



Materials Education Symposia

6th International Materials Education Symposium

University of Cambridge, UK, April 10-11, 2014

5th North American Materials Education Symposium

University of Illinois at Urbana-Champaign,
March 20-21, 2014

Spring 2014 saw two key events for materials educators. Those teaching undergraduates about materials within engineering, design, architecture, sustainability, and other science subjects, were joined, in both Cambridge and Illinois, by several representatives of industry for two days of talks, workshops, discussion sessions, networking, poster sessions, and a social program. The Symposia provided opportunities to meet other educators and exchange ideas, while discussing the trends and ideas impacting materials teaching.

This report uses attendees' own words together with some highlights from the speaker program to show some of what happened in Spring 2014. To really find out more, why not meet the community in Singapore or at next year's events?





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Foreword by Prof Mike Ashby

Chair of the Symposia's Academic Advisory Committee

We live today in a world characterized by interaction. We interact through organisations, through trade, through the spread of ideas, and through personal communication, much of it enabled by the internet. When many entities interact there is feedback, some positive, some negative. The more intense the interaction and the more complex the system, the harder it is to predict the way the system as a whole will behave. Thinking in simple cause-effect relationships and developing ideas or projects in isolation is a poor way to tackle problems in the 21st century. *Instead we must recognize material science does not exist in a vacuum but is part of not one but many systems.* This recognition allows access to the richness that characterizes complex systems but it requires agility to embrace the possibilities that it offers.



“Above all, the sense of engagement, of a materials community that is forward-looking and enjoys what they do, was stronger than ever.”—Prof. Ashby

This perception of materials science and its teaching as components in wider systems permeated both the North American and International (Cambridge) Symposia. Materials science has escaped the narrowly-based, self-contained approach that characterised some subject areas. Instead we see Materials Science as a bridging subject, lying at the intersection of the pure and applied sciences. But it is only more recently that we have recognised its involvement with the industrial, economic, geo-political, environmental, and social systems in which we also operate. Incorporating this into our teaching is important since it will affect the working lives of our students. Cross-disciplinary teaching and interdisciplinary involvement of students in team-based projects is now widely adopted, in some cases displacing traditional methods entirely. But to accept this as the new norm is too hasty. We need *detail-hounds*—those whose fascination is to understand one component of a system in the greatest possible depth. We need *big-picture thinkers*—those who can see the links and the interactions. And we need *communicators*—those who can get the ideas, interactions and consequences across to the public and to government. The challenge is to encourage and support all three.

I won't go into details of the presentations here—the report that follows does that well. I will, however, say that, in my view, these were among the best of the Materials Education Symposia yet, combining perspectives from history, from current teaching experience, from industry, and from national advisors. Above all, the sense of engagement, of a materials community that is forward-looking and enjoys what they do, was stronger than ever.

On behalf of the Advisory Committee, I would like to thank all those whose presentations and contributions made the 2014 Materials Education Symposia such interactive and collaborative events. I am personally grateful to all those who joined me on the Advisory Committee, helping to put together this year's program from so many excellent submissions. We are particularly grateful



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Professor John Abelson and the University of Illinois at Urbana for hosting the North American Symposium and to Cambridge University for providing such convivial venues for this year's events.

I'm particularly pleased to acknowledge the continued support of:

- American Society for Engineering Education (ASEE), Materials Division;
- ASM International (the Materials Information Society);
- The University of Illinois at Urbana-Champaign (Department of Material Science);
- European Society for Engineering Education (SEFI);
- Federation of European Materials Societies (FEMS);
- University of Cambridge (Departments of Engineering and Materials Science & Metallurgy).

Finally, I would like to add my appreciation to that expressed by so many of the attendees for the quality of the presentations, to the attendees who created an atmosphere in which communication flowed, and to the team from Granta Design, who, as ever, oiled the wheels and smoothed the path on which the Symposia roll.



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Highlights from the 5th North American Symposium

University of Illinois at Urbana-Champaign, March 20-21, 2014

The 5th North American Materials Education Symposium was hosted by the University of Illinois at Urbana-Champaign. Attendees, representing both educators (teaching courses such as material science, engineering, sustainability, or design), and representatives from industry, were welcomed by **Prof. John Abelson** (University of Illinois at Urbana-Champaign) and **Prof. Mike Ashby** (Chair of the Symposium's Advisory Committee). They had gathered, as various participants explained, “*looking for new innovations for materials education*”, “*to see how other people address the issue of teaching engineering*”, and to find out more about “*teaching sustainable design and critical materials*”.

SESSION 1: Introducing Material Systems & Sustainability

Chair: Prof. Rick Sisson

Dr. Ron Kander (Executive Dean, Kanbar College Of Design, Engineering And Commerce, Philadelphia University) started the main session with a robust look at the “Why, What, and How” of materials and engineering education: “*we don't have good ways to **communicate** understandings and insights about complex systems to one another and to key decision-makers.*” Overcoming this communication challenge by equipping students for lifelong learning and application became a repeated theme throughout the symposium.

Dr. Linda Cadwell Stancin (Director of Core Structures, Engineering, and Technology, Spirit Aerosystems, Inc.) further enhanced this point when addressing the requirements for engineers working in aviation. They need understanding not just of complex engineering issues, but also of design, production, performance, cost, and manufacturing—therefore, the systems approach is



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“valuable for industry”. **Dr. Mark De Guire** (Department of Materials Science & Engineering, Case Western Reserve University) continued the emphasis on teaching across the disciplines, highlighting the importance of hands-on teaching, a topic which was picked up repeatedly by a variety of speakers. **Dr. Philip White** (School of Sustainability, Arizona State University) gave some examples of integrating sustainability into multidisciplinary teaching and raised the challenge of how educators can support understanding of ecological design in engineering education.

Over the course of the morning, it became apparent that sustainability must no longer be thought of as an “add on extra”. Making this point, **Dr. Suzanne Keilso** (Loyola College, Loyola University Maryland) focused on the compatibility of sustainability education and career focused education in materials. These themes were reflected in the morning’s concluding discussions. For example: how and where to include sustainability in the curriculum; who should teach it; which courses should cover it; and even what it includes.

SESSION 2: *Design & Simulation in Materials Education*

Chair: Dr. Mark De Guire

During the afternoon, the topic of interdisciplinary teaching and the need to help students consider real world situations came up again and again. Opening the session, **Dr. John Nychka** (Chemical and Materials Engineering, University of Alberta, Canada) emphasized how educators need to help students to “adapt solutions to real problems”, and look out for examples of good and bad design in their daily lives. Similarly, **Dr. Lisa Hix** (Technology, Design, and Safety Department, Keene State College) spoke about how students should be encouraged to “*take into account where materials come*



It was good to discuss lots of topics about teaching in a relaxed atmosphere.





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from and where they go... because nothing disappears!” She also highlighted the importance of equipping students to formulate the appropriate questions and research solutions to improve sustainability within the industrial economy.

Turning to the topic of simulations, **Dr. Tanya Faltens** (Network for Computational Nanotechnology, Purdue University), considered the challenge of helping students to really understand materials engineering concepts. She gave a demonstration of online visual 3-D simulations, which provide interactive engagement, supporting students as they explore the underlying science “from atoms to materials.”

Experiential, problem-based learning was the topic addressed by **Dr. Kyle Gipson** (College of Integrated Science & Engineering, James Madison University). His ‘Real-world Simulated Engineering Design Projects’ give students the freedom to propose methods, where to do it, to consider the costs, and forces them to justify their decisions. “*Students hate it during the project and appreciate it after!*” he concluded, explaining “*if you don’t get people upset, you are not doing anything: if you are not breaking anything, you are not learning.*”

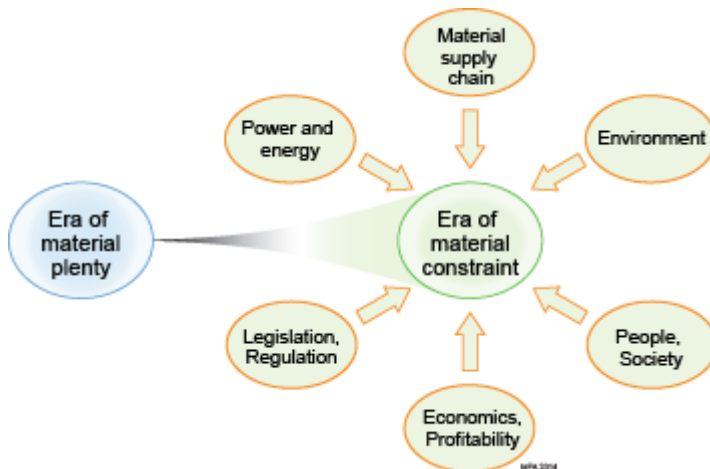
Another advocate of the hands-on approach was **Dr. Paul Eason** (Mechanical Engineering, College of Computing, Engineering & Construction, University of North Florida). Asking “*can accreditation be fun?*” he emphasized that, for good materials courses, educators should “*not map the outcome of courses to ABET but to the skills students need to gain for that subject.*” By taking this approach, he has instigated internships, student design competitions, and attracted externally funded research. He even suggested that “*students should build/develop/invent any needed new lab equipment*” as part of this approach.

SESSION 3: Material & Energy-efficient Design

Chair: Prof. John Abelson

The second day again provided extended opportunities for discussion and sharing of ideas. It was, particularly, a day of thoughtful questioning. **Prof. Timothy Gutowski**, (Mechanical Engineering, Massachusetts Institute of Technology), focused on the challenge of teaching about sustainability in

engineering. Asking “*what will our students be doing 10 years from now?*”, **Prof. Mike Ashby** (Cambridge University Engineering Department) acknowledged that many will be charged with managing materials-related risk, and discussed how teaching should respond to these changes. One change, as **Dr. Ashley White** (Materials Research Program Manager U.S. Green Building Council) suggested in her talk, should be bringing health into the Sustainable Building Materials Conversation.





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Of course, being sustainable doesn't have to be dull. **Dr. Eric Weber** (School of Architecture, University of Nevada) explained how his students have been exploring how technology can be a tool that assists people to reconnect with materiality, texture, light, and time, creating opportunities for memorable experiences as they designed the Solar Decathlon House. **Dr. Jacob Gines** (School of Architecture, Mississippi State University) is also taking a materials approach to teaching sustainability within architecture. He decided to include lab exercises in his teaching (“often architecture students just design and never build”), encouraging students to feel and touch materials, and to apply this as they consider culture, people, communities, and ecology.

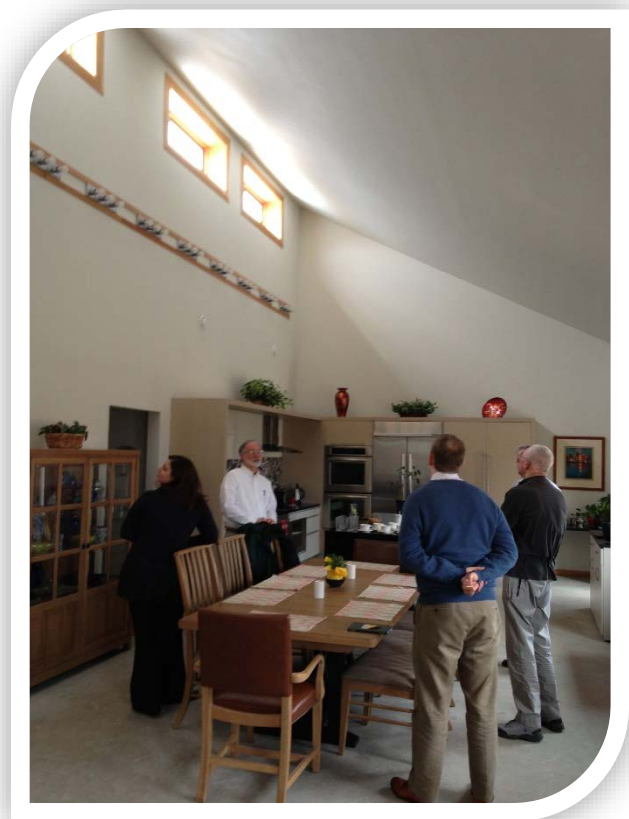
I enjoyed getting in touch with materials education developments, and having a great time with kindred spirits.

SESSION 4: Hands on: Demos & Projects

Chair: Dr. John Nychka

Hands-on teaching was something of an overarching theme throughout the whole symposium. However, the final session brought out some specific examples, **Prof. John Abelson** (Material Science and Engineering, University of Illinois at Urbana-Champaign) shared his experiences of the “zero-net energy home” at Ty Newell (pictured), and how this is encouraging students to use Systems Thinking—considering house location, number of windows, solar gain vs. heat loss, etc. **Prof. Rick Sisson** (Dean of Graduate Studies, WPI, USA), highlighted the success of project work with interdisciplinary students. He found that visual inspections of bridges, tunnels, etc. (degradation mechanism, fire, freeze-thaw effects, etc.), complimented the lectures, as well as giving students an insight into what employees at these places actually do.

Dr. Bill Heffner (Associate Director, Lehigh University, USA) gave some entertaining examples of teaching Chemistry, Optics, Nano, food science, electronics, processing, rheology, physics, thermo, data collection, and automation. His students study glass with candy glass and home-built apparatus. **Dr. Kathleen Stair** (Department of Materials Science and Engineering, Northwestern University), also spoke of the success of hands-on sessions. Her “discovery labs” are built on projects that are “*fun, cool, and technologically important.*” She noted that it is not always the students with the best academic grades that are the most creative and innovative.





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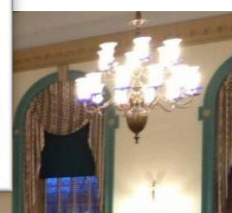
Prof. Rudolph Buchheit (Materials Science and Engineering, The Ohio State University), concluded the afternoon by issuing some more challenges: many universities are seeking to respond to elements of the Integrated Computational Materials Engineering (ICME) and Materials Genome Initiative (MGI) grand challenges pertaining to education of materials scientists and engineers. “*But what is the best way to produce graduates who are cognizant of the broad range of computational tools available to materials engineers and proficient to solve problems of practical importance themselves?*” Like many others during the two days, he shared both the successes and hurdles that they have faced in implementing new teaching approaches. Having issued these challenges, he was also able to issue an invitation: next year’s Materials Education Symposium will be hosted by The Ohio State University. He looks forward to finding out what has and hasn’t worked as participants take these ideas and integrate them into their teaching.

Read more and express your interest here: www.materials-education.com/2015/na

Networking and exchange of ideas during the social program



The informal and supportive atmosphere of the symposium meant that the educators present didn’t confine the discussions to the formal discussion sessions. Instead, questions about sustainability, interdisciplinary teaching, and preparing engineering undergraduates for industry spilled over into the evening meals and social program, which included tours of the historic sites, as well as today’s teaching laboratories.





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Poster Teasers and Poster Sessions at both Symposia

A particular feature of these Symposia is the ‘Poster Teaser’ session, which invites poster presenters to give a one minute introduction to their work during the program. These have been praised as a wonderful opportunity to get a quick overview of the many interesting ideas being presented. Coming just before the first break, they also helped match faces to names (and posters), enabling great discussions and networking opportunities right from the start.

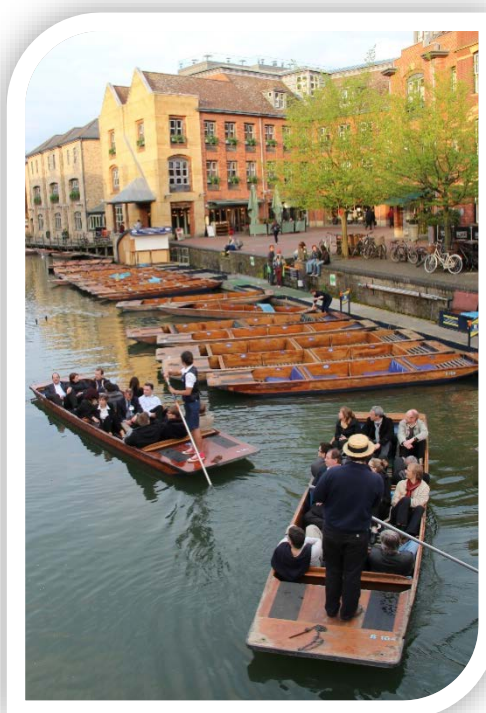
I consider the poster teaser session an attractive way of getting people involved in the symposium.

Highlights from the 6th International Symposium

Clare College, Cambridge University,
April 10 – 11, 2014

The 6th International Materials Education Symposium was this year hosted by Cambridge University’s Clare College. The second oldest of Cambridge’s 31 colleges, it provided a convivial atmosphere for discussion and sharing of ideas.

I appreciated the high-quality poster session.





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SESSION 1:

Materials and Sustainability

Chair: Prof. Peter Goodhew

Prof. Yves Bréchet (Grenoble-INP & Atomic Energy and Alternative Energies Commission, France) opened the International Materials Education Symposium with a look at “Sustainability and nuclear energy: materials issues”. He warned that “*common sense often vanishes in the passion*”, and argued persuasively for equipping students to properly handle materials selection problems. They must learn to take full account of resource demands (e.g., steel, aluminum, glass) when looking at the sustainability of energy production.

I particularly enjoyed the talks about sustainability, a topic that I am not very familiar with... a good opportunity to learn more.

Prof. Mike Ashby (University of Cambridge, UK) continued the theme, asking how we should prepare students for today’s “era of material constraint”. He highlighted that “*the increasing complexity of products creates a dependence on a large number of elements, some comparatively rare.*” In the discussions that followed, others emphasized the need for “*every lecturer to inject these issues into pre-existing teaching.*” It was also noted that interesting benefits are starting to be seen from mixing between the disciplines, for example, between political and engineering students.

Dr. Jonathan Cullen (Engineering, University of Cambridge, UK), provided one industry focused example. He reported on a five-year ‘journey’ with the steel industry, using cross industry engagement, evidence-based arguments, clear messages, and “a good deal of persuasion” to present demand reduction as a credible option for reducing emissions. Others agreed: “*we must teach our students that ‘sustainable materials’ might not be about finding new materials... but instead finding new ways to use less material.*”



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It is widely recognized that these topics must not be confined to engineering students. The final presentation in Session 1, from **Dr. Javier Orozco Messana** (Universitat Politècnica de València, Spain) looked at the importance and challenges of teaching sustainability for materials in architecture. Using LCA and Eco Audit approaches, students are being encouraged to consider reuse and recycling of building materials and components, as well as alternatives such as hybrid materials.

SESSION 2: Materials and Design

Chair: Dr. Hugh Shercliff

“*You don’t really understand metal until you’ve hit it*”, said **Prof. Mark Miodownik** (Director, Institute of Making, University College London, UK), as he shared his experiences at the Institute of Making, a multidisciplinary research club for those interested in the Made World: “from makers of molecules to makers of buildings, synthetic skin to spacecraft, soup to diamonds, socks to cities.” He reflected on the positive and negative impacts of multidisciplinary materials research as well as public engagement. “*As materials researchers,*” he noted, “*we are largely absent from newspapers. If we want to have a say in what the public think, that matters.*”

Dr. Xinxin Li (University of Science and Technology Beijing, China), provided suggestions for allowing engineering students much-needed industry experience when faced with challenges, such as economy and safety. A new virtual internship platform will provide a way for the University to help the steel industry train new employees, and also undertake joint scientific research.

I attended this series of symposia for the third time this year—so I was sure to get very valuable experience, and learn new approaches.



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In the next presentation, **Dr. Erik Tempelman** (Industrial Design Engineering, Delft University of Technology, Netherlands), explained that *“the study of manufacturing processes presents an excellent opportunity to (re-) acquaint students with many key concepts from the field of materials science.”* However, he sees a need for new teaching approaches that ensure students consider *“at what cost, and with which quality”* their designs can be manufactured. He also argued that education should focus on equipping the student for lifelong learning. Discussions on this topic at a previous Materials Education Symposium led Dr. Erik Tempelman, Dr. Bruno Ninaber van Eyben, and Dr. Hugh Shercliff to produce a new textbook: *‘Manufacturing and Design’*. They took this opportunity to present a copy to Prof. Mike Ashby.



‘Updating the Textbook’ was the topic of **Prof. Peter Goodhew’s** presentation (Universities of Liverpool and Derby, UK). He has been experimenting with the idea of a “comment-able” book—the original text, published as an Open Educational Resource, to which readers can add comments and provide an alternative point of view or an additional example, to any paragraph (see <http://teachingengineering.liv.ac.uk/>). This opened an interesting discussion on the role of paper textbooks vs online resources, and how to make the appropriate editorial processes work.

The final presentation on day one, by **Prof. Srinivasa Ranganathan** (Department of Materials Engineering, Indian Institute of Science, Bangalore, India), drew together many of the day’s themes. In speaking on the “coming of archaeological material science”, he emphasized the importance of interdisciplinary teaching, and the impact that studying real-world artifacts can have on students.

The best thing was... improving my knowledge of the latest news in materials education and meeting people from my field.

The day concluded with a lively discussion, facing up to the challenges of making “hands-on studies” available to everyone, everywhere—*“teaching by handling things can be very expensive.”* Those present also appreciated the call both to inspire the next generation of students and to *“educate readers of newspapers.”*

SESSION 3: Material Systems

Chair: Prof. Bill Clyne

One major challenge addressed on day two was how to train the next generation of engineering, design, and architecture students to think about materials and material systems in such a way as to equip them for both industry and research. “Systems thinking,” as **Dr. Ronald Kander** (Executive



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The atmosphere of the symposia is excellent!

Dean, Kanbar College of Design, Engineering and Commerce, Philadelphia University, USA) explained, “*is an interdisciplinary approach—teaching students to think from a systems’ point of view (rather than just delivering content and solutions)*”. Possible solutions were immediately forthcoming: **Janna Fabris** (Department of Materials Engineering, The University of British Columbia, Canada) took the specific example of Composite Process Design, emphasizing that “*new methods are required to cope with inherent uncertainty and risk associated with complex engineering system development.*” She explained how the Composites Research Network (CRN) is establishing a framework that attempts to capture knowledge that is correct, open, usable and useful, “*linking ‘know-how’ with ‘know-why.’*”

Several speakers drew on the automotive industry for examples of how thinking is being transformed. **Prof. David Embury** (McMaster University, Canada) took historic look: “*For over a century the automobile has provided a catalyst for development of Materials and related manufacturing processes. It is a driving force for social change*”. **Dr John Robertson-Begg** (School of Engineering and Technology, University of Derby, UK) agreed. In his presentation on “Reframing petrol heads—encouraging motorsport students to think about sustainability” he stressed the need for students to move away from focusing on speed. Teaching sustainability encourages them to think about manufacturing, not just design and materials. One ongoing challenge, he noted, is how to overcome the preconceptions from the different backgrounds of his multidisciplinary students.

Continuing the theme of interdisciplinary teaching, **Dr. Frederic Veer** (Materials Science, Delft University of Technology, Netherlands) gave some examples of how architectural engineering students (both architectural engineering and civil engineering) are studying structural design with



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glass. They are encouraged to analyze the problem, then find which materials have suitable properties and thus find a route to design a material or composite that would function better, using the Hybrid Synthesizer in CES EduPack. Students have also appreciated using the Eco Audit Tool to help them explore the environmental impact of the designed material/composite.

*I have met fantastic colleagues,
and I have collected a lot to
relevant information regarding
my main interest:
modernization of education.*

SESSION 4: Sparking Interest: Innovation in Materials Teaching

Chair: Dr. Noel Rutter

Sustainable technology is a topic that students often have some level of interest in. However, the challenge can be in teaching this, and other materials issues, in such a way that both inspires them and equips them to apply it in future industrial careers. In finding ways to teach about sustainable technology development, **Dr. Didac Ferrer** (Sustainability Science and Technology, Universitat Politècnica de Catalunya) highlighted how engineers should be trained to cooperate with the various stakeholders, and learn to think about long term perspectives. He showed results from 3 trials (University of Cambridge, UPC, and University of Illinois at Urbana-Champaign), where students apply the approach to a contextualized project taking into consideration the sustainable strategies available. **Dr. Ion Cosmin Gruescu** (Mechanical Engineering, University of Lille 1 – Sciences and Technology, France) showed how Eco-design tools and materials selection can be used to spark student interest. He highlighted the importance of “*integrating eco-criteria into the design process as a design requirement.*”

A particular highlight of the afternoon was the “In the Loop” critical raw materials game presented by **Katherine Whalen** (Industrial Design Engineering, Delft University of Technology, Netherlands). Sharing the results of her MSc project, she explained how a game-based approach can create





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awareness about materials criticality from the design point of view, enable interaction between different disciplines, and provoke questions that prompt the students to dig deeper.

Moving from “dummies to students” was the focus of the new active methodologies presented by **Dr. Núria Salán** (RIMA-GIDMAT, Materials Science and Technology Community of Practice, Spain). “*In a conventional classroom,*” she explained, “*student’s bodies might be in the room, but not their minds: they are like dummies*”. She encouraged educators to do a self-assessment on how they teach, and then try using the tools the students use for course communication (YouTube, Facebook, Skype). Often, students will be more inspired if you “*teach less content but teach them to think!*” She also emphasized the importance of sharing real research experiences so they get an idea what is actually being done/applied. Building on this, her students have particularly benefited from role-playing activities in teams. Students form groups and take the role of a company with corporate identity etc. She instigates an email exchange where she is the customer: they are the consultants and willingly do the necessary research to answer her inquiries.

The day’s final presentation, from **Dr. Ian Mabbet** (Baglan Bay Innovation & Knowledge Centre, UK), looked at raising awareness of materials education to expand the undergraduate talent pool. Revisiting a topic raised on Day 1 by Prof. Mark Miodownik, he talked about the importance of outreach and public engagement (lectures, workshops (all levels), and science festivals). “*Engaging and teaching students on STEM topics, specifically in materials, is key for future engineers and scientist,*” he concluded.

As the day drew to a close, **Prof. John Wang** (Materials Science & Engineering, National University of Singapore) gave an ‘Introduction to the 1st Asian Materials Education Symposium’. Building on the success of the Spring events in Europe and North America, he looks forward to welcoming speakers such as Prof. Mike Ashby (Cambridge University, UK), Prof Peter Goodhew (Universities of Liverpool and Derby, UK), Prof. David Embury (McMaster University, Canada), Prof. Srinivasa Ranganathan (Indian Institute of Science, Bangalore, India), Prof. Shih Choon Fong (National University of Singapore), and Prof Kristin Woon (Singapore, University of Technology and Design) to share the latest ideas on materials education at this first gathering of materials educators in Asia. Read more and register here: www.materials-education.com/2014/singapore/

In the final discussions, several key themes from the 6th International Materials Education Symposium were drawn together. These included:

- The importance of interdisciplinary teaching.
- Strengthening links between education and industry (e.g., real-world projects, access to resources and techniques used in industry, multidisciplinary teams and projects).
- Reinvigorating class-room teaching and project based work (new educational strategies and paradigms).
- Introducing sustainability alongside materials and design related teaching (meeting accreditation criteria, creating multidisciplinary teams).
- Raising the awareness of materials teaching across all fields of science, engineering, and design.

The broadening of materials education and help them produce embrace design, sustainability, and other domains is impressive.



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Social program and further opportunities for networking

Even before the first presentation, the Symposium was providing opportunities for networking and collaboration. Presenters enjoyed punting down the River Cam to arrive at Magdalene College for the candle-lit Presenters' Dinner on Wednesday night. About 30 attendees took up the opportunity of a tour of the new facilities at Cambridge University's Department of Materials Science & Metallurgy, on the West Cambridge Science and Technology campus. Clare College hosted the formal Symposium Dinner, providing a relaxed atmosphere to continue the first day's discussions. Participants also enjoyed a walking tour of Cambridge on the Saturday.



See you all next year!

Following the success of this year's events, the Academic Advisory Committee will meet to decide on next year's Symposium themes in June. They encourage those interested in sharing their materials education experiences to keep an eye on the Symposium website and consider submitting an abstract for a talk or poster... or both!

- **1st Asian Materials Education Symposium**
National University of Singapore, Dec 11-12, 2014
- **7th International Materials Education Symposium**
University of Cambridge, UK, April 9-10, 2015
- **6th North American Materials Education Symposium**
Ohio State University, March 25-27, 2015

*The atmosphere is
unique, supporting,
and helpful.*

To find out more, and register your interest, please visit www.materials-educations.com.