), then I have to represent its structure using P(x) and Q(x) with the quantifiers".

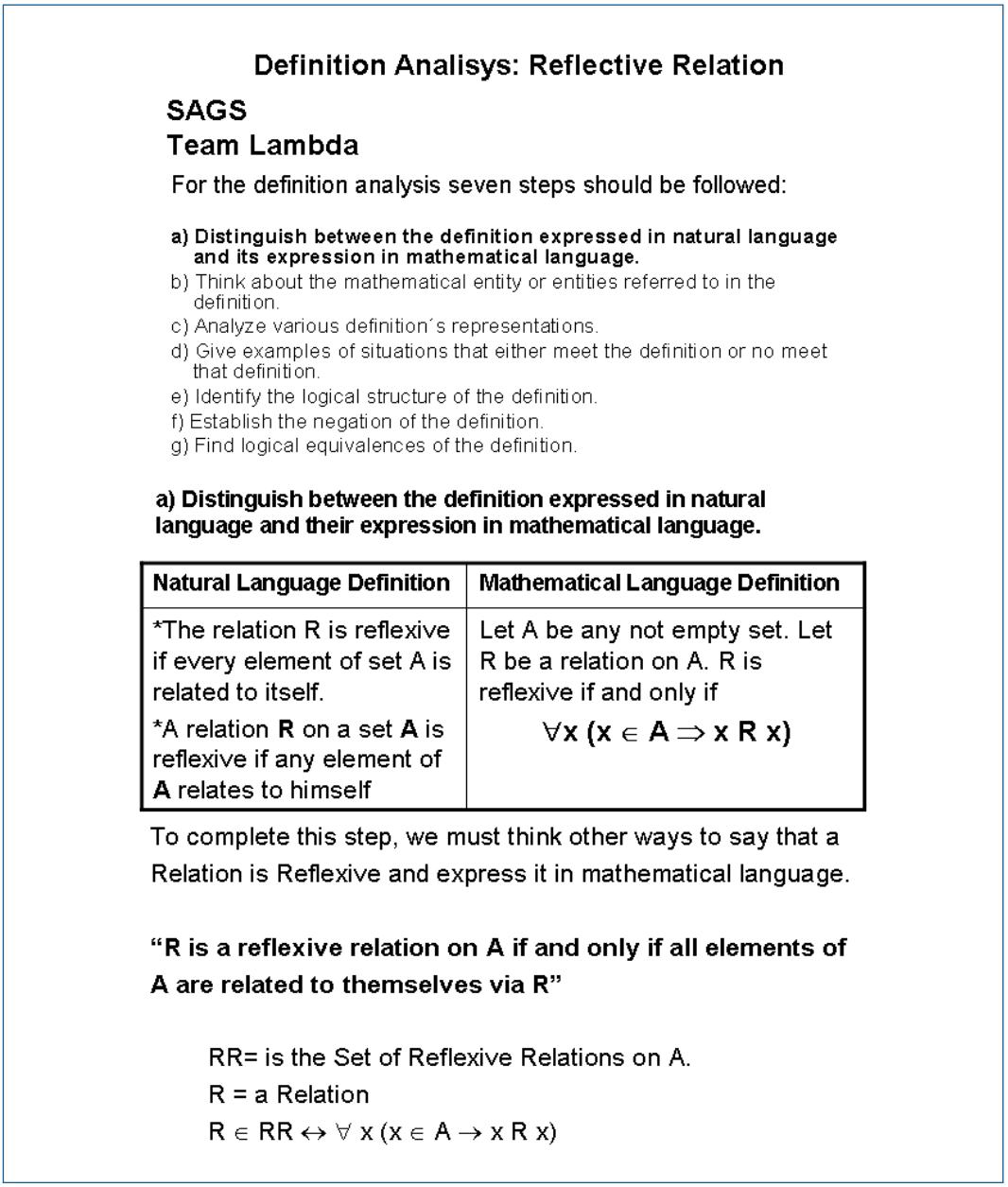
**Figure 7:** Example of first steps of OBA use in a chat session.

For instance, the following intervention by Cinthya (Figure 7) shows how she explicitly states the first step for the OBA: "First is the analysis of the definitions. Please, tell me if I'm doing OK." At certain times, the instructor intervened actively to remind the students of the actions that structured the OBAs and guided them to establish a link to the learning content. In the following sequence, for example, the student shows some early recognition of the logical structure of a statement. Thus,

the instructor intervenes to remind her of one of the scaffolding actions related to the translation of statements and the recognition of their logical structure.

After the instructor's indications on basic logical structures, Mary remembers the need to use the predicates and quantifiers. Feedback and scaffolding for solving exercises was not only provided by the instructor; at times, other students who participated in chat sessions also contributed to this assistance intervention.

In addition to the chat and forum interaction, the weekly quizzes that the students performed for each unit also informed on the skills development by means of the OBAs, For example, Figure 8 shows part of a student's answer to the first question the third weekly quiz. In this quiz, the student begins rewriting the entire OBA for definition analysis. Then he solves the exercise one step at a time.



**Definition Analisys: Reflective Relation**

**SAGS**

**Team Lambda**

For the definition analysis seven steps should be followed:

**a) Distinguish between the definition expressed in natural language and its expression in mathematical language.**
b) Think about the mathematical entity or entities referred to in the definition.
c) Analyze various definition´s representations.
d) Give examples of situations that either meet the definition or no meet that definition.
e) Identify the logical structure of the definition.
f) Establish the negation of the definition.
g) Find logical equivalences of the definition.

**a) Distinguish between the definition expressed in natural language and their expression in mathematical language.**

| Natural Language Definition | Mathematical Language Definition |
|---|---|
| *The relation R is reflexive if every element of set A is related to itself.<br>*A relation **R** on a set **A** is reflexive if any element of **A** relates to himself | Let A be any not empty set. Let R be a relation on A. R is reflexive if and only if<br>$\forall x\,(x \in A \Rightarrow x\ R\ x)$ |

To complete this step, we must think other ways to say that a Relation is Reflexive and express it in mathematical language.

**"R is a reflexive relation on A if and only if all elements of A are related to themselves via R"**

RR= is the Set of Reflexive Relations on A.
R = a Relation
$R \in RR \leftrightarrow \forall\, x\,(x \in A \rightarrow x\ R\ x)$

**Figure 8:** Using the OBA to analyze a definition.

The student's response shows the first step of the definition analysis, expressed in both natural language and mathematical language. The student began his analysis by writing the expressions in both languages in a table. He concluded this step by proposing a different way of expressing the definition in natural language and its corresponding formalization in mathematical language. The student was able to propose his own way of describing the reflexive relationship concept and formalizing it in mathematical language. These actions show how the student used the OBA, and hence, they bear witness to his mastery of the targeted skill to translate a sentence expressed in natural language into mathematical language.

## 6. Conclusions: assessment of the course design

The need for remedial courses to promote Mexican students' successful participation in the CEDINET master's degree program has been confirmed in recent decades (Ramírez, 1996; 2005). In face-to-face educational situations, the development of mathematical skills is a complex teaching and learning task. Consequently, re-locating it in the virtual context is a risky business in its own right. Particularly, the instructional design and its implementation in an LMS constitute a fundamental challenge to higher education instructors. In this course, the techno-pedagogical design allowed the participants' interaction within the system to be anticipated by promoting student-student synchronous and asynchronous interaction followed by whole-class student-instructor highly structured synchronous interaction. On the one hand, this was pedagogically enabled by the TAI model. On the other, it was technologically facilitated by the flexibility of the LMS and the incorporation of the WIRIS application.

However, and most importantly, the online instructional design presented in this article strongly suggests that the second generation of AT provides useful theoretical elements for promoting the development of the pursued abilities by means of virtual tools. Based on AT, it was possible to define the course objectives in terms of skills, knowledge and application conditions. This in turn allowed the focus to be placed on skills development, using mathematical content as a means, in contrast to traditional approaches of teaching mathematics in higher education, which often focus on content presentation.

In earlier works, we reported the positive assessment that all the participants made of the course (Remesal, 2008). After analyzing the participants' interactions on the virtual platform with regard to undertaking the translation exercises following the OBAs provided, we evaluate the course design positively with respect to three important teaching aspects. First, regarding the content sequence, starting with logical-language proficiency and moving towards an understanding of semi-formalized mathematical texts appeared to be a highly appropriate strategy to facilitate the development of the target abilities. Second, the interaction structure and norms had three positive effects: (1) they allowed the resolution of exercises; (2) they fostered the appropriation of content and the development of abilities; and (3) they encouraged social interaction between pairs of students at a distance. And third, the incorporation of specific software (WIRIS) helped the participants to overcome difficulties in handling algorithmic and pictographic codes in virtual written communication.

Nevertheless, the insufficient duration of the course poses a clear limitation for the full development of the intended abilities, since the development of skills requires gradual practice; indeed, five weeks is too short a time span. In future editions of this course, a longer term (up to eight weeks) should be considered. In addition, we are looking at three possible directions for the next research and instructional steps. First, a longitudinal study is needed to identify how students use the OBA for the analysis of definitions on the Master of CS after the remedial course. This longitudinal project would facilitate the assessment of the remedial course. Second, we intend to expand the remedial course to other related content, such as *Modal Logic* and *Dynamic Logic* of the master's degree program. Finally, audio and videoconferencing tools will be added to upcoming editions in order to establish whether interaction is enhanced through their use.

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## References

ANTONINI, S. (2001). "Negation in mathematics: obstacles emerging from an exploratory study". *Proceedings of the 25th PME Conference*. University of Utrecht. Pages 49-56.

BARKER-PLUMMER, D.; COX, R.; DALE, R.; ETCHEMENDY, J. (2008). "An empirical study of errors in translating natural language into logic". *Proceedings of the 30th Annual Meeting of the Cognitive Science Society/CogSci*. Pages 505-510.

BOCA, P.; BOWEN, J. P.; DUCE, A. (eds) (2006). *Teaching Formal Methods: Practice and Experience*. Electronic Workshops in Computing (eWiC) series. London: BCS London Office.

DURAND-GUERRIER, V. (2003). "Which notion of implication is the right one? From logical considerations to a didactic perspective". *Educational Studies in Mathematics*. Vol. 53, pages 5-34.

DURAND-GUERRIER, V.; BEN-KILANI, I. (2004). "Négation grammaticale versus négation logique dans l'apprentissage des mathématiques. Exemple dans l'enseignement secondaire Tunisien". *Les Cahiers du Français* Contemporain. Vol. 9, pages 29-55.

ENGESTRÖM, Y. (1987). *Learning by expanding: An activity-theoretical approach to developmental research*. Helsinki: Orienta-Konsultit Oy.

ENGESTRÖM, Y. (2000). "Activity theory and the social construction of knowledge: A story of four umpires". *Organization*. Vol. 7, No 2, pages 301-310.

GALPERIN, Y. (1969). "Stages in the development of mental acts". In: COLE, M.; MALTZMAN, I. (eds). *A handbook of contemporary Soviet psychology*. New York: Basic Books. Pages 249–273.

JUAN, A. A.; HUERTAS, A.; STEEGMANN, C.; CORCOLES, C.; SERRAT, C. (2008). "Mathematical e-learning: state of the art and experiences at the Open University of Catalonia". *International Journal of Mathematical Education in Science and Technology*. Vol. 39, No 4, pages 455-471.

JUÁREZ, M.; RAMÍREZ, J. L. (2010). "Colaborar para aprender y enseñar matemáticas online". *Didac*. Nos 56-57, pages 71-75.

JUNGK, W. (1981). *Conferencias sobre la enseñanza de la matemática*. Havana: Ministerio de Educación.

LAVE, J. & WENGER, E. (1991). *Situated Learning: legitimate peripheral participation*. Cambridge: Cambridge University Press.

LACITY, M. C.; JANSON, M. A. (1994). "Understanding qualitative data. A framework for text analysis methods". *Journal of Management Information Systems*. Vol. 11, No 2, pages 137-155.

LEONTIEV, A. N. (1984). *Actividad, Conciencia y Personalidad*. Mexico: Cartago.

MAURI, T.; COLOMINA, R.; DE GISPERT, I. (2009). "Diseño de propuestas docentes con TIC en la enseñanza superior: nuevos retos y principios de calidad desde una perspectiva socioconstructivista". *Revista de Educación*. Vol. 348, pages 377-399.

MERISOTIS, J. P.; PHIPPS, R. A. (2000). "Remedial education in colleges and universities. What's really going on?" *The Review of Higher Education*. Vol. 4, No 1, pages 67-85.

MEYER, A.; RUBINFELD, R. (2005). *Mathematics for computer science* [course notes]. *MITOPENCOURSEWARE*. Massachusetts Institute of Technology.
<http://ocw.mit.edu/OcwWeb/Electrical-Engineering-and-Computer-Science/6-042JFall-2005/CourseHome/index.htm>

RAMÍREZ, J. L. (1996). *Reporte del proyecto: "Estructuración de una metodología para la enseñanza de las matemáticas discretas para la maestría en ciencias de la computación en el CENIDET"* [internal report, course notes]. CENIDET. Departamento de Desarrollo Académico.

RAMÍREZ, J. L. (2005). *Reporte del proyecto: "Identificación de dificultades en los cursos de matemáticas de los programas de maestría del CENIDET"* [internal report]. CENIDET. Departamento de Desarrollo Académico.

REMESAL, A. (2008). *Lectura de textos semi-formalizados de matemáticas para computación. Informe técnico de evaluación* [internal report]. CENIDET/Universidad de Barcelona.

REMESAL, A.; JUÁREZ, M.; RAMÍREZ, J. L. (2011). "Technopedagogical design versus reality in an interinstitutional online remedial course" [paper]. *EARLI 2011 Education for a Global Networked Society*.
<http://aremor.wordpress.com/publications-2/>

SAMARAS, A. P.; GISMONDI, S. (1998). "Scaffolds in the field: Vygotskian interpretation in a teacher education program". *Teaching and Teacher Education*. Vol. 14, No 7, pages 715-733.

SELDEN, A.; SELDEN, J. (1996). "The role of logic in the validation of mathematical proofs". *Proceedings of The DIMACS Symposium on Teaching Logic and Reasoning in an Illogical World*. Rutgers University.

SLAVIN, R. E. (1994). *Cooperative Learning. Theory, Research, and Practice*. Boston: Allyn and Bacon.

SMITH, G. G.; FERGUSON, D.; GUPTA, S. (2004). "Diagrams and math notation in e-learning: Growing pains of a new generation". *International Journal of Mathematical Education in Science and Technology*. Vol. 35, No 1, pages 681-695.

SUTNER, K. (2005). *CDM: Teaching discrete mathematics to computer science majors.* Carnegie Mellon University.
<http://www.cs.cmu.edu/%7Esutner/papers/jeric.pdf>

TALLIZINA, N. F. (1988). *Los fundamentos de la educación superior*. Mexico: UAM-Ángeles Editores.

VALVERDE, L. (1990). *Un método para contribuir a desarrollar la habilidad fundamentar-demostrar una proposición matemática*. [Unpublished doctoral thesis]. Universidad de la Habana.

VYGOTSKY, L. S. (1988). *El desarrollo de los procesos psicológicos superiores*. Barcelona: Grijalbo.

WILLIG, C. (2004). *Introducing qualitative research in psychology. Adventures in theory and method.* Philadelphia: Open University Press.

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**Dossier "Mathematical e-learning"**

ARTICLE

# Distance Training of Mathematics Teachers: The *EarlyStatistics* Experience

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## Abstract
The affordances offered by modern Internet technologies provide new opportunities for the pre-service and in-service training of mathematics teachers, making it possible to overcome the restrictions of shrinking resources and geographical locations, and to offer, in a cost-effective and non-disruptive way, high-quality learning experiences to geographically dispersed teachers. This article focuses on how information and communication tools made available online could be exploited effectively to help improve the quality and efficiency of teacher training in statistics education. First,

it describes the main pedagogical issues and challenges underlying distance education in general, and online teacher training in particular. Then, it provides an overview of *EarlyStatistics*, an online professional development course in statistics education targeting European elementary and middle school teachers, and the main lessons learned from the pilot delivery of it. The article concludes with some instructional implications.

**Keywords**
statistics education, e-learning, blended learning, teacher training

## *Formación a distancia para profesores de matemáticas: la experiencia de EarlyStatistics*

***Resumen***
*Las potencialidades que ofrecen las modernas tecnologías de internet brindan nuevas oportunidades a la formación inicial y permanente del profesorado de matemáticas, que permiten superar las limitaciones impuestas por recursos cada vez más escasos y por la ubicación geográfica, y que para este colectivo geográficamente disperso significan el acceso a un aprendizaje de calidad, económico y compatible con el resto de actividades. Este artículo se centra en cómo aprovechar eficazmente las herramientas de comunicación e información disponibles en línea para mejorar la calidad y la eficiencia de la formación del profesorado en la educación de estadística. En primer lugar, describimos los principales problemas y retos pedagógicos de la educación a distancia en general, y de la formación de profesorado en línea en particular. A continuación, ofrecemos una visión general de EarlyStatistics, un curso virtual de desarrollo profesional para la educación estadística dirigido al profesorado de educación primaria y primeros cursos de secundaria (de 6 a 14 años), y las principales conclusiones derivadas de la edición piloto del curso. Concluyen el artículo algunas sugerencias educativas.*

***Palabras clave***
*enseñanza de estadística, aprendizaje virtual, aprendizaje mixto, formación del profesorado*

# 1. Introduction

In recent years, it has been recognized that for mathematics teacher training to become more effective in producing real changes to classroom practices, it ought to promote continuous, professional development opportunities that are cumulative and sustained over the career of a teacher (Joubert, 2009). The financial and logistic difficulties of engaging teachers in face-to-face training, as well as the need for professional development that can fit with teachers' busy schedules and can draw on powerful resources often not available locally, have encouraged the creation of online professional development programs for teachers (Dede, 2006).

This article analyses the possibilities of information and communication tools made available by modern Internet technologies to improve the quality of initial and in-service teacher training in statistics education. First, it discusses the main pedagogical issues and challenges underlying distance education in general, and online teacher training in particular. Then, it provides an overview of *EarlyStatistics*,

a European Union-funded program that has utilized distance education to offer teacher training in statistics education. The article concludes with some implications for distance teacher training.

## 2. Distance education: main pedagogical perspectives and challenges

Educational institutions at all levels, including leading research universities, are becoming increasingly involved in distance education initiatives. Online course delivery has become common in a wide variety of disciplines, including mathematics and statistics, and this expansion is likely to continue, owing to ever-greater access to the Internet and emphasis on lifelong learning.

Several advantages associated with distance education have been identified in the literature. Distance education offers flexibility and convenience, allowing learners to determine their own place, pace, time and content of study. Further, the distance option may give students the opportunity to take courses from prominent experts in their field of study (Evans, 2007). Moreover, from the viewpoint of statistics education, network-based training creates some unique opportunities for enhancing statistics instruction. The Internet offers a vast array of tools and resources that can be used for a better understanding of statistical concepts. Interactive Java-applets and virtual statistical laboratory experiments, for example, allow for the visualization of statistical ideas and hands-on simulations with a high pedagogical potential (Vermeire, 2002). Several statistics instructors mention using technological tools and resources in their online courses (e.g., Everson, 2008).

In spite of the undisputed benefits and proliferation in recent years of online programs, concerns remain about their quality, as research suggests that the effectiveness of distance education is variable and inconsistent (Evans, 2007). While most studies indicate that students taking courses with an online component have similar achievement and satisfaction levels compared to students in traditional, face-to-face classrooms (Dutton, 2005), there is growing evidence of many web-based distance-learning courses failing to meet the expectations raised.

Early attempts at Internet-based instruction assumed that setting up an attractive website with interesting online and multimedia applications was sufficient for learning to take place. It is now recognized that the level of success of a distance-learning course is determined by multiple factors. Elements in the design of a web-based course such as the content and structure of the course, the presentation of the online materials and the amount of interaction between instructors and learners – as well as among learners themselves – are important factors affecting students' learning and attitudes (Tudor, 2006). Another important criterion of the level of success of web-based statistical training is the extent to which instruction allows learners to experience the practice of statistics and to apply statistical tools in order to tackle real-life problems (Vermeire, 2002).

In addition to the general issues and considerations regarding distance education in statistics, the distance training of statistics teachers poses special challenges. For example, one of the main challenges for developers of online teacher training programs is how best to take advantage of the variety social networking tools and technologies now available in order to foster the creation of online

communities of teaching practitioners as vehicles for teacher learning and development. Research studies in this area indicate that online communities of practice are indeed a promising model for both pre-service and in-service mathematics teacher training (e.g., Cady, 2009). They have enormous potential to support the professional development of teachers by placing educators at the center of their learning, thus promoting their independence and self-directed learning. Online communities of practice facilitate not only communication, but also the collaborative finding, shaping and sharing of knowledge. At the same time, existing research highlights several difficulties in building and maintaining online communities involving shared professional learning.

Despite the early enthusiasm and encouragement of participants, many online communities of practice fail to thrive (Riverin, 2007). For example, after examining 28 studies, Zhao (2001) reported that there was little conclusive evidence to demonstrate the effective use of reflective online communities of practice. Other studies (e.g., McGraw, 2007) raise several issues that consistently create challenges for community building among participating teachers and for sustainability, including barriers to access, usability, sociability, lack of time to spend in online discussions, and language. In statistics education, while it is well-documented in the literature that incorporating discussion and active learning into the statistics classroom can help students learn to think and reason about statistical concepts, it has proved challenging to bring these important learning approaches to an online course (Everson, 2008).

Gould (2005), in their first offering of INSPIRE, a distance education professional development course targeting new secondary school statistics teachers in the U.S., which had community building as one of its main objectives, experienced disappointment, with a much lower than anticipated level of student-student interaction. A more successful example of a program adopting a community-building approach to the distance training of statistics teachers is Becoming a Teacher of Statistics, an online graduate-level course offered by the University of Minnesota that prepares teachers of introductory statistics at college and high school levels (Garfield, 2009). While originally delivered in a face-to-face setting, the course was subsequently converted into an online course to make it accessible to a wider variety of pre-service and in-service teachers. The first online version of the course was offered in spring 2008, with very encouraging outcomes. Evaluation of the course indicated that it was equally successful, and it provided students with parallel experiences to those in the face-to-face class.

## 3. Experiences of distance teacher training in Europe

In modern, information-based society, statistical concepts are occupying an increasingly important role in mathematics curricula across Europe. The subject, however, has been introduced into mainstream mathematics curricula without adequate attention being paid to teachers' professional development. There is substantial evidence of poor understanding and insufficient preparation to teach statistical concepts among many pre-service and practicing teachers (e.g., Espinel, 2008).

In this section, we provide a brief description of the main experiences gained from implementing the European Union-funded program *EarlyStatistics:* Enhancing the Teaching and Learning of Early Statistical Reasoning in European Schools (226573-CP-1-2005-1-CY-COMENIUS-C21). *EarlyStatistics*

has exploited the affordances offered by Open and Distance Learning (ODL) technologies to improve the quality of statistics instruction offered in European schools. The project consortium, comprising five higher education institutions in four countries (Cyprus, Greece, Norway and Spain) developed, pilot tested and is currently offering an online professional development course targeting elementary and middle school mathematics teachers across Europe. The course, which is the first of its kind in Europe, aims to help teachers improve their pedagogical and content knowledge of statistics through exposure to innovative learning methodologies and resources, and cross-cultural exchange of experiences and ideas.

Before being offered to the European educational community, the *EarlyStatistics* course and its accompanying resources were pilot tested locally in three of the partner countries (Cyprus, Greece and Spain). Fourteen teachers participated in the pilot delivery. In order to evaluate the applicability and success of the course, there was also follow-up classroom experimentation. Participating teachers developed and delivered teaching episodes integrating the use of the course tools and resources provided to them. The course was revised based on feedback received from the pilot delivery, and then entered into the European Union Lifelong Learning Training Database for European-wide recruitment. It is offered to the European educational community as a Comenius in-service training course targeting elementary and middle school mathematics teachers. The course has already been offered twice. The consortium intends to continue offering the course in subsequent years, thus facilitating access to larger numbers of mathematics teachers involved in statistics education.

Presented below are an overview of the *EarlyStatistics* course design and a synopsis of the main findings from the pilot delivery of the course.

## Design of the *EarlyStatistics* course

### *EarlyStatistics* course content and structure

The *EarlyStatistics* course design focuses on participatory and collaborative learning. Teachers enhance their knowledge about statistics and its pedagogy through hands-on and computer-based practice, experimentation, intensive use of simulations and visualizations, feedback from one another and reflection. Then, being actual practitioners, they apply what they learn to a real classroom setting.

The *EarlyStatistics* course lasts for 13 weeks and is made up of six Modules. In Modules 1-3 (Weeks 1-6), the focus is on enriching the participants' statistical content and pedagogical knowledge by exposing them to similar kinds of learning situations, technologies and curricula to those they should employ in their own classrooms. The conceptual "Framework for Teaching Statistics within the K-12 Mathematics Curriculum" (Franklin, 2007), has been used to structure the presentation of content. Statistics is presented as an investigative process that involves four components: (i) clarifying the problem at hand and formulating questions that can be answered with data; (ii) designing and employing a plan to collect appropriate data; (iii) selecting appropriate graphical or numerical methods to analyze the data; and (iv) interpreting the results. In order to help teachers go beyond procedural memorization and acquire a well-organized body of knowledge, the course emphasizes

and revisits a set of core statistical ideas. Through their participation in authentic educational activities such as projects, experiments, computer explorations with real and simulated data, group work and discussions, participating teachers learn where and how the "big ideas" of statistics apply, and develop a variety of methodologies and resources for their effective instruction.

In Modules 4-6 (Weeks 7-13), the focus shifts to classroom implementation issues. Teachers customize and expand upon provided materials, and apply them in their own classrooms with the support of the design team. Once the teaching experiment is completed, they report on their experiences to the other teachers in their group, and also provide video-recorded teaching episodes and samples of their students' work for group reflection and evaluation.

Each module involves a range of activities, readings and contributions to discussion, as well as the completion of group and/or individual assignments. Both the dialogue and the assignments are structured so as to explicitly establish links between theory and practice. Reflective questions create situations for the participating teachers to critically examine the subject matter and to make new connections between theory and their personal and professional experiences. The Marijuana Survey task presented in Figure 1, taken from Watson (2010), is indicative of the activities in which teachers engage during the course.

Look carefully at this task:

**Decriminalise drug use: poll**

SOME 96 percent of callers to youth radio station Triple J have said marijuana use should be decriminalised in Australia.
The phone-in listener poll, which closed yesterday, showed 9924 - out of the 10,000-plus callers - favoured decriminalisation, the station said.
Only 389 believed possession of the drug should remain a criminal offence.
Many callers stressed they did not smoke marijuana but still believed in decriminalising its use, a Triple J statement said.

*Is the sample reported here a reliable way of finding out public support for the decriminalisation of marijuana? Why or why not?*

1. What are the big statistical ideas in this problem?
2. Please can you give an example of an appropriate response and an inappropriate response that your students might give?
3. What opportunities would this problem provide for your teaching?
4. A student gave this answer: *"Yes, because 10000 people is enough to get an accurate average of the view of the public"*. How would you move this student's understanding forward?
5. A student gave this answer: *"No, because it is not everyone in Australia voting"*. How would you move this student's understanding forward?
6. A student gave this answer: *"No, because some people could be lying"*. How would you move this student's understanding forward?

**Figure 1:** The Marijuana Survey task (Watson, 2010)

The course activities encourage critical reflection on workplace practice and productive interaction among course participants. Members of the *EarlyStatistics* consortium with expertise in statistics education act as facilitators of a deeper learning experience by guiding discussions, encouraging the full, thoughtful involvement of all participants and providing feedback.

## Media and technology choices

The *EarlyStatistics* pilot course is delivered using a blended-learning method. At the beginning of the course, there is a face-to-face meeting with all participants. Teachers from all over Europe gather together to attend a one-week-long intensive seminar (they can finance their expenses by applying for an in-service training grant). They are first introduced to the objectives and pedagogical framework underpinning the course. They then become familiarized with the facilities offered by the e-learning environment and, more importantly, they get the chance to meet and interact with one another.

The remainder of the course is delivered online, through text, illustrations, animations, audio/video and technology-rich interactive problem-solving activities. The instructional content and services of the project's dedicated information base are used for teaching, support and coordination purposes. In addition to the course content, the site (http://www.earlystatistics.net/) offers access to various other links and resources:

- *Technologically enhanced instructional materials* for statistics teaching and learning.
- *A digital Video Case Library* containing segments of real teaching episodes, obtained from the classrooms of the teachers participating in the pilot delivery.
- *A database of Student Work Samples* developed through contributions made by the participating teachers.
- *Collaboration tools* for professional dialogue and support, including email, conferencing, chat rooms, discussion forums, wikis, etc.
- *Archived forum discussions*.
- *Reports and articles* arising from the project.
- *Links to statistics education resources* available on the Internet.
- *Multilingual interfaces* (English, Greek and Spanish) to partly overcome language barriers.

In order to offer teachers flexibility and to accommodate different time zones, the largest portion of the course is delivered asynchronously. There is also some synchronous communication through the use of technologies such as audio/video streaming and videoconferencing.

Central to the course design is the functional integration of technology and core curricular ideas, and specifically the integration of statistics educational software (the dynamic software Tinkerplots© and Fathom©) and a variety of online activities and resources (e.g., simulations, animations, video clips, etc.). The aim of the latter is to stimulate and engage teachers while providing them with the opportunity to model and investigate real-world statistics-related problems.

## Evaluation of *EarlyStatistics*

In *EarlyStatistics*, evaluation was an integral part of the project design. It was a process carried out at every stage of project development in order to ensure that all key activities were performed on time and effectively, and that any necessary revisions or improvements to the project's methodologies, products and outcomes were identified in a timely manner. It included both formative and summative assessment tools, protocols and services, and was conducted both internally and externally. The main external evaluation took place during the pilot delivery of the course and the follow-up classroom experimentation. Multiple forms of assessment were used to collect and document evidence of changes in teachers' pedagogical and content knowledge of statistics, in their attitudes towards the subject and in their teaching practices as a result of participating in the course: pre- and post-questionnaires, video-recording of classroom episodes, teacher and student interviews, samples of student work and use of statistics automatically generated by the online information base.

The overall feedback from the target user groups from all partner countries participating in the pilot delivery of the *EarlyStatistics* course, as well as from external experts in statistics education regarding the course content, services and didactical approaches was generally very positive. Key conclusions drawn from the analysis of user feedback were that *EarlyStatistics* was quite successful at helping teachers improve their pedagogical and content knowledge of statistics by offering interactive, technology-rich instructional materials and services that enhance the teaching and learning process, and also by providing course participants with the opportunity to collaborate with other teachers and thus initiate the construction of a community of practice. Moreover, data obtained from the teaching experimentations in the course participants' classrooms suggest positive gains in student learning outcomes and attitudes towards statistics (for more details see Chadjipadelis, 2008).

In the survey administered on completion of the pilot delivery of the course and the follow-up interviews, teachers were asked to indicate "what they liked the most about the *EarlyStatistics* course". The flexibility and convenience associated with distance education was an aspect of the course appreciated by all 14 course participants. They all considered the distance training nature of *EarlyStatistics* to be an advantage of the course, since it made it possible for them to determine their own place, pace and time of study: "It is a form of training that does not place stifling limits and restrictions of freedom on the teacher"; "You decide your own workload"; "You can follow your own pace of work". Further, a few teachers noted that the distance option gave them the opportunity to attend a course in statistics education offered by experts in the field originating from different European countries.

The promotion of communication and collaboration among teachers was an aspect of the *EarlyStatistics* course that was also considered by all of the course participants to be an important strength of the program. Teachers enjoyed the interaction and the sharing of experiences and ideas with the other teachers: "I liked the interaction with the other teachers. It is useful to share your ideas and problems with other teachers from different educational levels". In particular, teachers praised the fact that *EarlyStatistics* had allowed them, through computer-mediated communication, to share content, ideas and instructional strategies with teachers from different countries and educational

systems: "It is good to 'hear' colleagues from other countries that face similar problems like you and sometimes, because of a different view on a point, suggest ideas you didn't think of".

Another aspect of the *EarlyStatistics* course that was also much appreciated by teachers is the fact that the course dialogue and assignments were carefully designed to be learner-centered, and to make explicit links between theory and practice by utilizing participating teachers' own experiences as learning resources. Several of the course participants pointed out that *EarlyStatistics* offered them professional development that addressed their workplace educational needs because it was deeply contextualized in their professional activity: "It is a form of training that respects teachers' professional experience and contributes to the improvement of their educational work through the enrichment of experiences and the exchange of opinions with other teachers that work in different cultural and educational environments."

The *EarlyStatistics* project won, ex-aequo with *Maths4Stats* (a joint project coordinated by Statistics South Africa), the 2009 Best Cooperative Project Award in Statistical Literacy. This prestigious award is given every two years by the International Association of Statistics Education (IASE) "in recognition of outstanding, innovative and influential statistical literacy projects that affect a broad segment of the general public".

Despite the overall success of the pilot course, a number of shortcomings have also been identified. The biggest difficulty experienced by the consortium was in achieving the successful building of an online community of teaching practitioners, which was one of the main objectives of *EarlyStatistics*. From the outset of the project, we were well aware of the challenges in developing such a community, of the fact that merely forming a discussion group and providing the technology does not automatically lead to the establishment of relations and group cohesion (Gordon, 2007). The experience gained from pilot testing the course further alerted us to the fact that community building, particularly in a cross-national context, is very difficult. Despite the fact that we employed several strategies to promote teacher dialogue and collaboration, we experienced similar disappointment to that of Gould (2005), with a lower than expected level of online interaction among participating teachers (Meletiou-Mavrotheris, 2011).

While at the beginning of the course there was considerable enthusiasm and very high participation in the discussion forums, interaction dropped off over time. A total of 229 messages were sent to *EarlyStatistics* over the 13 weeks that the course lasted (76 messages/month on average). However, the vast majority of the messages (167 messages, 73% of all messages sent) were sent in the first six weeks of the course. In contrast to the vibrant interaction and rich dialog characterizing the earlier part of the course, towards the end of the course it was often the case that only 3-4 teachers would actively participate in the discussion forums, while the rest would make minimal or no contributions.

The analysis of the data obtained from the pilot delivery of the *EarlyStatistics* course and follow-up classroom experimentation has provided the consortium with invaluable insights regarding the course's effectiveness in delivering its stated aims. In particular, findings from the pilot delivery have allowed us to identify a number of factors that adversely affected the online participation of course participants (Meletiou-Mavrotheris, 2011). These factors informed the revision of the course to better support community building among participating teachers.

A main factor contributing to our limited success in building an online community of practice during the pilot delivery was the fact that there was no face-to-face meeting with all course participants. There were a few face-to-face meetings with local teachers, but not with the group as a whole. Course participants got the chance to virtually meet teachers from other countries through videoconferencing, but this cannot be considered as effective as face-to-face interaction. As a result, while teachers built strong local groups, their interaction with participants from other countries was limited. In current offerings of the course, teachers are recruited from across Europe, and at the start of the course there is a face-to-face meeting with all participants. This initial in-person meeting reinforces the online engagement of teachers by helping to mitigate the problem of trust and social presence online.

## 4. Conclusion

In a world where the ability to analyze, interpret and communicate information from data are skills needed for daily life and effective citizenship, developing a statistically literate society has become a key factor in achieving the objective of an educated citizenry. Recognizing teachers' ongoing professional development and learning as a linchpin of instructional innovation and success for their students (Ginsberg, 2003), *EarlyStatistics* has exploited the affordances offered by open- and distance-learning technologies to help improve the quality of statistics instruction in European schools. The project consortium has incorporated into the course design best pedagogical practices in statistics education, adult education and distance learning. The course is based on current pedagogical methodologies utilizing collaboration, statistical investigation and exploration with online interactive problem-solving activities. Particular care has been taken to build on participating teachers' knowledge and experiences, and to promote collaborative and participatory learning. Teachers from different countries have the opportunity to improve their content and pedagogical knowledge of statistics through open-ended investigations, simulations, visualizations, collaboration and reflection on their own and on others' ideas and experience.

The *EarlyStatistics* project outputs and services are useful not only to teachers, but also to academic experts in statistics education, to teacher training institutions and to designers of online professional development programs across Europe and internationally. Academic experts and material developers can become more sensitized to the needs of statistics teachers in different countries, supporting the development of new professional development methodologies and materials grounded on a community-building model. Teacher training institutions can gain a clearer understanding of the issues facing statistics teaching and learning, and can use the project outputs for further improvement of their teacher training programs.

A particularly important issue in the online professional development of teachers is ensuring the successful building of an online community of practice. The first experiences with *EarlyStatistics* concur with the research literature, indicating that the successful building of an online community of practice is very challenging. As Gould and Peck (2005) have pointed out, leading a discussion of substance on

a discussion board is more challenging than in a real classroom. For Kling (2003), the transformation of a group into a community is "a major accomplishment requiring special processes and practices" (p. 221). An online community of practice will not automatically take shape through the availability of an online space. Rather, it requires carefully crafted designs – both technical and social (Rourke, 2007).

Teaching online courses is a new, unexplored territory for most statistics instructors. Online instruction is similar yet different from face-to-face learning, and requires new teaching skills and strategies. Online instructors' new role as course facilitators turns them into both guides and learners (Heuer, 2004). In order to facilitate student success and to foster online participation, they must be trained in this new mode of instruction while developing the art of becoming online guides. Online courses should also be subject to continuous evaluation and enhancement. Garfield (2009), whose distance teacher training course has been quite successful in achieving learner participation and collaboration, explain that their online courses are subject to an ongoing cycle of evaluation and improvement. Each time an online course is taught, changes are made to the way in which discussion assignments are structured and used, based on feedback received from students and on careful examination of the patterns of interaction occurring within different discussion groups. *EarlyStatistics* has also adopted an iterative model of continuous improvement. Evaluation continues to play a pivotal role in each subsequent offering of the course. This allows us to continuously improve the quality and effectiveness of *EarlyStatistics*, which is the first online professional development course in the area of statistics education at the European level.

## References

CADY, J.: REARDEN, K. (2009). "Delivering online professional development in mathematics to rural educators". *Journal of Technology and Teacher Education*. Vol. 17, pages 281-298.

CHADJIPADELIS, T.; ANDREADIS, I. (2008). *EarlyStatistics Evaluation Report* [internal document]. Project: 226573-CP-1-2005.

DEDE, C. [et al.]. (2006). *Research Agenda for Online Teacher Professional Development*. Cambridge, MA: Harvard Graduate School of Education.

DUTTON, J.; DUTTON, M. (2005). "Characteristics and performance of students in an online section of business statistics". *Journal of Statistics Education*. Vol. 13, No 3.

ESPINEL, C.; BRUNO, A.; PLASENCIA, I. (2008). "Statistical graphs in the training of teachers". In: C. Batanero; G. Burrill; R. Reading; A. Rossman. (2008). *Proceedings of the Joint ICMI/IASE Study Teaching Statistics in School Mathematics. Challenges for Teaching and Teacher Education*. [CD-ROM]. Monterrey, Mexico: ICMI & IASE.

EVANS, S. R. [et al.]. (2007). "Evaluation of Distance Learning in an Introduction to Biostatistics Course". *Statistical Education Research Journal*. Vol. 6, No 2, pages 59-77.

EVERSON, M. G.; GARFIELD, J. (2008). "An innovative approach to teaching online statistics courses" [online document]. *Technology Innovations in Statistics Education*. Vol. 2, No 1. [Accessed: 30 July 2011]. <http://repositories.cdlib.org/uclastat/cts/tise/>

FRANKLIN, C. A. [et al.]. (2007). *Guidelines for Assessment and Instruction in Statistics Education (GAISE) report: A pre-K-12 Curriculum Framework*. Alexandria, VA: American Statistical Association.

GINSBERG, M. B. (2003). *Motivation matters: A workbook for school change*. San Francisco: Jossey-Bass.

GORDON, S.; PETOCZ, P.; REID, A. (2007). "Tools, artefacts, resources and pedagogy – stories of international statistics educators" [online document]. In: P. L. Jeffery (comp.). *Australian Association for Research in Education 2006 Conference Papers*. AARE. [Accessed: 30 July 2011]. <http://www.aare.edu.au/06pap/gor06358.pdf>

GOULD, R.; PECK, R. (2005). "Inspiring Secondary Statistics" [online document]. *MSOR Connections*. Vol. 5, No 3. [Accessed: 30 July 2011]. <http://mathstore.ac.uk/headocs/53inspiringstats.pdf>

HEUER, B. P.; KING, K. P. (2004). "Leading the Band: The Role of the Instructor in Online Learning for Educators" [online document]. *The Journal of Interactive Online Learning*. Vol. 3, No 1. [Accessed: 30 July 2011]. <http://www.ncolr.org/jiol/issues/PDF/3.1.5.pdf>

JOUBERT, M.; SURTHERLAND, R. (2009). *A perspective on the literature: CPD for teachers of mathematics*. University of Bristol: National Centre for Excellence in Teaching Mathematics.

KLING, R.; COURTRIGHT, C. (2003). "Group Behavior and Learning in Electronic Forums: A Sociotechnical Approach". *Information Society*. Vol. 19, pages 221-235.

MCGRAW, R.; LYNCH, K.; KOC, Y. (2007). "The multimedia case as a tool for professional development: An analysis of online and face-to-face interaction among mathematics pre-service teachers, in-service teachers, mathematicians, and mathematics teacher educators". *Journal of Mathematics Teacher Education*. Vol. 10, No 2, pages 95-121.

MELETIOU-MAVROTHERIS, M. (2011). "Online Communities of Practice as Vehicles for Teacher Professional Development". In: A. Juan; M. A. Huertas; S. Trenholm; C. Steegmann (eds). *Teaching Mathematics Online: Emergent Technologies and Methodologies*. IGI Global. Pages 142-166.

MELETIOU-MAVROTHERIS, M.; SERRADÓ, A. (2011). "Distance Education of Statistics Teachers". In: C. Batanero; G. Burrill; C. Reading (eds). *Teaching Statistics in School Mathematics-Challenges for Teaching and Teacher Education: A Joint ICMI/IASE Study: The 18th ICMI Study*. DOI 10.1007/978-94-007-1131-0_36. Springer Dordrecht Heidelberg London New York. Pages 383-394.

RIVERIN S.; STACEY, E. (2007). "The Evolution of an Online Community – A Case Study". *Research and Practice in Technology Enhanced Learning*. Vol. 2, No 3, pages 267-297.

ROURKE, L.; KANUKA, H. (2007). "Barriers to Online Critical Discourse". *International Journal of Computer-Supported Collaborative Learning*. Vol. 2, No 1, pages 105-126.

TUDOR, G. (2006). "Teaching Introductory Statistics Online – Satisfying the Students". *Journal of Statistics Education*. Vol. 14, No 1.

VERMEIRE, L.; CARBONEZ, A.; DARIUS, P.; FRESEN, J. (2002). "Just-in-time Network Based Statistical Learning: Tools Development and Implementation". In: B. Phillips (ed.), *Proceedings of the Sixth International Conference on Teaching Statistics (ICOTS6)*. Cape Town, South Africa: IASE.

WATSON, J. M.; NATHAN, E. L. (2010). "Biased Sampling and PCK: The Case of the Marijuana Problem". In: L. Sparrow; B. Kissane; C. Hurst (eds). *Shaping the future of mathematics education: Proceedings of the 33rd Annual Conference of the Mathematics Education Research Group of Australasia*. Fremantle: MERGA.

ZHAO, Y.; ROP, S. (2001). *A critical review of the literature on electronic networks as reflective discourse communities for inservice teachers* [online document]. [Accessed: 30 July 2011]. <http://www.ciera.org/library/reports/inquiry-3/3-014/3-014.pdf>

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**Dossier "Mathematical e-learning"**

ARTICLE

# On How Moodle Quizzes Can Contribute to the Formative e-Assessment of First-Year Engineering Students in Mathematics Courses

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## Abstract

Given the importance of formative assessment in the context of the European Higher Education Area, it is necessary to explore new tools to implement innovative strategies for the formative assessment of students. Moodle's quiz module represents an alternative to traditional tools, such as paper-and-pencil tests. In 2008, we carried out a project subsidised by the Institute of Education Sciences at the Universitat Politècnica de Catalunya - BarcelonaTech (UPC), the main aim of which was to elaborate a number of Moodle question pools and to design, implement and assess a series of quizzes from these pools. The project covered the compulsory undergraduate subjects in applied mathematics included in the first- and second-year syllabuses for all branches of Engineering. From the students' results, it was then necessary to examine and revise the reliability of the quizzes as an assessment tool of the teaching and learning process. The analysis of the psychometric coefficients provided by Moodle proved to be a useful tool for assessing whether the questions had an appropriate level of difficulty and were suitable for discriminating between good and bad performers. Taking into account the psychometric analysis of this first project, in 2009 we initiated a new project, in which we planned to revise thoroughly the quizzes created in the former project, to improve their suitability as an assessment tool. This paper shows: i) the students' results in the quizzes performed in the two academic years in the courses Mathematics 1 and Mathematics 2 – both taught in the first year of the four bachelor's degree programmes in Biological Systems Engineering organised by the School of Agricultural Engineering of Barcelona at the UPC, as well as the students' attitudes towards activities of this kind; and ii) the revision and fine-tuning of the quizzes from the psychometric analysis to improve their reliability. Finally, the analysis of the results reported leads to a discussion on the advisability of using this tool for the formative assessment of students.

## Keywords

mathematics, quizzes, Moodle, assessment, psychometric analysis

# *Los cuestionarios del entorno Moodle: su contribución a la evaluación virtual formativa de los alumnos de matemáticas de primer año de las titulaciones de Ingeniería*

## *Resumen*

*En el contexto del Espacio Europeo de Educación Superior, en el que la evaluación formativa desempeña un papel esencial, es necesario explorar nuevas herramientas con el fin de implementar estrategias innovadoras de seguimiento y evaluación de los estudiantes. El módulo de cuestionarios en el entorno Moodle representa una alternativa frente a las metodologías tradicionales, como pueden ser las pruebas escritas. En el marco de las ayudas para la mejora de la docencia concedidas por el Instituto de Ciencias de la Educación de la Universidad Politécnica de Cataluña - BarcelonaTech (UPC), durante el curso académico 2008/2009 se llevó a cabo un proyecto docente cuyo objetivo principal era el diseño de preguntas tipo test y su posterior implementación en cuestionarios del entorno Moodle para asignaturas de matemáticas y estadística correspondientes a primeros cursos de titulaciones de ingeniería. Con los resultados de los cuestionarios realizados por los estudiantes, se vio que era conveniente analizar y revisar su fiabilidad y adecuación para avalar estas actividades de evaluación del proceso de aprendizaje. El análisis de los coeficientes psicométricos facilitados por Moodle resultó ser una herramienta útil a la hora de valorar si las cuestiones propuestas tenían el nivel de dificultad adecuado y si, en consecuencia, eran convenientes para discriminar entre buenas y malas prácticas. En el marco de otro proyecto, también subvencionado por la UPC, durante el siguiente curso académico 2009/2010 se revisaron de forma exhaustiva los cuestionarios implementados con el fin de mejorar su eficiencia como herramienta de evaluación. En este trabajo se presentan: i) los resultados de los cuestionarios realizados por los estudiantes durante esos dos cursos académicos en las*

*asignaturas Matemáticas 1 y Matemáticas 2 de primer año de los cuatro grados de Ingeniería de Biosistemas de la Escuela Superior de Agricultura de Barcelona de la UPC, así como la opinión de los estudiantes sobre este tipo de actividad, ii) la revisión y adaptación de los cuestionarios a partir de los índices psicométricos para mejorar su eficiencia. Finalmente, a partir de los resultados analizados se hace una reflexión sobre la conveniencia de utilizar este tipo de herramientas para la evaluación formativa de los estudiantes.*

***Palabras clave***
*matemáticas, cuestionarios, Moodle, evaluación, análisis psicométrico*

# 1. Introduction

The Bologna Declaration and the implementation in 2010 of the European Higher Education Area (EHEA) brought about crucial changes both in the curriculum and in teaching-learning methodologies in university studies (ENQA, 2005). The EHEA promotes a student-centred system based on the student workload required to achieve the objectives of a programme of study. These objectives should be articulated in terms of learning outcomes to be acquired. Learning outcomes are sets of competencies, expressing what the student will know, understand or be able to do after completion of a process of learning. Competencies represent a dynamic combination of attributes, abilities and attitudes, which should correspond to specified learning outcomes. In this framework, student workload consists of the time required to complete all planned learning activities such as attending lectures, seminars, independent and private study, project preparation and examinations. The assessment of students is a cornerstone of the EHEA and is expected to "measure the achievement of the intended learning outcomes and other programme objectives" (ENQA, 2005). ENQA's guidelines for the assessment of students also include desirable procedures that should be followed in the assessment process.

According to the EHEA guidelines, it is clear that formative practices are a central component in the assessment of students. Among the aspects that lecturers must take into account when designing and developing tools for formative assessment of the teaching-learning process, we would stress the following: i) To reflect on actions before, during and after the learning process, on the part of the lecturer and the learner; ii) To include assessments for both learning outcomes and learning processes; iii) To provide feedback to improve both the teaching and the learning processes; iv) To incorporate student self-assessment and self-regulation procedures; and v) To explain and share evaluation criteria with students.

Furthermore, several studies have pointed out the increasing role of information and communication technologies (ICTs) in the field of assessment (Delgado and Oliver, 2006; Graff, 2004; Steegmann et al., 2008), to the extent that *e-assessment* has emerged as a new issue in the educational arena (Brinck and Lautenbach, 2011; Crews and Curtis, 2011; Daly et al., 2010; Ferrão, 2010). Given the importance of formative assessment in the context of the EHEA, it is fundamental

to explore new evaluation strategies to innovate assessment methods. As Ferrão (2010) points out, the system of e-assessment must have the hardware and software necessary for test generation and administration.

Most Spanish universities have adopted Moodle as a learning management system (LMS) to help educators create quality online courses and administer learner outcomes (Steegmann et al. 2008). Therefore, in this paper we focus on the quiz module provided by Moodle. This module allows for the creation of quizzes with different question types, adapted to the specific objectives to be achieved at any step in the teaching-learning process, supplying prompt, automatic feedback. A powerful tool for monitoring and diagnosing students' learning, Moodle's quiz module represents an alternative to traditional face-to-face courses and paper-based testing. Regarding the quality of the e-assessment system, Moodle's quiz module supplies statistical methods to measure the reliability of the tests (Ferrão, 2010). It has been argued that, in relation to the use of ICTs, the boundaries between formative and summative assessment become blurred (Daly et al., 2010). However, if technologies are used to carry out low-stakes assessment activities on a regular basis, they can contribute to formative assessment. Moodle quizzes not only prove suitable for carrying out such activities, but they can also be modified and adapted according to learners' needs. As discussed in Daly et al. (2010), adaptivity is a key feature of e-assessment, since feedback is used formatively by learners to adapt their conceptions and approaches to a task, and by lecturers to adapt a task to learners' needs. We are well aware that quizzes have become a widely used tool for assessment in recent years (Ferrão, 2010). However, to our knowledge, there is no detailed survey on how to make the most of psychometric coefficients to refine quizzes implemented in undergraduate mathematical courses.

This paper reports on the main outcomes of two educational projects where Moodle quizzes were used as a tool for formative e-assessment in the context of two compulsory undergraduate mathematical courses. The projects aimed:

1. To design a number of quizzes to assess regularly the topics of the two courses, with a subsequent analysis of the learners' results and their correlation with other teaching-learning activities involved in the courses, as well as to collect the students' attitudes towards e-assessment.
2. To carry out a psychometric analysis as a means of feedback on the learning activities in order to adapt them to the learners' needs and therefore to refine and improve their reliability as a tool for formative e-assessment.

## 2. Material and methods

Since 2009, the School of Agricultural Engineering of Barcelona (ESAB) at the Universitat Politècnica de Catalunya - BarcelonaTech (UPC) has offered the following bachelor's degree qualifications in Biosystems Engineering: Degree in Agricultural Engineering, Degree in Biological Systems Engineering, Degree in Agro-Environmental and Landscape Engineering, and Degree in Food Engineering. The four bachelor's degrees share a set of compulsory subjects in the first and second years, which count as six European Credit Transfer System (ECTS) credits each. Two first-year courses in mathematics,

Mathematics 1 and Mathematics 2, are included in this initial common set. It is worth noting here that the essentially biological profile of the ESAB has arguably contributed to the students' poor motivation in mathematical and statistical areas, and this has traditionally resulted in low pass rates. In order to improve the learning outcomes and to motivate the students, we decided to launch a series of low-stakes tasks as an incentive (Lim et al., 2011). Yet, if we wanted to meet the EHEA guidelines on assessment while dealing with a growing number of students, this would doubtless mean an increase in teaching staff workload. In order to carry out continuous assessment of our students without investing an excessive amount of time marking, it seemed appropriate to resort to the range of e-tools available.

In 2005, the UPC started to use Moodle, an open-source LMS that offers a wide variety of teaching tools (Cole, 2005). In order to make the most of the tools available, we started exploring Moodle's assessment facilities. In 2008/2009, we carried out a project subsidised by the Institute of Education Sciences at the UPC, the main aim of which was to design, elaborate and implement a substantial range of Moodle question pools for quizzes ("*Creació de qüestionaris des de l'entorn Moodle per a assignatures de matemàtiques i estadística corresponents a primers cursos de titulacions d'enginyeria*"). The project covered the compulsory undergraduate subjects in applied mathematics included in the first- and second-year syllabuses for all branches of Engineering. In practice, it was mainly centred on Mathematics 1 (M1) and Mathematics 2 (M2), compulsory for all students enrolled in the ESAB. In this project, we analyzed the students' answers, and carried out a psychometric analysis to identify the appropriateness of the questions asked in the quizzes. It is important to stress that a preliminary experience was carried out with a small group of students the year before the new bachelor's degree system started. This initial experience seemed to suggest that Moodle quizzes were certainly useful for the promotion of student involvement in mathematical subjects.

However, it is essential to bear in mind that the whole process should be permanently revised and updated. Therefore, carrying out an evaluation of the various experiences in Mathematics 1 and Mathematics 2 provided the research group with insights into the entire assessment process.

From those initial experiences, we planned to generate improved quizzes suitable for the mathematics courses mentioned above. The psychometric analysis provided by Moodle was a great tool for assessing whether the questions were suitable for discriminating between good and bad performers, with an appropriate level of difficulty.

Taking account of the psychometric analysis of that first project, in 2009/2010 we carried out a new project in which we planned to revise thoroughly the quizzes created in the former project in order to improve their reliability as an assessment tool ("*Revisió i millora de l'eficiència de qüestionaris MOODLE implementats en assignatures de matemàtiques i estadística corresponents a primers cursos de titulacions d'enginyeria*").

In order to supervise the students' progress at different stages of the learning process (Heck and Van Gastel, 2006), we created quizzes for different contexts, such as diagnostic and post-performance tests, computer lab sessions and chapter checking after the accomplishment of each unit of content. This contribution focuses on the set of Moodle quizzes that were designed as take-home assignments for chapter checking, to be completed within a given time frame. The topics covered by each of the

quizzes in Mathematics 1 and Mathematics 2 were aligned with the learning goals and required outcomes of the course (Tables 1 and 2). Since different kinds of questions can help to develop different skills (Smith et al., 1996; Blanco et al., 2009), the questions used in these quizzes were of several types: multiple-choice, true/false, short-answer, numerical, matching and embedded (cloze) (Table 3).

Summative assessment in both courses is carried out on the basis of a weighted formula computed as follows: two or three written tests during the semester (45%); a cumulative final written exam (40%); computer lab sessions (5%); quizzes (5%); and several homework and coursework assignments (5%). It is within this framework that the quizzes have to be considered.

Table 1. Topics covered by quizzes in Mathematics 1.

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 |
|---|---|---|---|---|---|
| Functions of a real variable | Functions of several real variables | Determinants and Systems of linear equations | Complex numbers | Optimization of functions of a real variable | Optimization of functions of several real variables |

Table 2. Topics covered by quizzes in Mathematics 2 (ODEs: Ordinary Differential Equations).

| Q1 | Q2 | Q3 | Q4 | Q5 | Q6 | Q7 | Q8 |
|---|---|---|---|---|---|---|---|
| Basic integration by substitution | | Integration by substitution | Integration by parts | Integration by partial fractions | General topics on ODEs | Separable ODEs | Homogeneous ODEs |

Table 3. Number of questions and question types corresponding to the first project (changes made in the second project in brackets).

| | Number of questions | Multiple-choice | True/False | Matching | Short-answer/ Numerical | Cloze |
|---|---|---|---|---|---|---|
| M1 | 83 | 65 (60) | 10 (18) | 3 | 5 (2) | |
| M2 | 59 | 19 | 38 | | | 2 |

## 3. Results and discussion

As an interactive and dynamic tool, Moodle quizzes have an impact on the lecturers' and students' attitudes towards computer-assisted assessment. Moreover, the fact that the number of enrolled students has been growing in recent years means that we have to apply the EHEA guidelines (ENQA 2005) to groups of 60 students or more. Hence, the automatic assessment offered by the quizzes can free up time for lecturers to concentrate on other aspects of the learning process (Blanco et al., 2009). As mentioned earlier, the UPC's LMS – Atenea – is based on Moodle. From the very beginning, the university's strategy has been to encourage lecturers and students to use this LMS to work towards

the learning and teaching process as understood by the EHEA. So, the use of Moodle's quiz module, as described in this paper, is a move in that direction. This section is organized as follows. The first subsection analyzes the students' results for the quizzes set in both academic years (2009/2010 and 2010/2011). The second subsection presents the main results for the psychometric analysis of the quizzes. The third and final subsection discusses the students' opinions on the quizzes.

## 3.1. Analysis of the students' results

In the context of our projects, Moodle's quiz module provided information about which questions our students got wrong or partially right, overall quiz results and individual responses. In both projects, we performed a linear regression analysis relating the score mean of the quizzes to the final mark of Mathematics 1 and Mathematics 2, computed using the above-mentioned weighted formula (Figure 1). Overall, the analysis was significant and displayed a good positive linear correlation, with the following correlation coefficients: 0.69 (p-value<0.001) for M1 in 2009/2010 (with $N_1$=91 students); 0.55 (p-value<0.001) for M2 in 2009/2010 (with $N_2$=78 students); 0.44 (p-value<0.001) for M1 in 2010/2011 (with $N_3$=176 students); and 0.67 (p-value<0.001) for M2 in 2010/2011 (with $N_4$=154 students). These results led us to conclude that Moodle quizzes can be regarded as a suitable tool to inform students of their performance throughout the learning process, in line with Ferrão (2010).

It is interesting to note that, from the data, it is possible to recognize the different strategies that the students use to pass the course. These different behaviours can explain some of the atypical or extreme observations collected over the two years in question. The year 2009/2010 was an exceptional course because there were only new students in the two courses, that is, none of them were retaking the year. In contrast, in the following year, new students and students retaking the course were mixed in the same classroom. The behaviour of the latter was noticeable; their quiz results were different from those of the former (Figure 1). Moreover, it is evident that the results for the Mathematics 2 course were better than those for the Mathematics 1 course, especially in 2009/2010. This is understandable in the following context: i) the nature of the topics of this second subject of mathematics is different from the first one, with new topics for all the students and, in some way, independent from those studied in previous mathematics courses at high school (Tables 1 and 2); ii) the students of Mathematics 2 have already gone through a previous mathematics course and have therefore learnt how to adapt successfully to the environment; and iii) the students who chose to pursue the second subject are the good students from the previous semester (that is to say, they passed Mathematics 1) or, if they were retaking the course, they may have had some advantage over the students taking the subject for the first time. This aspect becomes much more evident in the year 2010/2011, Mathematics 2, as Figure 1 shows. The four scatter plots show a higher concentration of points in the first and third quadrants. When it comes to Mathematics 2 in 2010/2011, it is true that marks are mainly concentrated in the first quadrant only. This means that most of the students who took the quizzes, passed both the quizzes and the course in general, thus providing more evidence supporting the particular nature of Mathematics 2 observed in the second academic year.

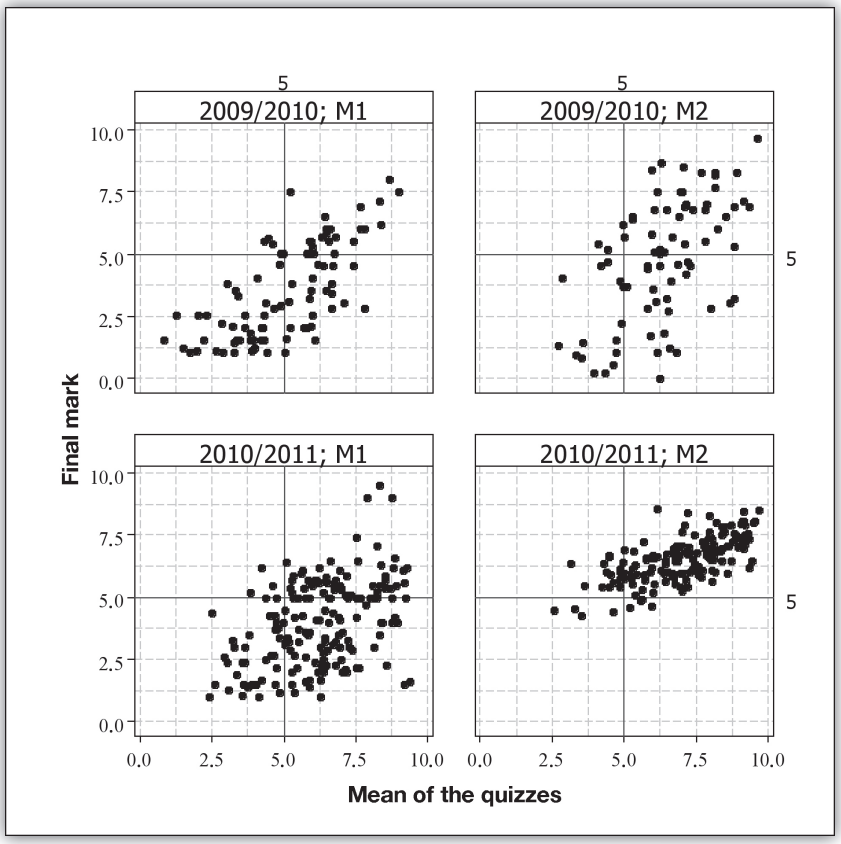


**Figure 1.** Scatter diagrams of the mean of the students' scores in the quizzes and the final mark in the two subjects (M1: Mathematics 1, and M2: Mathematics 2) in the years 2009/2010 and 2010/2011.

## 3.2. Psychometric analysis

As Ferrão (2010) argues, the e-assessment system must provide a set of tools to analyze the reliability of the tests and, consequently, to ensure the quality of the system. Psychometric analysis is a great tool for assessing whether the quizzes are a reliable instrument for measuring the students' performance, attitudes and abilities (Heck and Van Gastel, 2006). Moodle's quiz module performs the item analysis of a quiz, a particular tool associated with psychometrics. Having performed the item analysis, the module allows all the statistical reports to be exported as a spreadsheet file, rendering all the information easier to manage.

In this section, we discuss two parameters provided by the item analysis of the quizzes: the Facility Index (FI) and the Discrimination Coefficient (DC). These parameters, calculated as explained by classical test theory, can help us answer whether the questions are well chosen in order to demonstrate concepts and of an appropriate level of difficulty, and whether the questions are suitable enough to discriminate between good and bad performers. The FI describes the overall difficulty of the questions. This index represents the ratio of users that answer a question correctly. In principle, a very high or low FI suggests that a question is not useful as an instrument of measurement. The DC is a correlation coefficient between scores at the item and at the whole quiz level, ranging from -1 to +1. This is another measure of the separating power of the item to distinguish proficient from weak learners.

Although it is necessary to be cautious when relying upon item-discrimination parameters (Burton, 2001), we opted for the DC because it is associated with the Moodle tools available. In addition, since the quizzes did not contain disparate topics, as Tables 1 and 2 show, they met one of the requirements indicated by Burton (2001) for the performance of a more reliable item-discrimination analysis.

At the beginning of the first project, we decided to group the DC values into three categories: Low (DC < 0.33), Medium and High (DC > 0.66). In order to discard those questions with FI values that were either too low or too high, the boundaries were set at 15 and 85, respectively. Quizzes with just a few questions with FI values between 15 and 85 should be newly constructed, as should those with low DC values. In 2009/2010, we set ourselves the goal of revising and redesigning those quizzes with low DC values or with FI values that were either too low or too high.

When it comes to Mathematics 1, from the information provided by Moodle, only those questions with FI values that were either very low or very high should be rewritten, as should those with low DC values. In Blanco and Ginovart (2010b), there is a detailed description of how the revision of questions was tackled. Once revised, the quizzes were run again and a new psychometric analysis was carried out. Table 4 shows that the results of the psychometric analysis obtained in the second year are generally better than those obtained in the first year. Another way to display the results of the psychometric analysis is to focus on the individual quiz questions, rather than on the quizzes as units. The plots in Figure 2 and Figure 3 seem to indicate an improvement in the psychometric analysis after the revision, with higher DC values in the second year than in the first year.

Table 4. Mathematics 1: Psychometric analysis corresponding to 2009/2010 and 2010/2011.

| *M1* | | *FI (%)* | | *DC* | | |
|---|---|---|---|---|---|---|
| | | *Range* | *% of questions with FI between 15 and 85* | *% of questions with Low DC* | *% of questions with Medium DC* | *% of questions with High DC* |
| Q1 | 2009/2010 | 14-82 | 93.3 | 20 | 80 | 0 |
| | 2010/2011 | 36-84 | 100 | 0 | 100 | 0 |
| Q2 | 2009/2010 | 32-85 | 100 | 13 | 74 | 13 |
| | 2010/2011 | 41-91 | 80 | 7 | 80 | 13 |
| Q3 | 2009/2010 | 22-87 | 94.1 | 18 | 76 | 6 |
| | 2010/2011 | 25-96 | 64.7 | 12 | 82 | 6 |
| Q4 | 2009/2010 | 57-86 | 90 | 0 | 90 | 10 |
| | 2010/2011 | 23-87 | 90 | 20 | 70 | 10 |
| Q5 | 2009/2010 | 24-73 | 100 | 21 | 50 | 29 |
| | 2010/2011 | 21-86 | 92.9 | 7 | 86 | 7 |
| Q6 | 2009/2010 | 29-66 | 100 | 8 | 76 | 16 |
| | 2010/2011 | 18-78 | 100 | 8 | 76 | 16 |

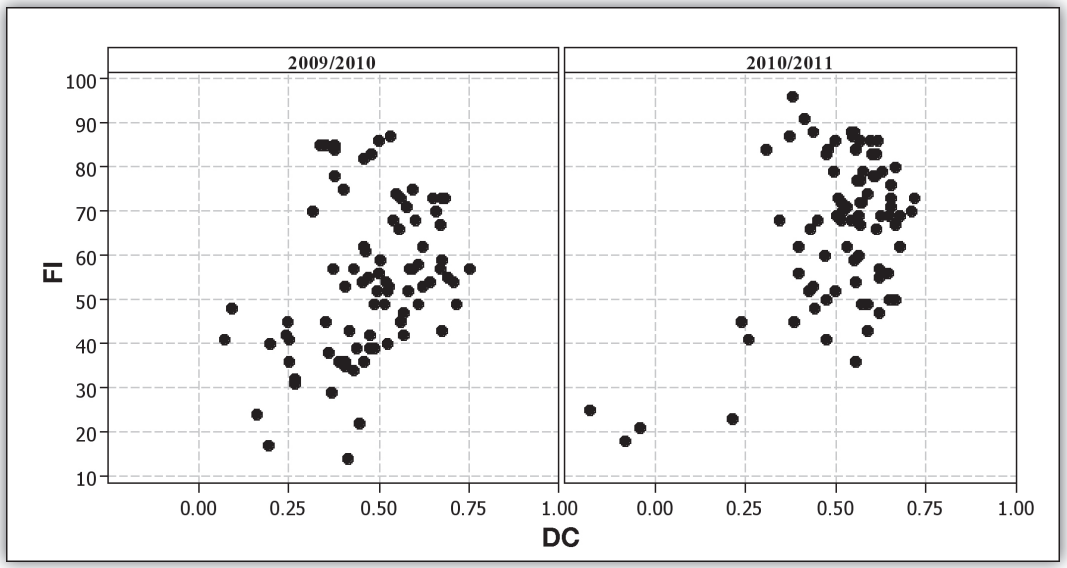


**Figure 2.** Mathematics 1: Scatter plots of FI and DC, corresponding to all the questions used in the six quizzes in the years 2009/2010 and 2010/2011.

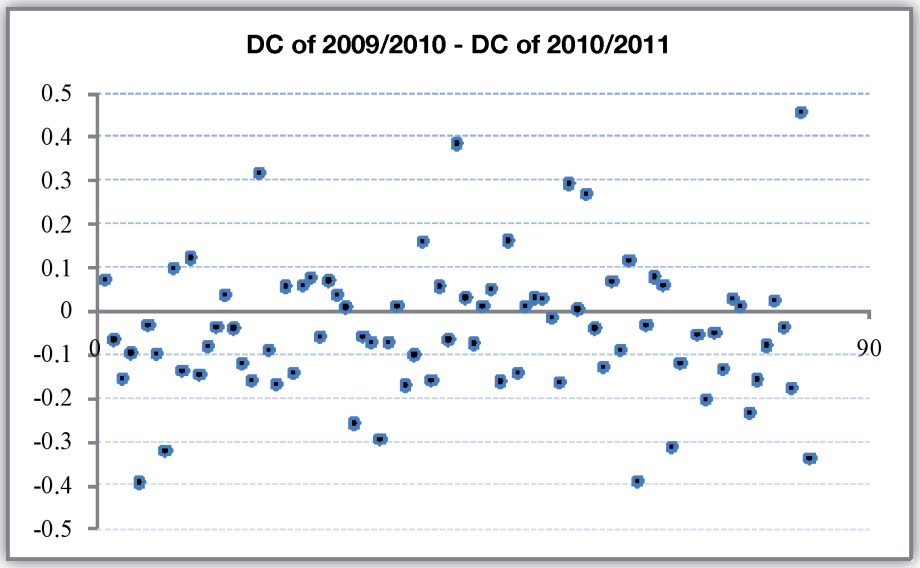


**Figure 3.** Mathematics 1: Plot of the difference between the DC values in 2009/2010 and in 2010/2011 for each question.

With regard to the eight quizzes performed in Mathematics 2, in the first year (2009/2010), the solutions for the quizzes were made available on the UPC's virtual teaching campus. There was therefore a risk that this, together with the fact that the quizzes were take-home assignments, might tempt the students to copy the answers from the previous year. Consequently, to prevent the students from cheating, in the second year 2010/2011, we redesigned the quizzes already answered the previous year by introducing a few changes, mainly numerical, enough to maintain the essence and reliability of the quizzes. Nevertheless, this could not be taken for granted, since factors alien to the questions, such as changes in the student cohort or changes in the teaching team, might have an impact on the results of the item analysis of a particular quiz. As Figure 4 suggests, such changes

in the questions, however slight, could lead to different outcomes, depending on the features of the group of students involved. The positive results obtained in the second year, as noted above, are reflected in higher FI values in general. The random distribution of values around zero in Figure 5 aligns with the fact that no specific action was taken to improve the DC of the quiz questions of Mathematics 2, in contrast to Figure 3, where the values tend to concentrate in the area below zero. Notwithstanding the slight changes made to the quizzes, it is possible to assert that they maintained their DC values in the main. This is therefore acceptable in terms of arguing in favour of the DC's reliability as a psychometric parameter in our study.

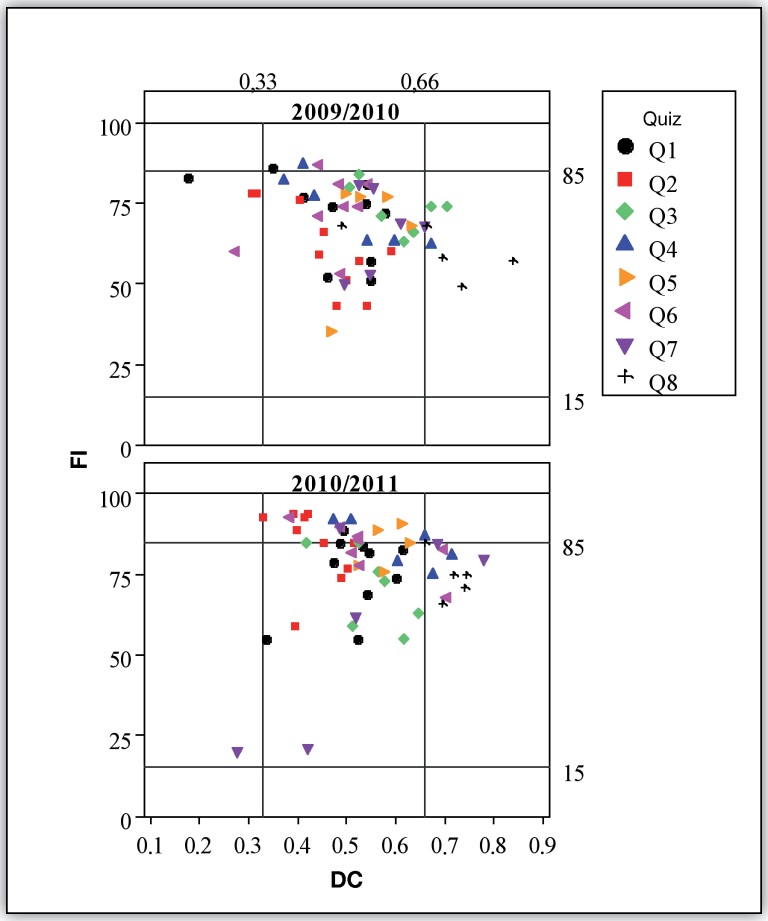


**Figure 4.** Mathematics 2: Scatter plots of FI and DC, corresponding to all the questions used in the eight quizzes in the years 2009/2010 and 2010/2011.

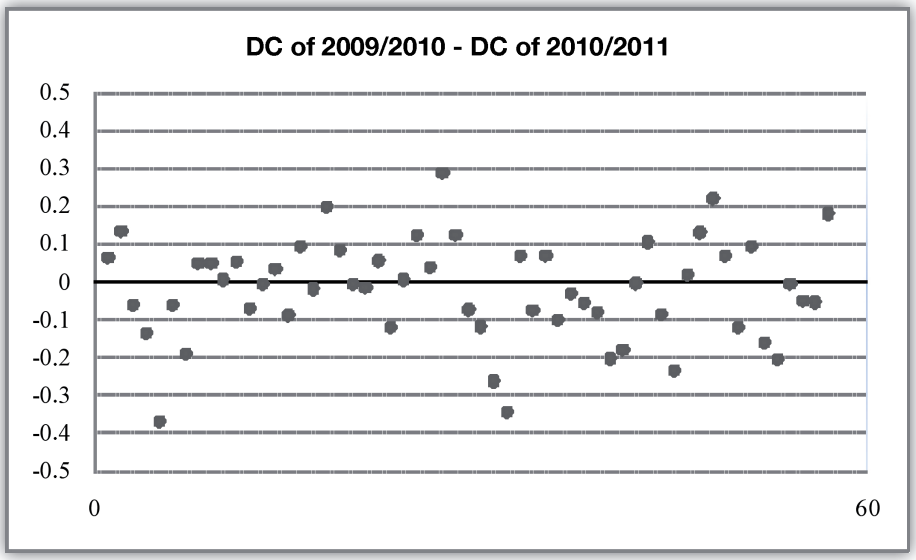


**Figure 5.** Mathematics 2: Plot of the difference between the DC values in 2009/2010 and in 2010/2011 for each question.

## 3.3. Analysis of the students' ratings of Moodle quizzes

Some years before the creation of the four bachelor's degree courses in Biosystems Engineering at the UPC, the teaching and learning of mathematical topics at the ESAB was hindered by the students' underachievement, absenteeism and lack of motivation. In order to overcome such obstacles, we decided to work on a new design for the subjects with a substantial increase in the use of computer-assisted methodologies. Therefore, we designed a methodology based on the use of electronic tools aiming at solving standard problems and fostering lecturer-student communication.

At the end of each semester of the academic years 2009/2010 and 2010/2011, we asked our students to rate certain aspects of the quizzes performed and of the use of Moodle. Even though this is not the only source of feedback, the students' ratings provide an excellent guide for designing the teaching process and, in particular, for assessing student motivation. The interaction between the lecturer and the learner helps the former to adapt the learning and assessment tasks to the latter's needs (Daly et al., 2010). Table 5 gives a summary of their answers.

The students were also invited to note down the positive and negative aspects of the quizzes. It is important to underscore the following positive aspects, as expressed by the students themselves:

*"It is an easy way to put into practice the theoretical concepts learnt in class"*
*"Quizzes are entertaining"*
*"Quizzes provide an instantaneous correction of my responses"*
*"Quizzes helped me to be in contact with the subject"*
*"It is an indirect way to enhance the study"*

When it comes to the negative aspects, the students not only tended to regard the time available to perform a quiz as insufficient, but they also complained about the poor feedback provided once

the quizzes had been performed. Moreover, when asked what improvements they would suggest, the students placed emphasis on getting more feedback on the answers.

Yet, from the results shown in Table 5 and the positive and negative aspects mentioned above, our overall impression is that the students of Mathematics 1 and 2 regarded the quizzes performed positively, both in 2009/2010 and in 2010/2011.

Here it should be noted that the authors undertook a similar project dealing with Moodle quizzes on a Statistics course (Blanco and Ginovart, 2010a). The results of this experience, in keeping with the results obtained in Mathematics 1 and Mathematics 2, would support the advisability of using this type of formative assessment in teaching and learning in higher education.

Table 5. Mathematics 1 and Mathematics 2: The students' ratings.

| *QUESTION* | *2009/2010 M2 n=83 (%)* | *2010/2011 M1 n=158 (%)* |
|---|---|---|
| **Have you used Moodle before on this course?** | | |
| Not at all | 21.7 | 7.0 |
| Rarely | 30.1 | 16.5 |
| Sometimes | 32.5 | 53.8 |
| Often | 10.8 | 17.1 |
| Always | 4.8 | 5.7 |
| **Overall, I would rate the quizzes performed as** | | |
| Very poor | 0.0 | 3.1 |
| Poor | 12.0 | 8.8 |
| Satisfactory | 41.0 | 40.9 |
| Good | 33.7 | 40.3 |
| Very good | 13.3 | 6.9 |
| **The quizzes helped me to understand some of the topics covered in the theoretical classes** | 4.8 | 6.3 |
| Strongly disagree | 15.7 | 8.2 |
| Disagree | 21.7 | 36.1 |
| Neutral | 42.2 | 41.1 |
| Agree | 15.7 | 8.2 |
| Strongly agree | | |
| **Once answered, I got enough information about correct answers** | | |
| Strongly disagree | 4.8 | 8.2 |
| Disagree | 22.9 | 22.0 |
| Neutral | 31.3 | 34.6 |
| Agree | 30.1 | 25.8 |
| Strongly agree | 10.8 | 9.4 |
| **Performing the quizzes has made me more interested in the subject** | | |
| Strongly disagree | 2.4 | 8.2 |
| Disagree | 16.9 | 16.5 |
| Neutral | 41.0 | 52.5 |
| Agree | 30.1 | 17.7 |
| Strongly agree | 9.6 | 5.1 |

| QUESTION | 2009/2010 M2 n=83 (%) | 2010/2011 M1 n=158 (%) |
|---|---|---|
| **I think my scores in quizzes were fair** | | |
| Strongly disagree | 3.7 | 2.5 |
| Disagree | 4.9 | 3.8 |
| Neutral | 25.6 | 19.6 |
| Agree | 41.5 | 53.2 |
| Strongly agree | 24.4 | 20.9 |

## 4. Conclusions

This paper has presented the results obtained from two projects subsidised by the Institute of Education Sciences at the UPC, the main aim of which was to design and implement a number of Moodle quizzes for the formative e-assessment of students enrolled on mathematics courses for Engineering bachelor's degrees. Subsequently, the reliability of the quizzes as assessment tools was analyzed to ensure the quality of the e-assessment system proposed.

Following the ENQA's report about the standards and guidelines for quality assurance in European higher education, the design and development of the Moodle quizzes involved a reflection that was clearly motivated by the diverse aspects of the teaching-learning process, on the part of the lecturer and the learner.

First of all, it was fundamental to prove whether the consistency of the e-assessment system used aligned with that of the traditional assessment tools used so far. The correlation between scores in the quizzes and the final mark of each subject (Mathematics 1 and Mathematics 2) for the years 2009/2010 and 2010/2011 showed that Moodle quizzes could be regarded as a suitable tool to inform students of their performance throughout the learning process. In addition, the particular use of the quizzes as low-stakes assessment activities for chapter checking contributed to the promotion of student self-regulation and regular work throughout the year. Therefore, this paper provides evidence that Moodle quizzes represent a consistent alternative to open-ended tests in terms of continuous and formative assessment.

In order to meet the requirements of formative assessment, the e-assessment system had to supply tools for the lecturers to adapt an activity to the learners' needs, thus improving its reliability from the feedback obtained. The item analysis provided by Moodle's quiz module turned out to be an interesting psychometric tool to estimate, refine and improve the reliability of quiz questions. In relation to the psychometric analysis performed with the 14 quizzes and with the responses of around 500 students, we achieved a significant step forward in the treatment and comprehension of two indicators, namely, the Facility Index and the Discrimination Coefficient.

Finally, a key aspect in the design and development of the e-assessment system was to check whether the students had a favourable view of it. The fact that the students' ratings of the Moodle quizzes were very positive reinforced the idea that activities of this kind were suitable for mathematics

teaching and learning. But not solely mathematics, since the system could be extrapolated naturally to other courses. The results reported in this paper, as well as the students' attitudes, are very encouraging in terms of continuing to work with this e-assessment system and even extending it to other disciplines in the future.

The experience acquired in the development of the reported projects, together with the data generated by the implementation of the quizzes, allowed us to visualize an optimal way to drive forward the effective use of Moodle's quiz module for the formative assessment of students in keeping with the EHEA guidelines. It is worth noting that, by means of this e-assessment system, we managed to carry out the continuous formative assessment of a considerable number of students without overburdening the lecturers with marking or jeopardising assessment quality. This would not have been possible if we had not made full use of Moodle as the LMS supported by our university; this greatly facilitated not only the implementation of tools, but also the collection and analysis of the results. In short, from the results presented in this paper, we can conclude that Moodle quizzes are a consistent and reliable tool for formative e-assessment and consequently we hope that our study will become a reference for further uses of the quiz module.

## Acknowledgments

We gratefully acknowledge the financial support received from the Institute of Education Sciences (UPC).

## References

BLANCO, M.; GINOVART, M. (2010a). "Moodle quizzes for assessing statistical topics in engineering studies". In: K. Resetova (ed.). *Proceedings of the Joint International IGIP-SEFI Annual Conference 2010. Diversity unifies – Diversity in Engineering Education*. Brussels: SEFI.

BLANCO, M.; GINOVART, M. (2010b). "Análisis de la eficiencia de cuestionarios Moodle como herramienta de evaluación de asignaturas de matemáticas correspondientes a primeros cursos de titulaciones de ingeniería". In: *Proceedings of the VI CIDUI: New Areas of Quality in Higher Education. A comparative and trend analysis*. Barcelona: UPC.

BLANCO, M.; ESTELA, M. R.; GINOVART, M.; SAÀ, J. (2009). "Computer Assisted Assessment through Moodle Quizzes for Calculus in an Engineering Undergraduate Course". *Quaderni di Ricerca in Didattica (Scienze Matematiche)*. Vol. 9, No 2, pages 78-84.

BRINCK, R.; LAUTENBACH, G. (2011). "Electronic assessment in higher education". *Educational Studies*. Vol. 37, No 5, pages 503-512.

BURTON, R. F. (2001). "Do Item-discrimination Indices Really Help Us to Improve Our Tests?". *Assessment & Evaluation in Higher Education*. Vol. 26, No 3, pages 213-220.

COLE, J. (2005). *Using Moodle. Teaching with the popular open source course management system*. Sebastopol (CA): O'Reilly Community Press.

CREWS, T. B.; CURTIS, D. F. (2011). "Online Course Evaluations: Faculty Perspective and Strategies for Improved Response Rates". *Assessment & Evaluation in Higher Education*. Vol. 36, No 7, pages 865-878.

DALY, C.; PACHLER, N.; MOR, Y.; MELLAR, H. (2010). "Exploring formative e-assessment: using case stories and design patterns". *Assessment & Evaluation in Higher Education*. Vol. 35, No 5, pages 619-636.

DELGADO, A. M.; OLIVER, R. (2006). "La evaluación continua en un nuevo escenario docente / Continuous assessment in the new teaching scenario". *RUSC*. Vol. 3, No 1, pages 1-13.

ENQA (2005). *ENQA report on Standards and Guidelines for Quality Assurance in the European Higher Education Area*. Helsinki: Multiprint.

FERRÃO, M. (2010). "E-assessment within the Bologna paradigm: evidence from Portugal". *Assessment & Evaluation in Higher Education*. Vol. 35, No 7, pages 819-830.

GRAFF, M. (2003). "Cognitive Style and Attitudes Towards Using Online Learning and Assessment Methods". *Electronic Journal of e-Learning*, Vol. 1, No 1, pages 21-28.

HECK, A.; VAN GASTEL. L. (2006). "Mathematics on the threshold". *International Journal of Mathematical Education in Science and Technology*. Vol. 37, No 8, pages 925-945.

LIM, L. L.; THIEL, D. V.; SEARLES, D. J. (2011). "Fine tuning the teaching methods used for second year university mathematics". *International Journal of Mathematical Education in Science and Technology*. Pages 1-9, iFirst.

SMITH, G. H.; WOOD, L. N.; COUPLAND, M.; STEPHENSON, B.; CRAWFORD, K.; BALL, G. (1996). "Constructing mathematical examinations to assess a range of knowledge and skills". *International Journal for Mathematical Education in Science and Technology*. Vol. 27, No 1, pages 65-77.

STEEGMANN, C.; HUERTAS, M. A.; JUAN, A. A.; PRAT, M. (2008). "E-learning de las asignaturas del ámbito matemático-estadístico en las universidades españolas: oportunidades, retos, estado actual y tendencias / E-learning in the area of maths and statistics in Spanish universities: opportunities, challenges, current situation and trends". *RUSC*. Vol. 5, No 2, pages 1-14.

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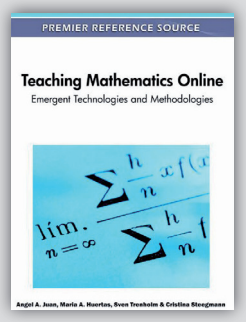
BOOK REVIEW




# *Teaching Mathematics Online: Emergent Technologies and Methodologies*

## Edited by Angel A. Juan, Maria A. Huertas, Sven Trenholm and Cristina Steegmann (2011).

**Hershey, PA: IGI Global. 414 pages.**

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<http://rusc.uoc.edu/ojs/index.php/rusc/article/view/v9n1-cuypers/v9n1-cuypers-eng>
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## Abstract

The following text reviews the book *Teaching Mathematics Online: Emergent Technologies and Methodologies*, recently published by IGI Global. This book brings together experiences and best practices related to the use of Web-based and computer-based methodologies to teach and learn mathematics courses in higher education. Although there is a plethora of books on e-learning and also a considerable amount of books on mathematics learning in secondary education, this is – as far as we know – the first book combining e-learning and mathematical education at the university level. Thus, it constitutes a basic reference for academics and practitioners of this constantly emerging field.

## Keywords

e-learning, mathematical education, higher education, computer-supported learning

### *Resumen*

*El siguiente texto es una reseña del libro Teaching Mathematics Online: Emergent Technologies and Methodologies, publicado recientemente por IGI Global. En él se han reunido una serie de experiencias y mejores prácticas relacionadas con el uso de metodologías basadas en internet y en sistemas informáticos que tienen por objeto la enseñanza y el aprendizaje de las matemáticas en el ciclo educativo superior. Pese a la gran cantidad de libros existentes sobre e-learning y la abundancia de obras referidas a la enseñanza de las matemáticas en el ciclo educativo secundario, este es –que sepamos– el primer libro que combina e-learning y enseñanza de las matemáticas a un nivel universitario. Así pues, nos hallamos ante una referencia básica para entornos tanto académicos como profesionales de esta disciplina en constante evolución.*

### *Palabras clave*

*e-learning, enseñanza de las matemáticas, enseñanza superior, aprendizaje asistido por ordenador*

In this voluminous book of over 400 pages, the editors bring together 18 chapters on mathematics e-learning. They do so for two main reasons, as quoted below:

- "to provide insight and understanding into practical pedagogical and methodological issues related to mathematics e-learning," and
- "to provide insight and understanding into current and future trends regarding how mathematics instruction is being facilitated and leveraged with Web-based and other emerging technologies."

The book contains a variety of chapters, addressing many interesting developments within the area of technology-enhanced mathematics learning. It contains chapters discussing best practices regarding mathematics e-learning in higher education, chapters providing theoretical or applied pedagogical models in mathematics e-learning, chapters describing emerging technologies and mathematical software used in mathematics teaching online, as well as chapters presenting up-to-date research work on how mathematics education is changing through the use of online teaching methods.

The book starts with an introduction by the editors. They give an overview of the various chapters, which they have grouped into the following three sections:

1. Blended Experiences in Mathematics e-Learning
2. Pure Online Experiences in Mathematics e-Learning
3. Mathematics Software & Web Resources for Mathematics e-Learning

The chapters are equally divided over the three sections. We briefly summarize the content of the various sections and chapters.

The first section focuses on experiences in mathematical e-learning, in which face-to-face teaching is blended with distance or online instruction. It starts with a chapter by Miller describing

the successful implementation of an asynchronous model for online discussions on a mathematics course for mathematics teachers. The section continues with a chapter by Abramovitz et al. on a blended experience in calculus courses for undergraduate engineering students, in which online assessments are used to help students understand theoretical concepts and theorems, and with a chapter by B. Loch, in which she describes how screencasts of live lectures as well as screencasts of short snippets of theory or examples have been used within an operations research course to supply online students with just-in-time information. Chapters 4 to 6 by Albano, Perdue and Divjak, respectively, discuss some experiences using general e-learning tools, ranging from LMSs, wikis and speaking avatars to video and social media, to enhance their face-to-face mathematics courses.

The second section of the book is devoted to experiences of purely online mathematics e-learning. It contains two chapters on the use of online communication and collaboration tools by Meletiou-Mavrotheris and by Silverman and Clay, both focusing on the education of mathematics teachers, and two chapters on the use and impact of online teaching material in bridging courses in mathematics for the transition from high school to university by Tempelaar et al. and by Biehler et al. The other two chapters by Jarvis and by Trenholm et al. both identify, review and evaluate a number of models and methods of mathematics e-learning.

The final section of the book is concerned with mathematical software and Web resources for mathematics e-learning. It contains a chapter by Cherkas and Welder reviewing some popular websites, a chapter by Alcazar et al. describing experiences with the software packages WIRIS, GeoGebra, SAGE and Wolfram Alpha, and a chapter by Lokar et al. describing the NAUK.si initiative to create Web-based learning blocks. Badger and Sangwin discuss the use of Gröbner basis techniques in the automatic grading of online exercises involving systems of equations. Misfeldt and Sanne discuss the problems that both students and lecturers face when writing mathematical formulas on a computer, as well as some solutions to these problems. The last chapter by Mac an Bhaird and O'Shea reviews a number of general-purpose software tools to be used in mathematics classes, including podcasts, screencasts and videos.

With this book, the editors have indeed succeeded in reaching their goals. They have brought together a great variety of interesting information about online Web resources and their use in both blended and online mathematics teaching. This collection of chapters provides a good insight into teaching methods, trends and possibilities offered by technology-enhanced mathematics learning.

Mathematics educators will certainly find both information and motivation in several chapters to improve their teaching through the good use of technology and online resources.

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