What We Have Learned at Mudd Design Workshop VI, 'Design and Engineering Education in a Flat World'*

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This paper summarizes and highlights the presentations and discussions that took place during a workshop on engineering and design education in a flat world. Mudd Design Workshop VI (MDW VI) was held at Harvey Mudd College in May 2007, and supported by Mudd's Center for Design Education. This article endeavours to capture the spirit of the participating engineers and designers who worked to identify and articulate important flat world issues in design and engineering education, as viewed in their everyday roles as educators, researchers and practitioners.

Keywords: Design education; design practice; globalization; flat world; design research

INTRODUCTION

THIS PAPER REPORTS the results of Mudd Design Workshop VI ("MDW VI"), "Design and Engineering Education in a Flat World," held at Harvey Mudd College, in Claremont, California, during 23–25 May 2007 (see Fig. 1). The results are in fact the intellectual products of much vigorous discussion and debate. The next section of the paper details both the organization of the workshop and the methodologies by which the results reported were identified and recorded. The results themselves then follow, subdivided into three parts: (I) What Have We Learned; (II) The Most Important Ideas and Issues; and (III) I like. . . I wish. . . .

HOW WE IDENTIFIED WHAT WAS LEARNED AT MDW VI

The Workshop was organized largely along the lines of its five predecessors [1–5], at Harvey Mudd College, in Claremont, California, during 23–25 May 2007 (see Fig. 1). —each session moderator was charged to capture what he or she believed to be the three or four most important ideas or issues brought out in a session, either from the presentations or from the ensuing discussion. The moderator of the Wrap-Up session (JWW) did the same for the keynote talk and other non-session presentations.

These key ideas were compiled as a Power-Point® presentation and also copied onto Post-it® notes (one key idea per note) before the Wrap-Up Session. Four identical sets of notes were prepared. The Wrap-Up Session started with a presentation of all of the captured 'most important' ideas and issues, with some discussion, mostly for clarification. The Workshop participants were then challenged to gather the thirty-four (34) ideas and issues according to common themes, in order to obtain a compiled set of major concepts on which participants might choose to work after the Workshop. The challenge was structured in that the participants were asked to construct affinity diagrams [6, 7]. Since having some fifty participants working together on a single affinity diagram seemed an unwieldy prospect, the audience was divided into four teams, each of which was challenged to group all of the 34 ideas and issues (see Fig. 2). This did complicate the final analysis since each team grouped items somewhat differently and assigned different titles to each of the affinity groups it formed.

Commonality was sought using a spreadsheet with the 34 ideas and issues as the rows, and the team groupings as the columns [8]. Columns were brought together according to the number of ideas and issues they had in common, and new overall headings were applied that seemed to capture the ideas of the several team group titles. These overall headings are the nine most important themes listed below along with the important ideas and issues that emerged during the Workshop's sessions and during and after the Workshop's two dinners. The results of an inspirational exercise conducted at the Workshop's closing luncheon are described later.

A baseline set of questions for the Workshop was proposed by the Chair (CLD) of the MDW VI Organizing Committee. He suggested that colleges and universities might think, as companies should,

Fig. 1. Designed for HMC's first-year design course, E4: Introduction to Engineering Design, the Parsons Design Studio was the venue for the MDW VI sessions.

Fig. 2. Scenes from the affinity diagramming exercise at MDW VI.

how their programs cannot be outsourced or easily replicated. Thus, they should emphasize what:

1. differentiates them from similar educational programmes;
2. adds value for students, their parents, employers and graduate schools.

Further, engineering programmes should note that many basic/standard engineering tasks have become commodities that are being outsourced. Engineering faculty and administrators should therefore ask for what environments are we preparing our graduates, what experiences should our students have and what skills should they gain?

The Workshop's keynote speaker, NASA's Chief Engineer, Christopher J. (Chris) Scolese, emphasized the need for non-commodity engineering graduates by pointing out that developing and nurturing systems engineers is a critical need. He demonstrated this need through a review of the international flavor of NASA's space exploration programmes.

WHAT HAVE WE LEARNED?

The Design and Engineering Education in a Flat World theme was extremely broad. Finding

commonality among the ideas brought forth in the varied sessions was difficult. Based upon input from the Workshop participants, the most important themes identified were (in descending order):

- Tools and methods will be needed for studying and supporting design, and for assessing outcomes.
- To effectively work globally, engineers will have to understand cultures and languages.
- Attributes and skill levels desired of graduates will have to be better defined.
- Engineers will need integrative, systems-thinking skills that differentiate them in a flat world.
- Collaboration and communication will be ultra-important to multi-cultural teams.
- Individual engineers' responsibilities in a global, multi-cultural environment will have to be defined.
- Faculty commitment—including their own global experiences—will be critical.
- Cross-cultural classes will be very important.
- Engineers and faculty with the needed systems viewpoint will be hard to find.

Departing from precedent set at previous MDWs, no attempt was made at MDW VI to elicit or assign action items for individual participants. Rather, this set of important themes challenges every participant (and every reader!) to consider what new or different things they can do to prepare today's engineers and the students who will be tomorrow's engineers to succeed in this new environment.

THE MOST IMPORTANT IDEAS AND ISSUES

Panel: The Engineer of 2020 and The Gathering Storm

The following were the key points identified and the questions raised during this panel discussion:

- The integrative intellectual skills needed by engineering graduates as identified in Engineer of 2020, the Boeing List of Desired Characteristics of the Engineer and the educational outcomes specified in ABET Engineering Criteria 2000 (3a–k) show close agreement.
- In view of the quadruple convergence of global warming, rapidly growing world population, the finite supply of natural resources and the inability or unwillingness of institutions and cultures to change, as identified in John McMasters' *Perfect Storm*, the need for engineering graduates with such integrative intellectual skills becomes more urgent. However, developing such skills demands educational models that are not consistent with the dominant academic research culture.
- Traditional engineering skills limited to specialized technical competence are increasingly vulnerable to being viewed as commodities and outsourced to lower-cost areas of the world, as enabled by the Internet. Integrative engineering skills that add value and can be used to differentiate employers in the marketplace are unlikely to be outsourced.
- Is the 4-year model adequate for professional engineers?
- What components of your engineering curricula will prepare engineering students to meet or prevent this challenge? What is missing from the curricula?

Assessing flat world skills

The following points were raised in this session:

- There is a need to develop and validate instruments that require less labour to process than is needed in conventional protocol analysis.
- Instruments to assess the design competencies of students and experts do exist.
- Develop a web-based repository of design problems and assessment tools.

After-dinner discussion: what does a 'flat world' really mean?

Harvey Mudd College's president, Maria Klawe, presided over an after-dinner discussion on the real meaning of Thomas Friedman's [8] now-famous phrase, a 'flat world'. In the context of considering the perceived value of cross-cultural education experiences, the following were discussed:

- Global Projects, in which geographically dispersed and culturally diverse student teams collaborate on design projects.
- Study Abroad, in which students spend a semester or a year studying at a college or university in a foreign country. It was noted that:
  - not many engineering majors do it;
  - engineering faculty should be role models and set examples.

Flat world teaching and design tools

This session produced the following insights:

- Cultural issues are central to good design.
- We do not have a flat world with respect to access to resources and opportunities.
- Metaphors and analogies are useful at different points in the design process:
  - metaphors describe 'why' or 'what' and are useful in problem definition or framing;
  - analogies describe 'how' and are useful for generating alternative designs in conceptual design.
- But, metaphors and analogies have limits:
  - they highlight and they hide;
  - the degree to which they are understood and communicated may well depend on language and culture.
- The theory of stuck!: detecting flow and stuck enables the opportunity for beneficial interventions.
- A spectacular failure is more useful than a mediocre success.

Cross-cultural considerations
The following points emerged during this session:

- Culture is difficult to define but it has clear effects on all aspects of engineering design, e.g. framing the problem, design process, design outcomes.
- Although not necessary for successful collaboration, language acquisition is essential for deep cultural awareness.
- Engineering professors can help student engineers understand the social aspects of technology with the help of progressive language faculty.

Multinational curricula
Three significant ideas were noted here:

- Transferring a design course from one country to another, or teaching a multinational design course can work, and there are several examples of it working well.

Table 1. Likes and wishes in teaching

	I Like:	I Wish:
=>	That my institution values teaching	I had a lot more time to do it
=>	Teaching undergraduate student design projects	I had another 10 years to do it
=>	That students tend to be suspicious when they first learn about it	I had more time to do it
=>	The learning I get when I teach	I could learn more faster
=>	Teaching open-ended design projects	I wish the dog was before the tail
=>	Being part of a community like this one	I wish we were more respected where I teach
=>	That the human element is coming to the fore	<pass>
=>	Teaching human factors issues	I was more effective at convincing students they were important
=>	Teaching as much as learning	I could pick up a few more extra degrees
=>	The personal relationship you can build up with the students teaching these sorts of projects	It was possible to do more of that
=>	That I really care about the students	. . .but sometimes too much
=>	The great bunch of students and that I'm at an institution where the community does value design education	It will remain institutionalized when I leave
=>	Seeing light bulbs go off in students' heads	I could make more of those light bulbs go off
=>	Creating an environment in which students can learn on their own	I didn't have to wait 2 years for another Harvey Mudd conference
=>	To use a strategy where I can let the students learn and be creative	I had more evidence to support this strategy of teaching
=>	The lateral thinking from this meeting	This knowledge would transfer outside the United States
=>	Learning more about teaching	More colleagues were interested in learning more
=>	That we have the opportunity to promote design creativity	Institutional silos had already changed
=>	Teaching	There were no meaningless requirements on the students
=>	That I care about teaching	I wish I knew whether my caring (about my teaching) really makes a difference
=>	To see students shine	There was more time to talk about teaching
=>	To see students as individuals	There was more time with them
=>	To see students out of the classroom	I was better at formative assessment
=>	Owning our graduate design courses	Take design research and connect it better to teaching design
=>	Teaching design in small teams	There was more faculty to handle more students
=>	Being part of innovation and change	It were easier
=>	Teaching innovation	I could do a better job at it
=>	Teaching	There were more faculty who wanted to improve
=>	As when teaching in pre-school I like weaving more skills together in my teaching	I knew how to do this with a class of 200 engineering students
=>	Fashion freedom—change the world	We could start doing this as soon as possible
=>	Teaching something I believe in passionately	That it was easier to do
=>	The relationship between engineering and the world	I had more time at meetings like this
=>	Laughing and playing with the students	I spent more time with students in the lab helping them when they're stuck

- Students in these courses can get a meaningful experience without foreign language knowledge, but having that knowledge can lead to a deeper experience. Faculty who intend to lead such courses over an extended period should strongly consider learning the language.
- The principal challenge facing multinational design courses is sustainability: these courses are expensive and they take a great deal of faculty time.

Communication and teamwork

This session put forward several intriguing ideas:

- Good communication fosters good teamwork. It is important for students and teams to be knowledgeable about teamwork, the principles of effective written and oral communication and about conflict management. Reflective activities help to reinforce the principles and help design teams grow in several positive directions—especially in the flow of new ideas.
- It is important to create 'collaborative relational space' to promote successful collaborations. Members of teams must be able to cross (shifting) disciplinary, cultural, physical and technological boundaries. Once members of the teams gained 'trust' in one another and the team, it helped them through conflicts.
- Studies have shown that distributed teams often face social issues of building trust and cohesion that co-located teams do not. As such distributed teams worked to overcome these issues, the teams' performance of other tasks suffered.
- Working with distributed teams in 'poor communities' required person-to-person communication to overcome the challenges associated with distance communication. Individuals on the teams need to know that setbacks and successes are going to occur and that good results can still be achieved.

Banquet talk and discussion: reflections on design thinking

Stanford's Bernie Roth entertained and stimulated the audience with some personal reflections on design thinking (see the CD of [8] for the PowerPoint® slides). Among many provocative points, he distinguished between trying to do something and (actually!) doing something, and reminded us that students are not just vessels to be filled by the teaching professor. Rather, they are people who need to have their own experiences and to develop their own stories.

Social entrepreneurship and sustainable design

This session produced four notable thoughts:

- Third world countries and people do not have the sort of infrastructure with which we are familiar (and which we take for granted).
- The alumni of a project class felt that working on a multidisciplinary team was the most important element of the class.
- A natural and important question for those interested in social entrepreneurship is: what is the natural boundary of our responsibility as engineers, that is, where are our systems boundaries?
- It is hard to find faculty for innovative engineering programmes.

I LIKE . . . I WISH . . .

In the continuing spirit of having the Mudd Design Workshops be more than a forum for pleasant discussion, the MDW VI participants were given one last assignment at the final luncheon Each attendee was asked to identify 'what I like . . . and what I wish . . . about my teaching'. The responses of those there, as captured in real time by Jonathan Hey and Patrick Little, were as listed in Table 1.

These lists of aspirations, of likes and of wishes, represent the inspiration expressed by the participants in Mudd Workshop VI as they got ready to go back to their jobs and face the very themes, issues and paradoxes to which they had been exposed over these three highly interactive days.

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