Ivan Mutis · Timo Hartmann *Editors*

Advances in Informatics and Computing in Civil and Construction Engineering

Proceedings of the 35th CIB W78 2018 Conference: IT in Design, Construction, and Management

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Letter from the Editors

The 35th CIB W78 conference took place in Chicago in 2018, with a theme focused on fostering, encouraging, and promoting research and development in the application of integrated information technology (IT) throughout the life cycle of the design, construction, and occupancy of buildings and related facilities. Organized by Professors David Arditi and Ivan Mutis (Illinois Institute of Technology, Chicago), Timo Hartmann (Technische Universität Berlin), Robert Amor (University of Auckland), and with special and valuable support from Bill East (Prairie Sky Consulting, USA), it brought together more than 200 scholars from 40 countries, who presented the innovative and unique concepts and methods featured in this collection of papers.

With the publication of these contributions, we expect to scaffold scholars' motivations to inspire and discover the pressing research questions that need to be answered in the coming decade. Framed under topic clusters as described in the introductory section, the Editors organized the responses of the 2018 worldwide, open call for submissions. Taking the number of submissions in each focus area as an indicator of research potential, the open call elicited the lowest response in the area of Systems of Integrated Computer and Physical Components (Cyber-Physical-Systems), which suggests underdevelopment of initiatives for scientific questions in this area. We look forward to seeing greater response to this area in the future.

Ultimately, the success of this event and its contribution to the field of informatics and computing in civil and construction engineering is the result of countless hours of investigation, development, and work from scholars across the globe. The Editors and organizing committee thank all who have supported the effort. We thank in particular the paper reviewers.

The research and approaches that have been developed and presented at this conference can immediately deliver extraordinary innovations to construction practices with benefits attributable to individuals, organizations, and the industry, as a whole. Looking forward, the legacy of this conference will be carried not only through its influence on the construction practice but also on research for years to come.

Ivan Mutis
Timo Hartmann

About CIB and CIB W78

CIB, officially named International Council for Research and Innovation in Building Construction, was established in 1953 under the name Conseil International du Bâtiment. The foundational objectives of CIB were to stimulate and facilitate the international cooperation and exchange of information between governmental research institutes in the building and construction sector, with an emphasis on those engaged in technical fields of research. Since its inception, the association has developed into a worldwide network that connects more than 5000 experts. These specialists represent the research institutes, university, and industry- and government-related entities that constitute the approximate 500-member organizations of CIB. Though the size and strength of the organization today has grown compared to the past, the focus of CIB and its members remains the same: the active collection of research and innovation information for all aspects of building and construction.

CIB W78, or work group 78, is one of the largest and most active working commissions of CIB. The scope of W78's work is broad, but its primary mission is to proactively encourage the integration of Information and Communication Technologies (ICT) into a facility's life cycle. It achieves this goal by disseminating research and knowledge among an international community of scholars and practitioners in a variety of means, most notably the annual international conference.

Contents

Introduction

A Vision for Research and Innovation in Informatics and Computing in Civil and Construction Engineering

While we move into the first quarter of the twenty-first century, the practice of civil, construction, and building engineering embraces an incommensurable transformation in the way we deliver products, process data, and interact with agents and technology. New paradigms focused on sustainable practices, and the effective use of data and information and computing technologies, and automation have framed the trends we see in research initiatives and fundamental problems in civil and construction engineering disciplines. The continuous expansion of interdisciplinary work among computing, informatics, and construction and civil engineering merges perspectives to create integrated or hybrid methods of observing, dissecting and solving central problems and of integrating relevant theories. The 2018 conference and this related publication is an effort to register diversity of thinking to understand a phenomenon, problem, dataset, or methods that enable value creation in practice and expand the frontiers of new, integrated knowledge.

We view the worldwide, open call for research initiatives as a survey of innovations and novel approaches to phenomena and problems in computing and informatics in civil and construction engineering. The compilation is organized under seven concept clusters to align the contributions to the forefront of trends on investment for scientific research. The selection in clusters was decided to better capture new advancements of knowledge within the focus areas. The conceptualization and focus were based mainly on reflections from visionary documents [1–3]. The focus areas cover the spectrum of aims of scientific questions and the fundamental aspects that advance understanding or solve problems. Within each area, evolving technology may transform activities and subsequently shape research practices in the coming decade (Fig. 1).

Ivan Mutis
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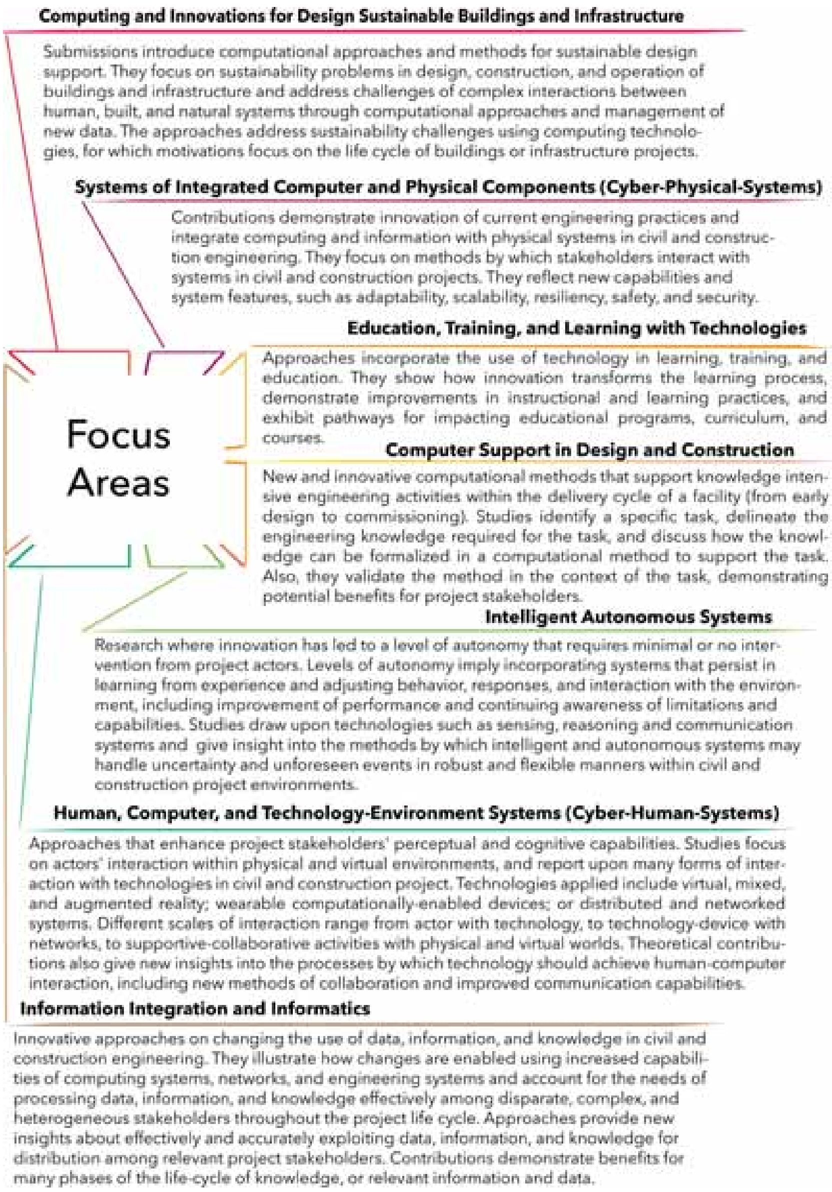

Fig. 1 Conference topics clustered in focus areas

References

1. National Science Foundation (NSF).: NSF's 10 Big Ideas. (2018) Available: https://www.nsf.gov/news/special_reports/big_ideas/
2. National Science Foundation (NSF).: Building the future investing in discovery and innovation. In: National Science Board, National Science Foundation (NSF), vol. NSF-18-45, Arlington, Virginia (2018)
3. Rajkumar, R., Lee, I., Sha, L., Stankovic, J.: Cyber-physical systems: The next computing revolution. In: Design Automation Conference, pp. 731–736. (2010)

108 Building Energy Modeling in Airport Architecture Design

Maria Antonietta Esposito and Alessandra Donato

Abstract

Energy efficiency and Building Energy Modeling are two successful approaches to architecture, engineering, construction and operation (AECO) programs. In recent year several education initiatives focusing on buildings energy management have been carried out to provide professional profiles with specific skills in technology, architecture, engineering, economics, management and environmental science. It enables them to plan, design, evaluate or research energy supply and design strategies aimed to reduce energy consumption according to sustainability concepts. Building energy performance optimization requires an integrated design approach to explore and evaluate different strategies for building energy saving and to assist in the decision making process along the life cycle including design, operation, management and decommission phases. Moreover, BEM (Building Energy Modeling) is increasingly being included into architecture and engineering curricula, introducing new methodologies and tools for architecture design to provide interdisciplinary profiles in the professional practice. The main objective of this contribution is to report the application of BIM technologies and BEM tools into the Environmental Design Lab training course at the School of Architecture at University of Florence, where the authors are involved into a cross-disciplinary teaching program which students undertake in the fourth year of their curriculum within the 5 years degree program.

Keywords

Building Energy Modeling • Multidisciplinary education • Architecture training program
Airport Terminal Design

108.1 Introducing BIM Technologies into Architecture Curriculum

Education plays a fundamental role in the development of the future sustainable society, providing training for architecture and engineering students of the next generation [1]. Over the past decade, universities worldwide have been looking for better ways to integrate environmental issues into architectural education.

Energy efficiency training in architecture needs to overcome many challenges that first of all include the unavailability of well-structured and integrated curricula [2].

More recently the transition from CAD (Computer Aided Design) to BIM (Building Information Modelling) made it possible to apply building-performance analysis methods as part of the design collaborative process.

BIM technologies have been integrated into traditional architecture and engineering university training programs, focusing on generic topics related to sustainable architecture design, building energy efficiency, renewable energies, and computing technologies to sustainable practices [3].

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In several countries BIM courses have successfully implemented in AEC programs but they are mainly focused on 3D modeling skills as well as analysis tools of particular BIM software packages considering the benefits of BIM in sharing and simulating construction information. However, this approach appears to be a barrier to the successful integration of BIM technology in education, and students will not be able to fully understand the BIM management workflow in a construction project [4].

BIM is a helpful teaching tool for construction estimation and quantity take-off skills and highly contribute to design comprehension skills and understanding of construction materials, methods, and processes [5].

BIM helps stakeholders involved at different stages of the design process to interact remotely and to use real-time data solving any conflicts since the early stage of the project, improving working efficiency, estimates accuracy, decision-making and project schedule [6, 7]. BIM is a very complex concept, which leads to a collaborative work environment, and creates an easier approach to the universal access of the architectural information, due to the creation of a federate model characterized by a common data environment [8].

In Italy, BIM design process is mandatory from 2019 for all public building projects above 100 million. To satisfy the AECO industry improved skills requirements, more and more universities are providing BIM courses within AEC programs at different levels of implementation. Typical BIM courses offered in the Italian universities consisting in BIM training computer Lab for students. However, this education is oriented towards the use of particular BIM software packages, with little consideration to BIM Management (BIMM), process and methods. Few University like the University of Parma, the University of Brescia and the University of Naples have successfully implemented BIM classes in their curriculum highlighting BIM information requirements, approaches, rules and regulations, workflows, building modelling, project management and execution plan using BIM.

As best practice, the Polytechnic University of Milan offers an Integrated Project Management and Design Tool with a lab activity to help students to practice with project management activities on a BIM based project. Information are the main value in modern construction processes and students will be shown how to manage these information starting from the very early stage of the design process using BIM and the latest design tools.

The University of Brescia focused on Project Management practice using BIM and construction phase as well as built augmented information.

The University of Parma implemented a BIM Lab divided in two modules within the Environmental and Land Management Engineering degree focusing on BIM methodologies and structured in a series of laboratory experiences including Building energy analysis topics and BIM tools for the building energy certification.

The Environmental Design Lab Training Course at the School of Architecture at University of Florence developed a new course integrating BIM contents and building performance simulation tools that aims to help students to better understand the BIM workflow in a construction project and use BIM to manage the construction process.

The challenge for the authors is to encourage the connection between university and industry, training students who will provide advice and assistance to future customers understanding what skills are needed in the industry to facilitate graduated employment. This work aims to show the effects on the introduction of new BIM-teaching methods on students experience reporting pedagogical strategies, training methods, timelines and tools with specific reference on their implication and effectiveness on students motivation, satisfaction and performance.

108.2 Environmental Design Lab Training Course

108.2.1 Program and Topics First Section

BIM methodology, based on parametric modeling, is helpful to share knowledge resources and information with the aim to facilitate communication between investors, professionals and contractors.

Architecture curriculum at Florence University has already integrated BIM contents in several computer application courses focused on 3D modeling and energy simulations software, providing basic and intermediate knowledge on BIM and energy tools. However, none of these courses introduces BIM technology as an interdisciplinary coordination process oriented to building design, construction, use and decommissioning accordingly with the life cycle view.

As a result, the main objective of this contribution is to show how BIM technologies and BEM tools can be integrated into architecture program as a process instead of a modeling tools or software.

The reported experience concerns the Environmental Design Laboratory Training Course (12 ECTS) at the School of Architecture at University of Florence, which consists of two modules:

- Building Systems Design Module
- Environmental Control Strategies Module.

The Building Systems Design Module focuses on building envelope design technologies. The study is applied to the field of Airport Architecture Design and it has been structured with reference to some key issues in the sustainable approach both in the airport planning and terminal design, life service in operation and looking forward it's evolution and end of life as well [9].

The lab adopts applicative methods and BIM tools according to European Directive 2014/24/EU and D.Lgs.560/2017 italian law, that require the use of BIM procedures and digital processes in the construction of public buildings.

Environmental Control Strategies Module aims at educate and train students in the use and development of competitive skills and tools for energy efficiency and sustainable approach design in a life-cycle perspective focusing on building envelope technology [10]. Furthermore, by using energy BEM technologies into an integrated approach to the design process, students are able to evaluate alternative design solutions contributing to decision making at the early stages design process and improving the whole building construction quality into an interdisciplinary perspective [11].

Both modules are carried out simultaneously into a cross-disciplinary teaching program with the trainers co-presence.

The course runs over a year, and topics were developed to match the objectives of both modules and were scheduled based on 2 semesters with a 4-h class per week, mixing both short theoretical lectures and workshop sessions.

The course involved 45 students who are in the fourth year of their Architecture curriculum divided into 15 groups of 3–4 members.

As case of study, students are required to redesign extension of the Genoa Airport Passenger Terminal and to identify design solutions for building envelope, which are appropriate to energy performance targets set by building components technical specifications and materials certification. In order to be able to create their own project proposal, students are required to study the construction details up to the scale of components, their properties, technical specifications and application methods.

During the course students are introduced to different Best Practices in the field of Airport Terminal Design and to the most innovative solutions for envelope technologies currently available within the construction market such as high performance glass facades, textile and metal roofs, shading systems, integrated PV technologies, etc.

108.2.2 Industry Involvement in Architecture Education

A fundamental aspect of the course concerns the direct involvement of the industry. The course is organized in close collaboration with experts from the civil aviation industry and managers from the Genoa Airport interested in airport development methodologies and design verification. Furthermore Genoa airport owners are direct beneficiaries of students design project outcomes, so they are involved at the early stage of the course providing technical documents, helpful and informative materials to students to carry out their assignments.

This type of partnership would be valuable not only for learning integrated practices using BIM, but mainly for bringing students in real-world projects establishing professional relationships, internships, and employment opportunities.

Professionals believe that interdisciplinary BIM processes and work-sharing and BIM-based communication are need to integrate such AEC competencies and to prepare students for internship and collaborative experience into a professional practice.

108.2.3 Course Objectives, Training Methods and Tools

The course objectives were developed to match the architecture curriculum needs in Building Systems Design taking into account building energy saving issues.

The main purpose considering the learning process is to improve students understanding in real-world professional experience, suggesting a training method applied in project-based scenarios.

Objectives course are listed below:

- *Objective* 1—educate students to the concept of BIM as a process and its applications in construction management;
- *Objective* 2—enable students to perform model-based planning, estimating, scheduling, coordination, and teamwork using BIM approach;
- *Objective* 3—carry out energy simulations analysis in project-based scenarios to solve sustainable design issues taking into account energy, environment, economic and social aspects.

Instructors carefully design course activities and materials to help students engage in experiencing and self-construction knowledge of BIM implementation workflows.

As a project-oriented course, instructors provided day-to-day coaching in a class to students in software use for the case study project. This approach is similar to on-the-job trainings in which students are involved in real-world projects under BIM experts' supervision.

Students are strongly encouraged to use building performance analysis tools and BIM technologies which are applied on the field to the Airport Architecture Design. As part of this work, students must to verify the existing building capacity to present peak day needs and to evaluate building spatial units by looking at the Levels of Service Analysis (LoS Analysis) according to IATA (International Air Transport Association) international standards. They were introduced to climate and site analysis tools to perform several simulation on a 3D environmental analysis model to address design of their project.

In addition, they were involved in practical workshops to integrate BIM concept with energy simulation tools for building performance analysis as contributing to decision making at the early stages design process and to improve the whole building construction quality into an interdisciplinary perspective. This approach can be used to select the best energy efficient design solutions and reduce the need for later design modifications that require extra time and cost.

The course program includes a series of activities which consist of lectures, presentations, computer labs and workshops. The training approach proposes a methodology structured on five stages listed in Table 108.1.

To realize a collaborative environment and class competition, students are required to work in team to exchange knowledge with other colleagues and to experience and learn collaboration, integration and teamwork.

Table 108.1 Summary on course structure and training methods

<table>
<tr><th>Program stage</th><th>Training methods</th><th>Assignments</th><th>Acquired skills</th></tr>
<tr><td>Airport design architecture and BIM processes</td><td>Lecture sessions
Group discussion</td><td>• Case study ID card + other 2 airports benchmarks
• Oral presentation on case studies</td><td>1. Know BIM regulatory framework (national and international)
2. Understand BIM process/ methods/tools
3. Investigate the state of the art on Airport Architecture Design</td></tr>
<tr><td>LoS (Level Of Service) analysis</td><td>Lecture sessions
Step by step instructions
Group discussion
Team work simulating Real-world professional practice</td><td>• Case study LoS analysis
• Oral presentation</td><td>1. Evaluate building spatial quality
2. Synthesize and report analysis results</td></tr>
<tr><td>Climate and site analysis</td><td>Lecture sessions
Software tutoring Lab
Step by step instructions</td><td>• Technical report
• Oral presentation</td><td rowspan="3">1. Analyze problems focusing on the objectives to be investigated
2. Learn how use software tools for parametric analysis and Interoperability
3. Apply BIM process/ methods/tools
4. Perform a model-based project evaluation
5. Synthesize and report analysis results</td></tr>
<tr><td>Building design modeling and energy simulation</td><td rowspan="2">Software tutoring
Project oriented course
Guest Lecturer for BIM approach
Team work simulating real-world professional practice
Lecture sessions
Software coaching</td><td rowspan="2">• BIM Project Case Study
• Oral presentation at final meeting</td></tr>
<tr><td>Technical solutions evaluation for building envelope</td></tr>
</table>

During a daily session, once instructor demonstrated how to use software tools solving case-specific BIM problems and providing a sequence of skill-building steps, then students followed step-by-step instructions to solve assignments on a series of interdependent problems. Step-by-step instruction, handouts and reading materials, video tutorials, coaching, and interactive simulations have been implemented as software tutoring methods in a physical class.

Also a virtual class has been created to facilitate group discussion and peer learning opportunities, and to raise stimulating topics for sharing knowledge and lecturing in class. Therefore students are required to sign up at Moodle online platform useful to publish announcements, news about the course program and assignments deadlines. Students need to use computers and tools, but also they need classrooms that facilitate team communication for improving interactions [12].

For integrated processes and teamwork, instructors turned classroom is a collaborative space simulating a real-world work environment, in which all teams collect information and make presentations to share their research activities and results with the whole class and facilitate work progress. This strategy appeared successful for modules integration and collaboration, simulating BIM processes and roles to create a collaborative learning for students with different skill and knowledge levels.

108.2.4 Assignments

Students have been involved in several activities in classroom to acquire critical-thinking abilities and practical experience working on a specific topic, developing a BIM execution plan through iterative design improvement cycles on a case study. Assignments have taken many forms considering the different stages of course program. As first team assignments, students carried out systematic analysis of Genoa Airport identifying two other benchmarks similar in terms of passengers traffic and size. By the end of first semester, working teams were asked to planning/designing a major expansion of Genoa Airport considering targeted LoS (Level of Service) analysis for the areas initial sizing. In order to investigate environmental issues, working teams performed a climate analysis on project site to identify strengths and weaknesses on design project, producing a short report to critically argue about different aspects of BIM implementation. In some cases individual assignments includes interviews, regulatory document analysis, BIM conference participation and students were asked to report results and observations to the classroom.

The final project, and the final presentation are useful to assess students ability to use BIM methods and sustainability approaches in project-based scenarios to develop more energy-efficient buildings (Fig. 108.1).

108.2.5 Assessment Methods and Students Evaluation

The course uses several assessment methods to provide the most useful and relevant information on students learning outcomes.

Direct assessments consist of tests, reports, assignments and presentations (individual or team). These methods report exactly what knowledge and skills students have acquired as a result of training course.

A weighted grading system was used to evaluate direct assignments outcomes according on inclusive criteria such as quality of technical contents, multidisciplinary approach, objectives achievement, clarity of work, graphics, communication and presentation skills, answering questions, and effort spent on teamwork.

Student work products have been reviewed throughout a year for evidence of learning during the course.

Students evaluation is based upon grading criteria depending on following factors:

- teamwork performance on final project and presentation at final workshop (up to 60%)
- participation in class discussions and training labs (up to 20%)
- assignments and oral presentations during the course (up to 20%)

Team-evaluation and peer assessment methods have been also used among student groups during classroom follow up on design project deliverables.

In addition to conventional assessment by instructors, working teams have been evaluated during a final Exam. Students presented their project proposals at a final exhibition “Redesigning GOA”, a one-day workshop that took place at the end of the course at the Genoa Airport (Fig. 108.2). Experts from the civil aviation industry and professionals from the Genoa Airport have been invited to participate. Students have reported details of strategies they implemented in their project proposals: some students only listed their strategies without discussing the reasons of some choice and their impact on design

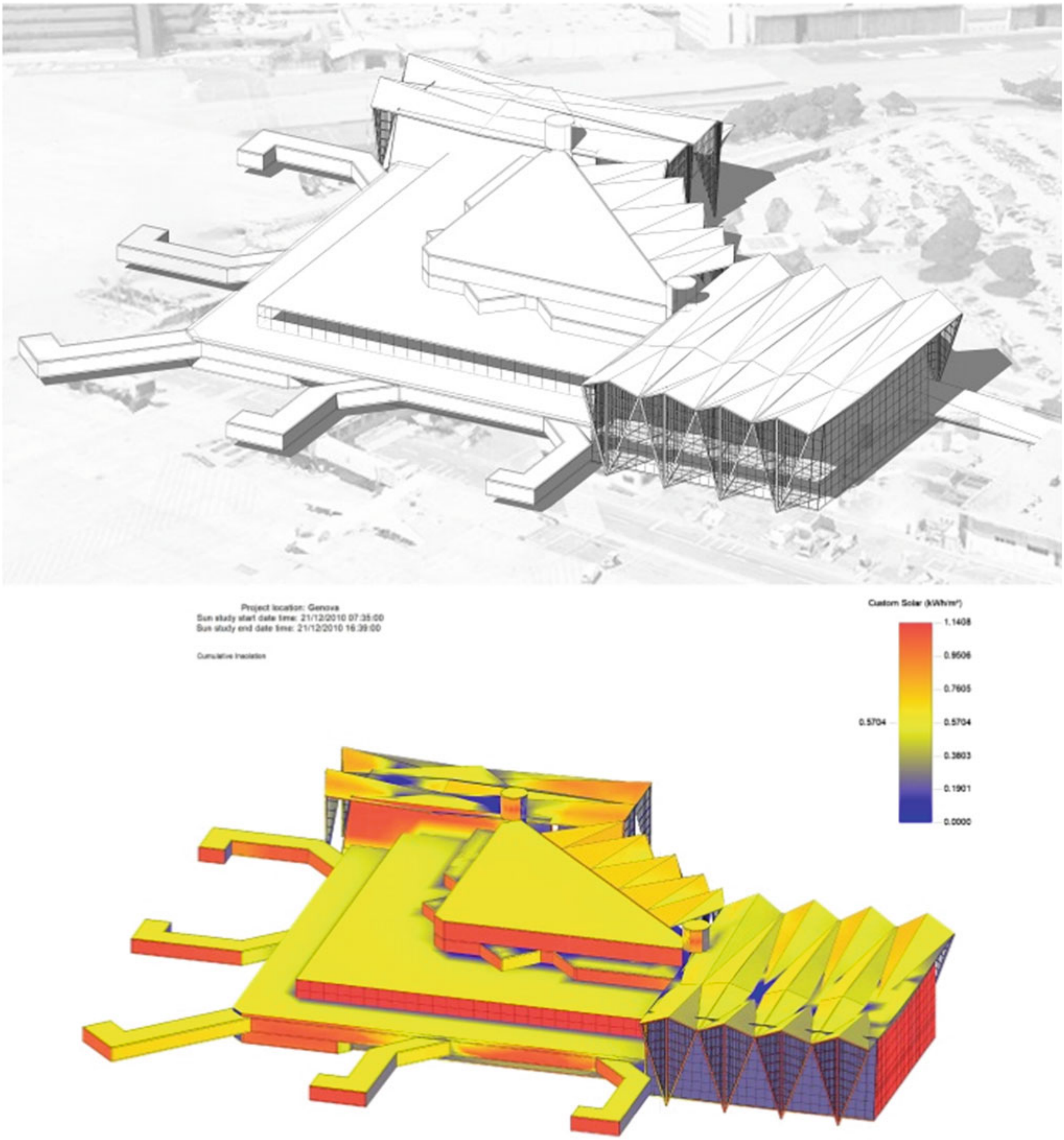

Fig. 108.1 Final Project: from BIM to BEM model of Genoa Airport expansion (Students: J. Amayou, G. Aspesi, D. Bufalo)

outcomes. Few students overcome this gap correctly interpreting client needs and showing results in a clearly and effectively way.

Assessments by professionals improved the learning experience of students leading to constructive comments on teams deliverables and outcomes. Authors initiative was so appreciated by the Genoa Airport General Manager, that led to internship opportunities for interested and qualified students who want to gain a general understanding of airport management and civil aviation industry.

Fig. 108.2 "Redesigning GOA" workshop and final exam at the Genoa Airport

108.3 Results

No data are available to evaluate quality course on students feedback and satisfactions before the end of the course. Students feedbacks on performance and quality of this cross-disciplinary teaching program will be available from surveys, interviews and online questionnaire designed for this course with rating and comments. This method includes a unified student rating of instruction used across the University of Florence to track the course results over time and improve overall course quality, including training methodologies and materials. Instructors monitored throughout a year percentages of students meeting the goal for each course objective to individuate successful strategies for future quality improvements. What appears is that the expected level of BIM competency for undergraduate students have reached intermediate levels on analysis, synthesizing, and evaluation abilities, while they still need to refine both technical and managerial skills.

Due to the high students number attending course, the main challenge into a cross-disciplinary perspective was to create a collaborative environment. This aspect requires more work for instructors to coordinate different tasks and to provide support to students which had more difficulties in learning from this kind of experience.

Authors believe that teamwork and classroom follow up are successful strategies to encourage students participation and joint-vision on final goals achievement.

108.4 Conclusions

Authors conclude that BIM competencies should be aligned with building energy efficiency and sustainability topics to provide the best educational outcomes in AEC education. Building modeling simulation tools play a key role in architecture design to assess overall building performances. A large literature review reported Building Information Modeling (BIM) adoption into AEC curriculum focusing on BIM modeling skills as well as analysis energy simulation tools, without taking into account BIM as process methodology [13, 14].

This paper proposed collaborative pedagogical methods reporting students experience within the Environmental Design Laboratory Training Course, providing students an effective method to approach the green building design issues using BIM and energy simulation tools to manage the overall design process. Course objectives, training methods and tools have been detailed focusing on the specific topic of Architecture Airport Design, with the direct involvement of experts from the civil aviation industry and managers from the Genoa Airport.

Assessment methods have been reported as well as students experience from the course and expected results for future improvements, and lesson learnt. Future challenges consist to take advantages over other international experiences and teaching strategies adopted by other educators in different countries, also creating opportunities for international student exchange programs between universities.

References

1. Jennings, P.: New directions in renewable energy education. Renew. Energy **34**, 435–439 (2009)
2. Ferrandiz, J., Fonseca, D., Banawi, A.: Mixed method assessment for BIM implementation in the AEC curriculum. In: Zaphiris, P., Ioannou, A. (eds.) Learning and Collaboration Technologies. LCT 2016. Lecture Notes in Computer Science, vol. 9753. Springer, Berlin (2016)
3. Rajagopalan, P., Wong, J.P.C., Andamon, M.M.: Building performance simulation in the built environment education Experience from teaching two disciplines. In: 50th International Conference of the Architectural Science Association Proceeding, pp. 359–368, University of Adelaide, Adelaide, Australia (2016)
4. Huang, Y.: Introducing an Advanced Building Information Modeling Course in Construction Management Programs, American Society for Engineering Education (2017)
5. Abbas, A., Ud Din, Z., Farooqui, R.: Integration of BIM in construction management education: an overview of Pakistani Engineering universities. In: International Conference on Sustainable Design, Engineering and Construction, Procedia Engineering, vol. 145, pp. 151–157, Springer (2016)
6. Ferrandiz, J., Banawi, A., Peña, E.: Evaluating the Benefits of Introducing "BIM" based on Revit in Construction Courses, Without Changing the Course Schedule. Springer-Verlag GmbH, Germany (2017)
7. Eastman, C., Teicholz, P., Sacks, R., Liston, K.: BIM Handbook: A Guide to Building Information, Modelling for Owners, Managers, Designers, Engineers and Contractors, 2nd edn. Wiley, New York (2012)
8. Forgues, D., Poirier, E., Staub-French, S.: The Impact of BIM on Collaboration: An Action-Cognition Perspective (2016)
9. Esposito, M.A., Bosi, F.: Architectural Design Technologies. Reshaping Design and Fabrication. Dida Press—Department of Architecture, Florence (2018)
10. Esposito, M.A.: Envelope's Details for the Green Airport Terminal. Firenze University Press, Florence (2010)
11. Nault, E., Aguacil, S., Rey, E., Andersen, M.: Energy performance analysis in interdisciplinary education—Lessons learned from a simulation-based teaching approach. In: PLEA 2017 Edinburgh—Design to Thrive, July 3–5, Edinburgh, UK (2017)
12. Zhao, D., McCoy, A.P., Bulbul, T., Fiori, C., Nikkhoo, P.: Building collaborative construction skills through BIM-integrated learning environment. Int. J. Constr. Educ. Res. **11**, 1–24 (2015)
13. Kandpal, T.C., Broman, L.: Renewable energy education: a global status review. Renew. Sustain. Energy Rev. **34**, 300–324 (2014)
14. Bozoglu, J.: Collaboration and coordination learning modules for BIM education. ITcon **21**, 152–163 (2016)

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