Maria M. Nascimento
Gustavo R. Alves
Eva Virgínia Araújo Morais *Editors*

Contributions to Higher Engineering Education

Springer

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ISBN 978-981-10-8916-9 ISBN 978-981-10-8917-6 (eBook)
https://doi.org/10.1007/978-981-10-8917-6

Library of Congress Control Number: 2018937320

Printed on acid-free paper

This Springer imprint is published by the registered company Springer Nature Singapore Pte Ltd.
part of Springer Nature
The registered company address is: 152 Beach Road, #21-01/04 Gateway East, Singapore 189721, Singapore

Preface

Education is the most powerful weapon, which you can use to change the world.

Nelson Mandela[1]

The world is full of new challenges and opportunities. If we look around, energy, climate change, aging population, economic development, and a lot of other issues, we see engineers playing a key role in implementing new solutions. The new approaches required are extremely valuable all through every engineering field, as they enable practical and creative actions in the face of a volatility, uncertainty, complexity, and ambiguity world. Therefore, the engineers' education is of a paramount importance.

Engineering education is about facilitating the learning of scientific and technical knowledge, as well as learning the principles of the professional practice of engineering. Nowadays, such professional practice requires other skills to train a twenty-first century engineer, known as soft skills, such as teamwork, creativity, and ability to communicate.

In Portugal, the stakeholders of the engineering education *process* got together to think how to improve their own work to generate the future professionals of the several engineering domains. That effort led to the foundation of the Portuguese Society for Engineering Education (SPEE). Afterward, the Society's international conferences began, and on its second meeting (CISPEE 2016) writing a book with the more relevant contributions was proposed. This initiative was encouraged by SPEE to promote engineering education. The six chapters of this book will offer the opportunity to spread some of the works in this field in Portugal.

The first chapter of this book, entitled "International Cooperation for Remote Laboratory Use," corresponds to the best paper presented at CISPEE 2016, held at the University of Trás-os-Montes e Alto Douro, Vila Real, Portugal, in October 2016, and it presents a very interesting cooperative work between several

[1]Source: "Lighting your way to a better future: Speech delivered by Mr. N. R. Mandela at launch of Mindset Network", July 16, 2003.

universities in Europe and in Latin America. It describes the VISIR+ Project which is an example of cooperative work in the field of engineering education.

The second chapter is about "Mature Learners' Participation in Higher Education and Flexible Learning Pathways: Lessons Learned from an Exploratory Experimental Research." It analyzes the students' ways of learning in higher education institutions.

Following the "The Flow of Knowledge and Level of Satisfaction in Engineering Courses Based on Students' Perceptions," the third chapter gives us a glimpse of some important aspects in engineering training and provides elements to eventually improve it.

The fourth chapter, entitled "Innovative Methodologies to Teach Materials and Manufacturing Processes in Mechanical Engineering," serves as a testimony of a different work approach implemented in engineering in higher education training.

As an example of the work integration between a higher education institution and a company, "'Learning by Doing' Integrated Project Design in a Master Program on Product and Industrial Design" is the fifth chapter and depicts situations where the students were involved in a real project, mimicking the situation where they were already operating in the job market.

Finally, the sixth chapter presents "The Views of Engineering Students on Creativity," another hint to some emphasized skills needed by the twenty-first-century engineer, and ultimately it enables us to picture its use in engineers training.

By the collaborative effort that all the authors made to bring us these best practices, I know this book will reach the global community of engineering education and that its spreading will lead to the discussion of the several challenges that will continue to emerge all over the world.

José Carlos Quadrado
President LACCEI, Past President IFEES
Past President ASIBEI

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About the Editors

Maria M. Nascimento has been an Assistant Professor at the University of Trás-Montes e Alto Douro (UTAD), Vila Real, Portugal, since 1985, where she teaches Statistics and Operations Research. She is an integrated member as a researcher of CIDTFF (Research Centre on Didactics and Technology in the Education of Trainers, CIDTFF, from University of Aveiro, and in its Lab-DCT/UTAD, the laboratory of CIDTFF at UTAD). Her main research and publication interests are teaching statistics and its attitudinal and didactical research issues, as well as the ethnomathematics research field. In addition, the critical thinking research field and in its connections to the statistical thinking in higher education are her other research interests. She is a Member of the Portuguese Engineers Society (OE) and of the Portuguese Society for Engineering Education (SPEE).

Gustavo R. Alves graduated in 1991 and obtained an M.Sc. and a Ph.D. degree in Computers and Electrical Engineering in 1995 and 1999, respectively, from the University of Porto, Portugal. He is a Professor at the Polytechnic of Porto—School of Engineering (ISEP) since 1994. He has authored or co-authored more than 200 conference and journal papers with referee process, 11 books, and co-edited a book (with Javier Garcia-Zubia, University of Deusto, Bilbao, Spain), about "Using Remote Labs in Education." He has also been involved in more than 18 national and international research projects. His research interests include engineering education, remote experimentation, and design for debug and test. He served as the Program Co-Chair of the First and Second International Conference of the Portuguese Society for Engineering Education (CISPEE 2013 and CISPEE 2016), and of the 3rd Experiment@ International Conference (exp.at'15), as General Chair of the 11th Remote Engineering and Virtual Instrumentation (REV 2014) conference and of the 3rd Technological Ecosystems for Enhancing Multiculturality (TEEM 2015) Conference, and also as a Program Committee Member of several international conferences. He is currently Associate Editor for the IEEE

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Eva Virgínia Araújo Morais is an Assistant Professor at the University of Trás-os-Montes and Alto Douro (UTAD) since 2000. She received her Ph.D. in Mathematics Applied to Economy and Management from the Lisbon School of Economics and Management (ISEG), Technical University of Lisbon, Portugal, in 2013. She has authored and co-authored several works in her main research fields, mathematical finance and critical thinking in higher education.

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Introduction

Maria M. Nascimento[2], **Gustavo R. Alves and Eva Virgínia Araújo Morais**

The Portuguese Society for Engineering Education

As stated in its Web page [1]

"*The Portuguese Society for Engineering Education* [acronym SPEE] *is a non-profit association that aims to promote engineering education through pedagogical training and personal development of teachers, dissemination, and collaboration in projects, exchange between people and national and foreign institutions and analysis and problems in the field of engineering education. Constituted by a public deed signed by a seminal group of founding members, it was launched (…) in 2010. It currently has 20 institutional partners, including the Portuguese Order Of Engineers, almost all university engineering schools and a significant group of polytechnics, and more than 200 individual partners working in an even wider range of schools, in a wide range of fields, from the most classic to the most modern.*"

Hence, a group of engineers that are teaching in different engineering schools and degrees in Portugal recognized that something more could be done to improve engineering education and SPEE was the way to gather efforts in order to be successful.

The International Conference CISPEE

SPEE devised an international conference to disseminate work and research done and to share views with each other. Thus, the international conferences—acronym CISPEE—arose and are dedicated to engineering education, and its goals are to become a major discussion forum for all stakeholders groups of engineering education. At the same time, CISPEE aims to gather academics, researchers, and

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professionals directly or indirectly linked to engineering education in order to discuss the progress in this work field and to disseminate its results and each new approach. Usually, CISPEE includes pre-conference workshops, plenary, thematic, and posters sessions. The authors are invited to present their work in the major conference topics: Engineering Ethics; Information and Communications Technologies (ICT) in Engineering Education; Continuing Engineering Education (CEE); Mathematics in Engineering Education; Tools to Develop Higher Order Thinking Skills; and Future Outlook of the Profession and Education in Engineering.

In 2013, this society organized the First International Conference of the Portuguese Society for Engineering Education (CISPEE 2013) held at ISEP, Polytechnic of Porto, Porto, Portugal, and the Second International Conference of SPEE was in 2016 (CISPEE 2016) and was held at University of Trás-os-Montes and Alto Douro (UTAD) in Vila Real, Portugal.

CISPEE 2016 edition brought together teachers and researchers from several engineering schools, from Portugal, and from the international community (e.g., Canada, Spain, South America, and Europe) to share good practices that may contribute to *(Re)Thinking Higher Engineering Education*, the issues related to critical thinking and problem-solving, communication, collaboration, creativity, and innovation in engineering education.

(Re)Thinking Higher Engineering Education was and still is challenging since engineering education is the activity of teaching knowledge and principles—higher education—related to the professional practice of engineering—life and life-long learning. Therefore, beyond the examination of the economic, cultural, and social factors, which influence the education of engineers in different higher education institutions, we should question ourselves about critical thinking and problem-solving, communication, collaboration, creativity, and innovation provided to engineering students (the four C referred in the 2010 American Management Association survey [2]). Training those skills in higher education students may change the way they look at issues, organize their views, and incorporate others' views in order to stimulate new perspectives and prevent biased views of a real situation or problem.

Higher Education in Portugal

Concisely, the Bologna Process (BP) in the context of the European institutions of higher education implied changes in aspects related to the role of the student, the process of learning and training, and the matrix of learning assessment. Underlying BP is the paradigm that emphasizes student centrality, focusing on learning and on its active role [3].

As stated in the Decree-Law no. 74/2006 of March 24, in Portugal, the main objectives were "to guarantee Bologna, a unique opportunity to encourage higher education, to improve the quality and relevance of the courses offered, to promote the mobility of our students and graduates, and to internationalize our courses." In 2008, the "Basic Law of the Educational System" established a model of organization by cycles where the "degrees [1st cycle], master [2nd cycle], and doctorate

[3rd cycle]" are given, as set in the Bologna Declaration. Another important concept is the European Credit Transfer System (ECTS), which translates the "unit of measurement of student work" (Decree-Law no.107/2008 of June 25 on the award of Degrees and Diplomas). The aim is to achieve one of the goals of the BP, that is the transition from the transmission of knowledge to a system centered on training and learning, and so, in addition to having to master the technical skills of a specialized area, it must be able to communicate, lead, work as a team, analyze, and solve problems. This approach requires an experimental component, a problem-based component, and others, and the acquisition of transversal skills should play a major role [3].

The Structure of this Book

In Portugal, the BP was implemented in higher education in 2010. Therefore, a parallel may be set between the engineering educators' concerns and the need they felt to associate—them and their surrounding institutions—in SPEE. As already mentioned, the appearance of CISPEE was almost immediate. At the two CISPEE editions, the committees—Scientific and Organizing—delegate in a jury the choice of the best paper and the best poster; thus, this year we decided to invite the best papers' authors to write a chapter for a book, since the publishing company accepted our proposal. We thought it was worthwhile to gather the best works of the authors under a larger theme of CISPEE 2016 (Re)Thinking Higher Engineering Education, so in the *Contributions to Higher Engineering Education* was not possible to include all the papers presented at CISPEE 2016 on the book.

The first chapter won the price of best paper and presents an "International Cooperation for Remote Laboratory Use," authored by 44 collaborators of the VISIR+ Project. The chapter presents the cooperation needed to implement a remote laboratory, named Virtual Instruments System in Reality (VISIR), in order to provide an additional experimental component in electrical and electronics engineering.

The second chapter studies "Mature Learners' Participation in Higher Education and Flexible Learning Pathways: Lessons Learned from an Exploratory Experimental Research." This chapter discusses a European and Portuguese problem that is the inclusion of a new kind of students in higher education, the mature students, and an alternative way to deal with the gaps those students present.

The third chapter presents "The Flow of Knowledge and Level of Satisfaction in Engineering Courses Based on Students' Perceptions." Based on a survey to students in higher education in two countries, some perception variables are analyzed in light of students' perceptions.

The fourth chapter discusses "Innovative Methodologies to Teach Materials and Manufacturing Processes in Mechanical Engineering." Again, the experimental and the problem-based component as well as other methodologies are implemented in order to engage the students in the classes.

The fifth chapter discusses "'Learning by Doing' Integrated Project Design in a Master Program on Product and Industrial Design." The chapter is about the problem-based implementation in a master in a design study scenario in connection with the industry and real clients.

The sixth and last chapter presents and discusses "The Views of Engineering Students on Creativity." In line with the needs of the twenty-first-century interpersonal, applied skills—creativity included—required also to engineers, an exploratory study is presented about the definitions about creativity of first-year students in two academic years.

In summary, involving the development of experimental components, we have Chapters "International Cooperation for Remote Lab Use" and "Innovative Methodologies to Teach Materials and Manufacturing Processes in Mechanical Engineering," and issues related to topics of the students in the remaining chapters: mature learners' participation and flexible training pathways, in Chapter "Mature Learners' Participation in Higher Education and Flexible Learning Pathways: Lessons Learned from an Exploratory Experimental Research"; flow of knowledge and level of satisfaction in Chapter "The Flow of Knowledge and Level of Satisfaction in Engineering Courses Based on Students' Perceptions"; "learning by doing" in practice product and industrial design in Chapter "'Learning by doing' Integrated Project Design in a Master Program on Product and Industrial Design"; finally, the views of engineering students on creativity in Chapter "The Views of Engineering Students on Creativity."

In order to disseminate information about all the authors devoted to the making of this book, at the end of each chapter we present their short biographic notes.

Conclusion

Contributions to Higher Engineering Education hopes that the reader will be also engaged in a better engineering education. We decided to write about our own experiences and researches in order to leave our testimony to other colleagues and spread the word. It is possible to share our concerns with others, it is possible to cooperate with others, and it is possible to do it in a different way: *The sky is the limit!*

In Isaac Asimov words [4]

"Science can amuse and fascinate us all, but it is engineering that changes the world."

We must continue to involve ourselves as teachers, as engineers, as stakeholders in order "*to promote engineering education through pedagogical training and personal development of teachers, dissemination, and collaboration in projects, exchange between people and national and foreign institutions and analysis and problems in the field of engineering education*."

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