RUSC Revista de Universidad y Sociedad del Conocimiento
Universities and Knowledge Society Journal
http://rusc.uoc.edu

DOSSIER

Mathematical e-Learning

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Recommended citation
JUAN, Ángel A.; HUERTAS, María Antonia; CUYPERS, Hans; LOCH, Birgit (2012). "Mathematical e-learning" [preface to online dossier]. *Universities and Knowledge Society Journal (RUSC)*. Vol. 9, No 1. *pp.* 278-283 UOC. [Accessed: dd/mm/yy].
<http://rusc.uoc.edu/ojs/index.php/rusc/article/view/v9n1-juan-huertas-cuypers-loch/v9n1-juan-huertas-cuypers-loch-eng>
ISSN 1698-580X

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.

Guest Editors of the dossier

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Hans Cuypers studied mathematics at Radboud University Nijmegen and Utrecht University, from which he obtained a doctorate. In the academic year 1989/1990, he was a visiting assistant professor at Michigan State University. The following year he held a position at the University of Kiel, Germany. Since September 1991, Cuypers has held a tenured position at Eindhoven University of Technology, where he now leads the Discrete Algebra and Geometry group. His main mathematical interests are discrete algebra and geometry, particularly (finite) geometry, group theory, graph theory, design theory, algebraic combinatorics, abstract and applied algebra, and computer algebra. His recent interests are interactive mathematics and e-learning. In particular, *MathDox*, a software system for interactive mathematics, has been developed under his guidance. Cuypers has published over 70 papers and three books on his research. His website is http://www.win.tue.nl/~hansc/.

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