Building Synthesis: 'Practicing' in Academia

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Introduction:

This paper outlines a new, and developing, teaching strategy at the University of Virginia, School of Architecture. Challenged to bring 'technical support' to the final year graduate comprehensive studio, 'Building Synthesis' enables an inter-disciplinary dialogue about environmental, structural and envelope design strategies between students, faculty, practitioners and industry.
The exploration of building systems within an academic setting often removes many of the pragmatics of practice. Given an architectural design has the potential for a multitude of construction responses, the majority of which are driven by factors far beyond the proverbial drawing board, there is a requirement for architecture students now to look more at process and to allied professions to gain an understanding of how a material or technology can be applied to meet both aesthetic and performance requirements. 'What do you want to see?' is fundamental in terms of design but, if you want to achieve success on site and a low level of energy consumption, so is how a building can be realized through the multitude of available and emerging materials, technologies and construction systems.

The 'Building Synthesis' course was conceived in response to a series of fundamental issues:

Inter-disciplinary:

Large scale building practice today is the product of multi-disciplinary and inter-disciplinary collaboration. A design team will consist of many professional voices working (in the best scenario) together with fabricators and contractors to meet the demands of a complex program. However, it can be difficult to establish a link with other disciplines within the academic system. The pragmatics of course organization and aligning syllabi within one department can be hard enough, not to mention coordinating architecture with, say, engineering. The teaching of structures and MEP even within architecture programs is usually not related directly to studio, rather compartmentalized and separate from the design process.

Performance analysis:

Post-design analysis can be used as a way for technical courses to integrate with design studio. But what if design, technical research and analysis could be assimilated directly through one studio project? The comprehensive studio project then becomes a *synthesis* of design, technical research and analysis. In order for a student's design proposal to be credible they need to establish that their environmental and technical 'narrative' performs credibly either through designation of precedent, or through the demonstration of performance models.

Fully integrated environmental strategy:

Whilst charged with preparing students for the profession, final year graduate studio also offers the opportunity to change practice and perceptions within the market environment. If the 'best of practice' and cutting edge advances are discussed and explored within the academic environment as a form of research development there is a real opportunity for a sustainable 'mind set' to be percolated through education into practice, and vice versa.

‘Test Bed’

Given the above, ‘Hothouse: double skin envelope - an environmental strategy?’ was a workshop I organized and ran at the invitation of the Architecture School at Washington University, St Louis as part of a series of environmental workshops. This became the ‘test bed’ for what has now been expanded into a listed course here at the University of Virginia.

Invited guests to the workshop were Patrick Bellew and Gerald Pde of Atelier Ten, Environmental Engineers, London & New York. Atelier Ten have been “delivering environmental and sustainability advice to clients and architects who are looking for 'greener' ways to build their buildings” since 1990, with extensive experience both in Europe and the USA.

The exploitation of an envelope's 'depth of surface' through the application of a double skin has become a widely taught, and applied, strategy over the past ten years or so. This workshop sought answers to the following: How successful are these double skins? Do they really make a difference to projected energy consumption? What are the real criteria for an environmental approach to envelope strategy? - Does more glass make environmental sense or does the very premise need to be challenged before we build another generation of potentially poorly performing buildings?

We investigated the aesthetic & environmental aspects of double skin envelope through an exercise which set a series of parameters including structure, orientation and location (New York, Anchorage, Atlanta and Las Vegas). Students were also given a 2D image from which to generate a ’depth of surface’ within the limited time available. (see fig. 1)

Based on outline principles and relatively simple energy analysis using ‘E-Quest’ software students were able to test basic performance assumptions of building envelope relative to their specific location in the US. By testing these assumptions, even in this short 12 hour design exercise, simultaneous consideration was given to environmental performance and aesthetic decisions for both a single and a double skin envelope.

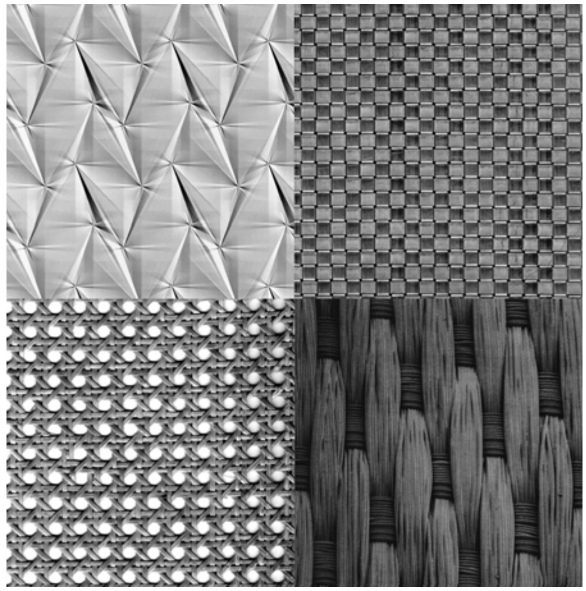

Fig. 1. 2D images given to students as ‘design generator’ (see footnote 1 for sources)

The basic parameters for all four location studies were as follows:

1. Orientation:
   south/ west
2. Location:
   LasVegas/Anchorage/New York/Atlanta
   (Specific TMY2 climatic data for each location was automatically retrieved by the programme from the Department of Energy website once longitude & latitude were inserted to the model).
3. Building type:
   High end office workspace
4. Floor to ceiling height: 10’
5. Floor to floor height: 12’
6. Depth of surface: 1’ to 6’
   as proposed
7. Overall building height:
   Max. 24 storeys
8. Max. Plan Depth: 15’
9. Typical Office plan: 150’ sq. feet
10. Structural system: Concrete frame
11. External Wall Construction:
    R11 Mass Wall only on south facing façade. All other walls were adiabatic
12. Glazing: Single pane glazing
13. Thermal comfort range: 70 - 78˚F

Annual Energy Consumption	Las-Vegas		Anchorage		New York		Atlanta	
(kWh)	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE
Space Cool	1560.1	865.8	125.3	132.2	547.9	445.8	900.7	588.7
Space Heat	0	31.9	1552.7	743.1	114	6.2	33.3	110
Vent. Fans	477.2	241.1	560.8	500	371	371	419.9	363.2
Pumps & Aux.	99.6	99.6	312.9	312.9	187	187	121.5	121.5
Misc. Equip.	1776.8	1776.8	1776.8	1776.8	1776.8	1776.8	1776.8	1776.8
Area Lights	1016.7	1016.7	1016.7	1016.7	1016.7	1016.7	1016.7	1016.7
Total Energy	4930.4	4031.9	5345.2	4481.7	4013.4	3803.5	4268.9	3976.9
Total HVAC Energy	2136.9	1238.4	2551.7	1688.2	1219.9	1010	1475.4	1183.4
HVAC % Savings	-	42%	-	34%	-	17%	-	20%
	Las-Vegas		Anchorage		New York		Atlanta	
Annual Energy Intensity	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE	SINGLE GLAZING	DOUBLE FAÇADE
(kWh/Sq.ft)	9.8608	8.0638	10.6904	8.9634	8.0268	7.607	8.5378	7.9538

Fig. 2a. Data output from Equest analysis of 'Hothouse' envelopes. Figures of the model & bar graph are expressed in kilo-watt hours.

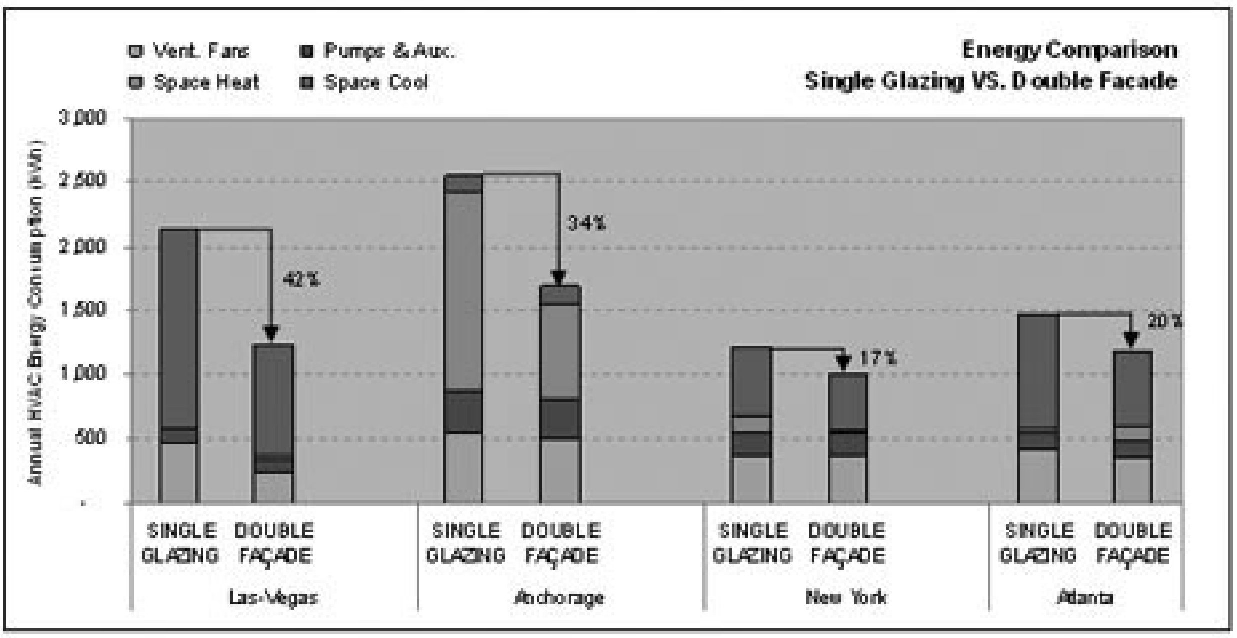

Fig. 2b. Comparative bar chart analysis from 'Hothouse' workshop

New York, New York:

The fundamental understanding of the requirements for building envelope design in this dense urban location were A) managing air pollution and B) managing solar heat gain.

Air quality management was proposed through a central air handling system, filtering and circulating incoming air. The higher up and greater the exposure to solar heat gain, the more opaque the envelope needed to be, this was counter to the common practice of building extensive repeated glass envelope over multiple storeys.

The application of a double skin indicated a 17% reduction in heating, ventilation and air-conditioning (HVAC) energy consumption.

Las Vegas, Nevada:

A punched surface to a thermally massive inner skin, to stop excessive temperature fluctuations and heat gain through the envelope, was explored with an external shading system as part of a double skin.

Students were able to assess that by introducing shading to the outer layer of a double skin envelope a possible 42% saving on annual HVAC energy consumption might be achieved primarily through reduced space cooling.

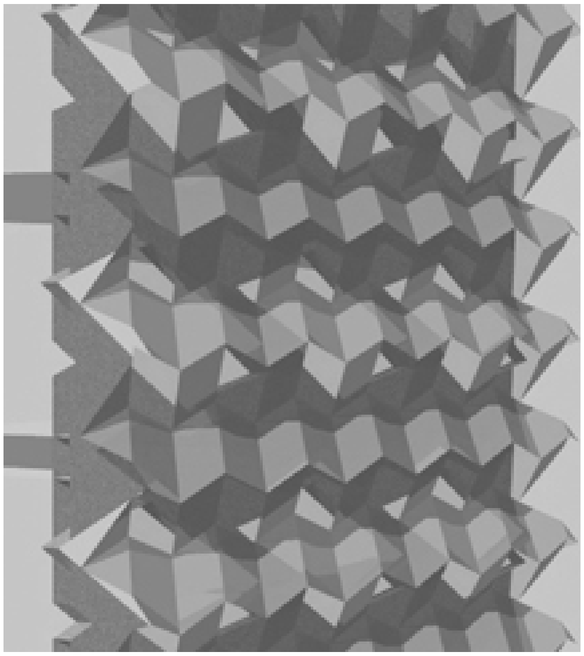

Fig. 3a. Las Vegas double skin proposal by Washington University students.

Anchorage, Alaska:

It was obvious that shading was not the issue for this colder climate, the key was maximising solar heat gain and insulation values to minimise heating requirements, energy consumption and heat loss through building envelope. A double skin envelope was seen to have its most effective application here, with insulated shutters that could be mobilised in the colder months. Whilst cooling requirements showed a slight increase in the model (an issue that no doubt could be resolved passively) space heating energy consumption was reduced by 34%.

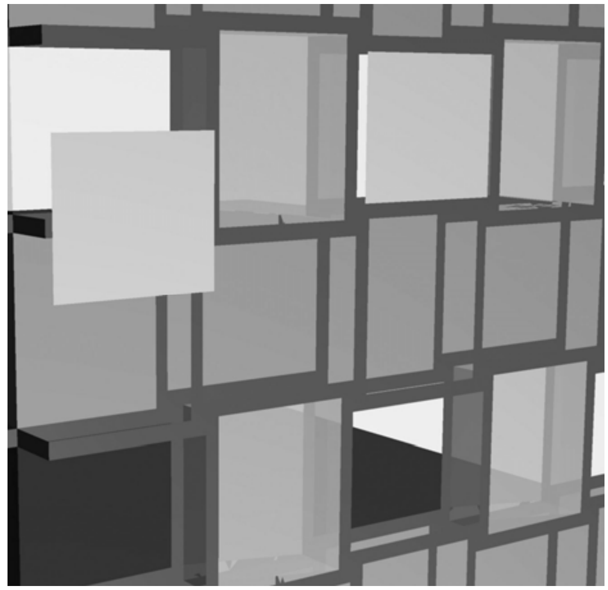

Fig. 3b. Anchorage double skin proposal by Washington University students.

Atlanta, Georgia:

An offset in the envelope was developed to take advantage of varying air pressures on the outside face of the building, this would also allow for built-in individual fan-coil units for use on hotter days of the year. Recognition that, with office environments, it was likely that some artificial cooling would be required and to allow for installation as part of the initial design rather than being a post occupancy 'add-on' made good sense! The application of a double skin indicated a 20% reduction in heating, ventilation and air-conditioning (HVAC) energy consumption for Atlanta.

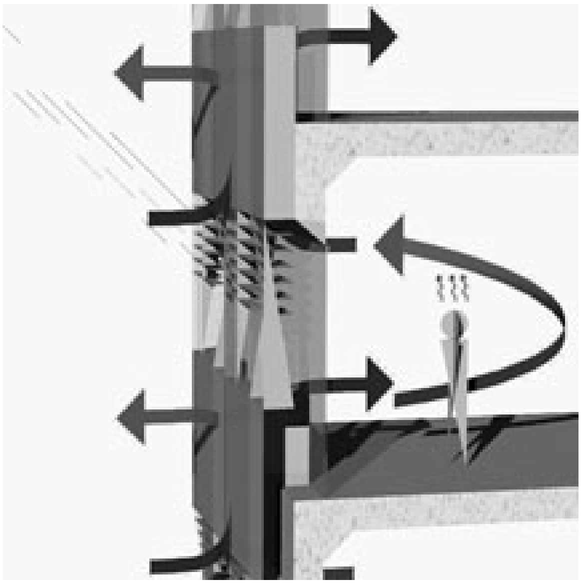

Fig. 3c. Atlanta double skin proposal by Washington University students.

'Output':
The figures are general and indicative only (see fig. 2a & 2b), but gave the students a sense of the implications of changes at the outline design stage and challenged assumptions that might have been made without this initial analysis. What are the important criteria for a building envelope that is to meet environmental expectations and requirements? If we assume that approximately 15-20% of a building's energy consumption might be attributed to building envelope – given this, small shifts in strategy have the potential to make a considerable 'sustainable' contribution and positive impact. What if we could make even single percentage improvements on all office envelopes built or refurbished from today onwards?

As we departed from our 36 hours at Washington University, Patrick Bellew asked the question: If we were to do this workshop again – what would we change? The fundamental conclusion had been that students rarely if ever actually *test* the aesthetic implications of design together with technical assumptions of environmental strategy; "obedient arrows" are freely drawn on diagrammatic sections indicating 'expected' air flows. Building design software that enables testing even at a basic level is enough to grasp the implications of major design decisions. Once the basic data had been inserted into the analysis model changes could be made to the design and fed directly back into the model for immediate feedback.

The importance of working on design and environmental analysis in parallel proved to be essential to investigating envelope design in terms of reducing energy consumption and complimenting rather than compromising aesthetic intention. Given another session, or even just a few more hours further performance analysis could have been done to expand our studies, and proposed solutions. As this workshop has developed into a semester long course additional and more sophisticated analysis has been considered together with input from other disciplines.

Building Synthesis fall 2006 course:

Building envelope strategies must primarily address the following: solar heat gain, glare control, natural light, thermal insulation, ventilation, sound & pollution – the design of systems is not a subdivided process though. Building design is a multi-disciplinary collaboration; an architect (now more than ever) needs to be aware of processes and technologies that will impact the perception, experience and performance of a building. This class seeks to investigate, develop and apply strategies at various scales of operation using *current* studio design projects as a focus and testing ground.

Building Synthesis is a required technical course developed specifically to support the comprehensive studio at the graduate level. Material is introduced through class presentations, discussions and readings. *Analysis* is then done through group and individual research. The *synthesis* of material is expected through both short workshop assignments and, predominantly, through the current comprehensive studio projects.

The studio assignment focuses on tall buildings (50-60 storeys high), with 1 million square foot of high-end office space as a required part of program. Class assignments and readings have been organized to both introduce a broad range of information prior to a specific topic and to support discussion and work presented by visitors. Students are encouraged to diagram and test assumptions and perceptions of tall building design using a wide range of media, both 'freehand' and digital. With the intention of putting an 'emphasis on energy efficiency and building performance analysis *within* the design process' ECOTECT software has been introduced to the students early in the semester to carry out analysis at a relatively simple scale throughout the design process. 'ECOTECT is a complete building design and environmental analysis tool that covers the broad range of simulation and analysis functions'. (see note 2)

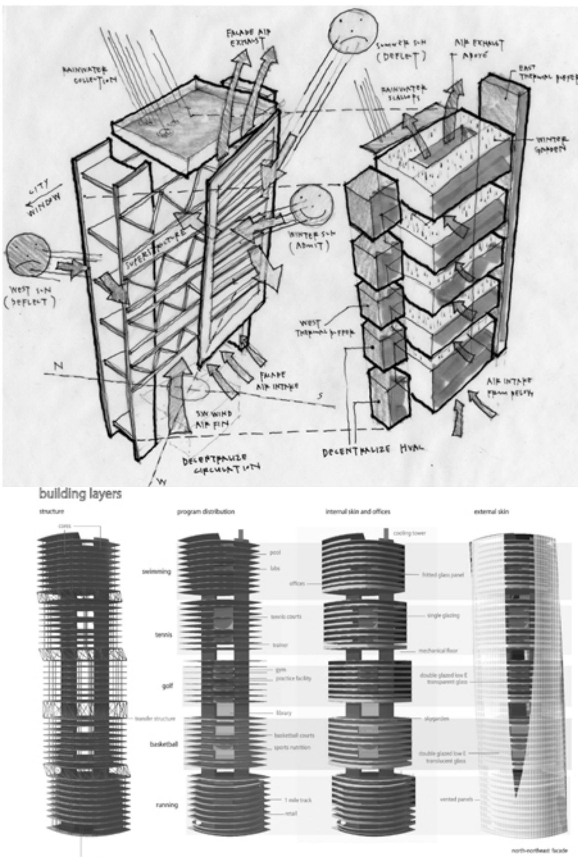

Fig. 4a. Work in progress by students at the University of Virginia.

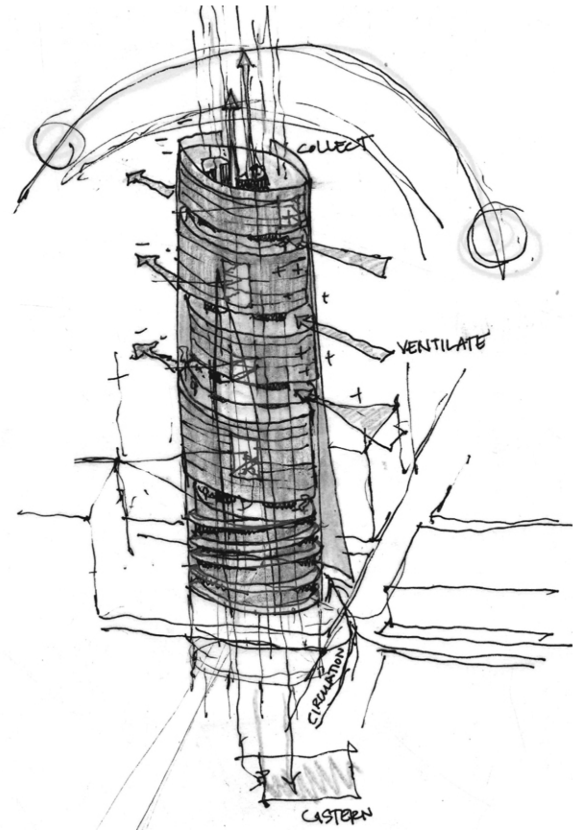

Fig. 4b. Work in progress by a student at the University of Virginia.

A number of visitors, including partners and directors of some of the professions most highly regarded consultants (engineers & architects), are scheduled to present and participate in class throughout the semester. The introduction of a multi-disciplinary voice to the class is considered very much as a practice scenario in the development of ideas and solutions. Visitors are available for desk crit discussions in the studio session after the morning class. Guests so far this semester include: Buro Happold (NY), Atelier Ten (NY), Skidmore Owings and Merrill Architects, Jane Wernick (structural engineer practicing in the UK), Julia Barfield (Marks Barfield Architects practicing in the UK – architects of the 'Millennium Wheel' & 'Sky House'), Otis Elevator Company, Louisa Hutton (Sauerbruch Hutton Architects as 2006 Harry S. Shure Professors). And still to come; Tim Macfarlane (Engineer and glass specialist), Matthias Sauerbruch (Sauerbruch Hutton Architects) and Permasteelisa Group USA (building envelope & cladding specialists). (see note 3)

'Working' Conclusion:

Previously technical courses at this stage of the program were not integrated with studio but rather run as a separate technical design 'exercise'. Because the course is now integrated completely with studio, students have a better grasp of the impact of design decisions on technical strategies, and vice versa – this is clear from their presentations at mid-term reviews and in group desk crits with visitors.

Building Synthesis is not structured in a traditional 'linear' fashion i.e. from small to large scale; students are actively encouraged to use analytic assessment to develop their *current* design strategies at multiple scales. Rather than carry out a project 'post completion' review or passively leaving them to find a way of synthesising course content from one studio semester to another, the syllabus knits technical and aesthetic aspects together. The flip side of being entirely interfaced with design studio is that if a student's project is out of sync in terms design development the supporting course needs to be flexible enough to keep them on track with material being presented throughout the semester.

The course also needs to be flexible enough to cope with the world of commerce, while visitors might have been scheduled at the beginning of summer 2006 it is only to be expected that, given the status of the projects they are working on, the course structure has had to absorb re-scheduling requirements. And, precisely because the syllabus is organised in a non-linear fashion, this has been relatively easy to accommodate.

There has been a considerable amount of dialogue with guests prior to their visits. Co-ordinating material content and relevant readings, and briefing them on studio design development is time consuming etc., however has made for very relevant and informative presentations and productive discussions. A class size of 19 seems to be a threshold for a successful workshop – any larger and the interactive nature of class might be disrupted?

Student and faculty feedback, and studio projects, at this mid-term stage show that this method of inter-disciplinary dialogue has been very constructive in the development and understanding of the possibilities for addressing environmental, structural and envelope strategy for tall buildings - bringing into question many of the assumptions about ways in which large scale building is currently developed in the USA.

Fig. 5. Class workshop sessions with visitors: Jane Wernick, Julia Barfield and Louisa Hutton – 10.13.06

Endnotes

[1] Image sources from top left clockwise:

- Lupton, Ellen, *'Skin: Surface, Substance, and Design'* pub. Princeton Architectural Press 2002 (Crease 2000 p.139)
- van Onna, Edwin, *'Material World Innovative Structures and Finishes for Interiors'* pub. Birkhauser 2003 (metal weaves 43)
- *wicker chair seating scanned directly*
- McQuaid, Matilda, *''Extreme Textiles, Designing for High Performance''* pub. Princeton Architectural Press 2005 (Satin Weave Glass Fiber p. 39)

[2] Refer to http://ecotect.com

[3] Access to this sort of caliber and expertise has been possible through a limited budget made available by the Department of Architecture at University of Virginia, sponsorship from some of the participating companies and by aligning the class schedule with visitors associated with other school funding.