What Is Our Perspective ?

FEFPA
Florida Educational Facilities Planners' Association, Inc.

Summer 2021 Conference
Diplomat Beach Resort
Hollywood, Florida
July 13, 2021

Next-Generation Higher Ed STEM Facilities: Trends, Planning, and Metrics

Mark W. Ranyak, AIA, NCARB, LEED AP
Laboratory Consultant

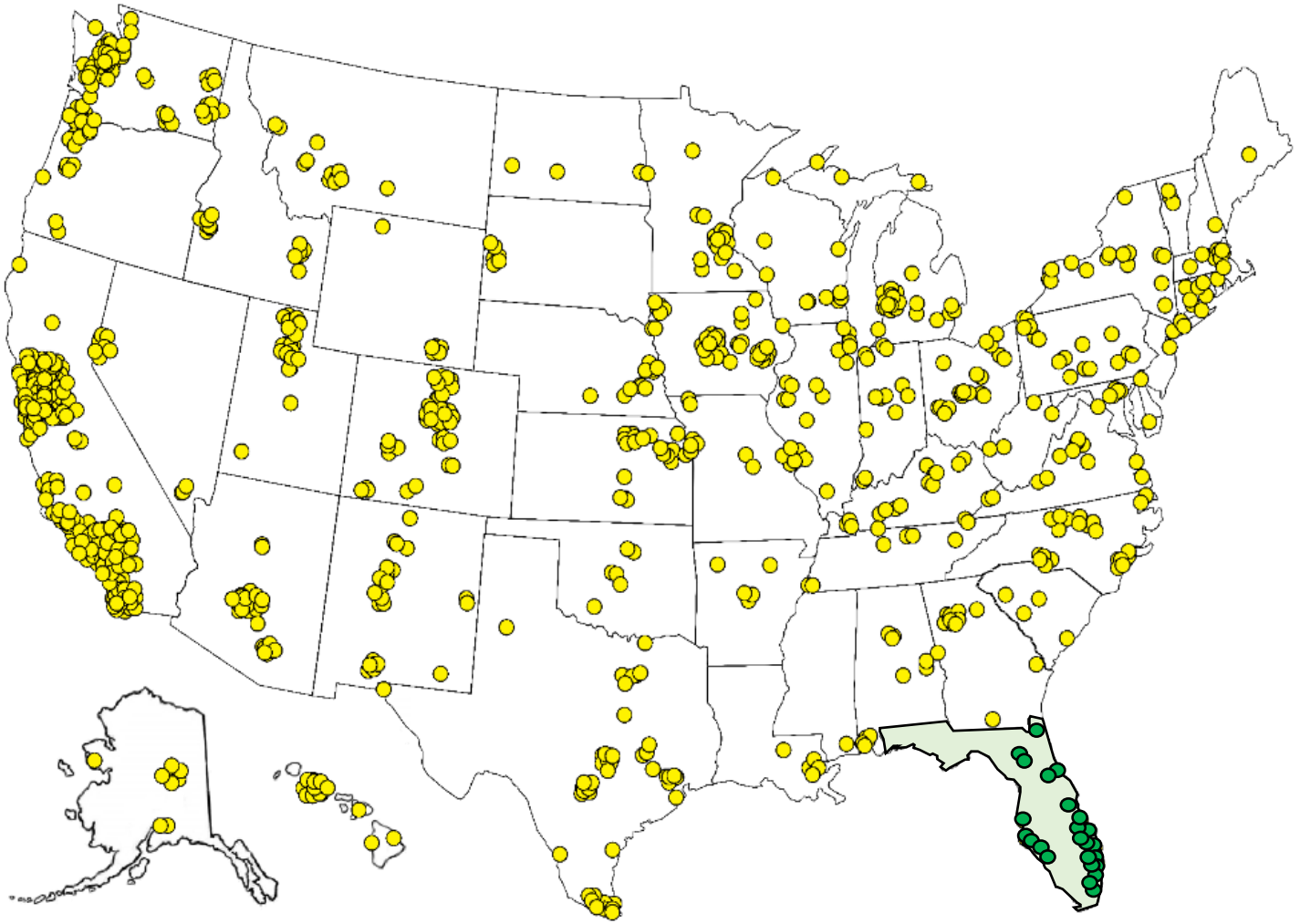
Michael Davison, AIA, NCARB, LEED AP
Laboratory Consultant

RESEARCH FACILITIES DESIGN

What Is Our Perspective ?

Laboratory Programming & Design Consultants – National Perspective

- 26 Architects, Engineers, Designers, & Technical Support Staff
- Focused 100% on Planning & Design of Laboratories
- Collaborated with more than 480 Architectural Firms
- More than 1,150 Projects in 50 States throughout the U.S., Canada, Australia, United Kingdom, Asia & Middle East
- 450 College and University Clients
- 90 Million GSF of Building Space
- $23 Billion Construction Value
- **More than 30 Florida Projects**



Laboratory Programming & Design Consultants – Local Experience

Broward College
- Science Building, South Campus

Eckerd College
- New Science Building Programming

Florida Atlantic University
- STEM/Life Sciences Building, Jupiter
- Research Laboratory II, Harbor Branch
- Biological & Geosicences Joint Use Facility
- FAU/Scripps 1, Jupiter
- FAU/Scripps 2, Jupiter
- Physical Science Building, Boca Raton

Florida Institute of Technology
- F. W. Olin Physical Science Building

Florida South Western University
- Renovation of Leonhardt Hall

Indian River State College
- William & Helen Thomas STEM Center

Institute for Health Living
- Incubator Laboratory Facilities

Lake-Sumter State College
- Science Building Renovation

Max Planck Society
- Florida Institute for Neuroscience

New College of Florida
- Heiser Natural Sciences Addition

Palm Beach State College
- Health & Science Building, Lake Worth
- Health & Science Building, Palm Beach Gardens

Saint Johns River State College
- Health & Science Building

Scripps Research
- Advanced Technology Building
- Biomedical Building
- Drug Discovery Building

South Florida State College
- Health & Science Building, Highlands

St. Lucie County
- Treasure Coast Research & Education Master Plan

Stetson University
- Sage Hall Programming

University of Florida
- Vet Med Academic Building
- Biological & Geosicences Joint Use Facility
- Microbiology Building

University of Miami
- Frost Institute of Chemistry & Molecular Science
- RSMAS Laboratory Renovation

University of North Florida
- Building 50 Renovation

University of South Florida
- Science Center

University of West Florida
- Science Laboratory Building

USDA Fort Pierce
- Horticultural Research Laboratory

What Is Our Perspective ?

As Laboratory Design Consultants, RFD has Collaborated with more than 480 Architectural Design Partners in our 35+ year practice.

Florida firms we've partnered with:

- Caldwell Associates
- Donadio and Associates
- Eckerd College
- EDSA
- Harvard Jolly Architecture
- Flad Architects
- Leo A Daly
- PGAL
- Ranon & Partners, Inc.
- RG Architects
- RLF Architects
- RSH
- Schenkel Shultz Architecture
- Spillis Candela / DMJM
- VOA Associates / Stantec
- The Weitz Company


Frost Institute for Chemistry and Molecular Science
University of Miami
Harvard Jolly Architecture


Advanced Technology, Biomedical, Drug Discovery
Scripps Research
Zeidler Partnership


Florida Institute for Neuroscience
Max Planck Society
PGAL


F. W. Olin Physical Science Building
Florida Institute of Technology
The Weitz Company

William & Helen Thomas STEM Center
Indian River State College
Donadio and Associates Architects


Biological & Geosciences Joint Use Facility
University of Florida/Florida Atlantic University
Schenkel Shultz Architecture


Research Laboratory II
Florida Atlantic University Harbor Branch
PGAL


Science Building
Broward College South Campus
Leo A Daly

Health & Sciences Building
Palm Beach State College, Palm Beach Gardens
Leo A Daly

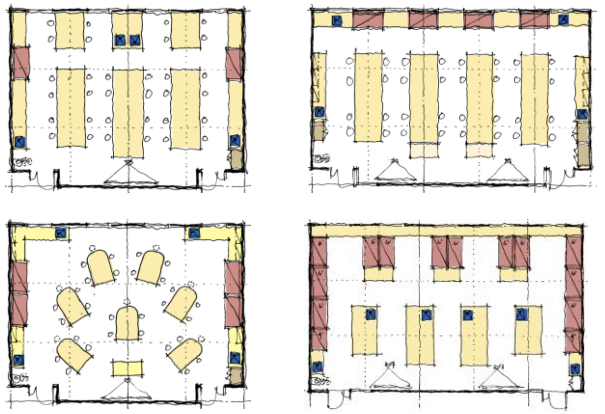
What Are Best Practices ?

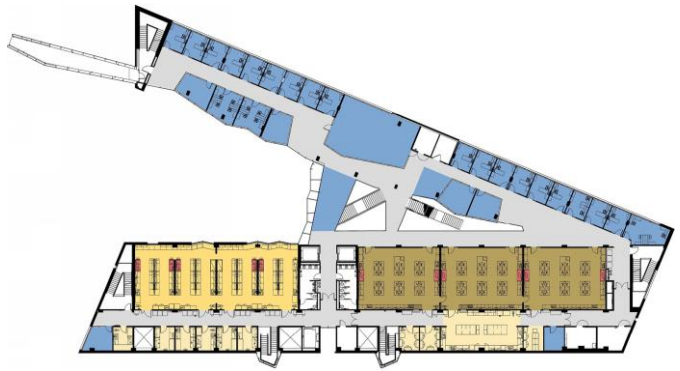
STEM Education for the Future - 2020 Visioning Report, National Science Foundation

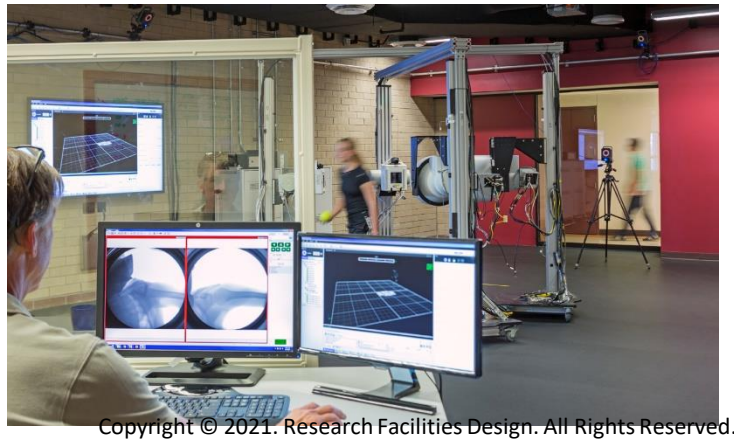
- Examined 7 outstanding STEM institutions for “Lessons for the Future”
- STEM learning environments are **student- centered, project-based, and personalized.**
- STEM learning environments intentionally **build communities of practice between students and faculty**, recognizing that learning is a social act that includes guidance and mentoring.

Presentation Outline

- **Considerations for STEM Environments**
  - STEM Communities
  - Recruitment & Retention
  - Engaged, Active & Applied Learning
  - Transparency, Connections & Extended Learning
- **Planning Trends for STEM**
  - Building Planning Considerations
  - Active Learning Laboratories
  - Research & Project Laboratories
- **Innovation & Maker Spaces**
- **Benchmarking & Metrics**
- **Key Takeaways**







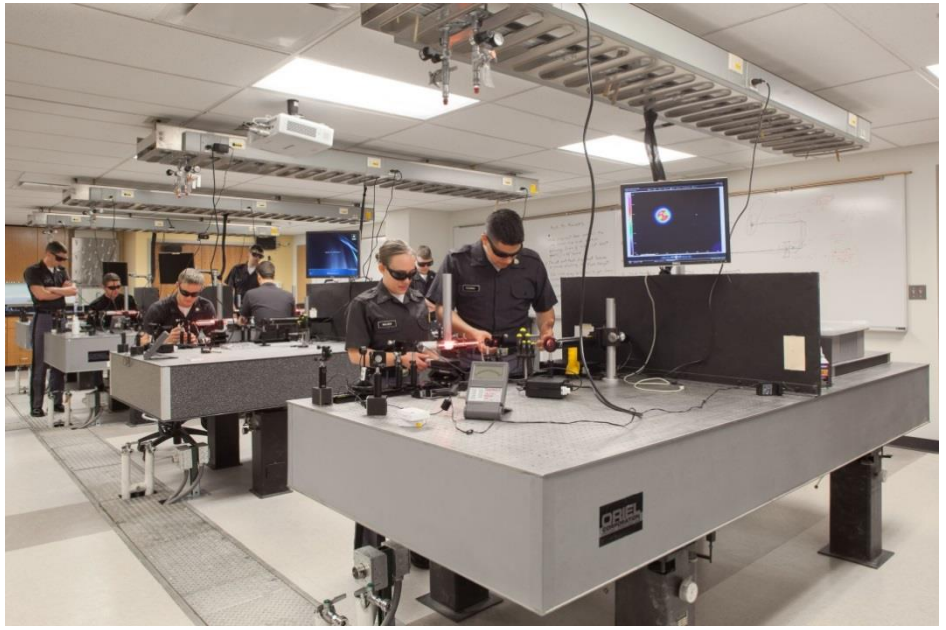
Extending STEM Communities

- Programs for Science & Technology
- Places for extended learning
- People that broaden your community

The Programs - **Basic Sciences**

Chemistry

Physics



Biology

Earth Sciences

Heiser Addition
New College of Florida
Harvard Jolly Architecture

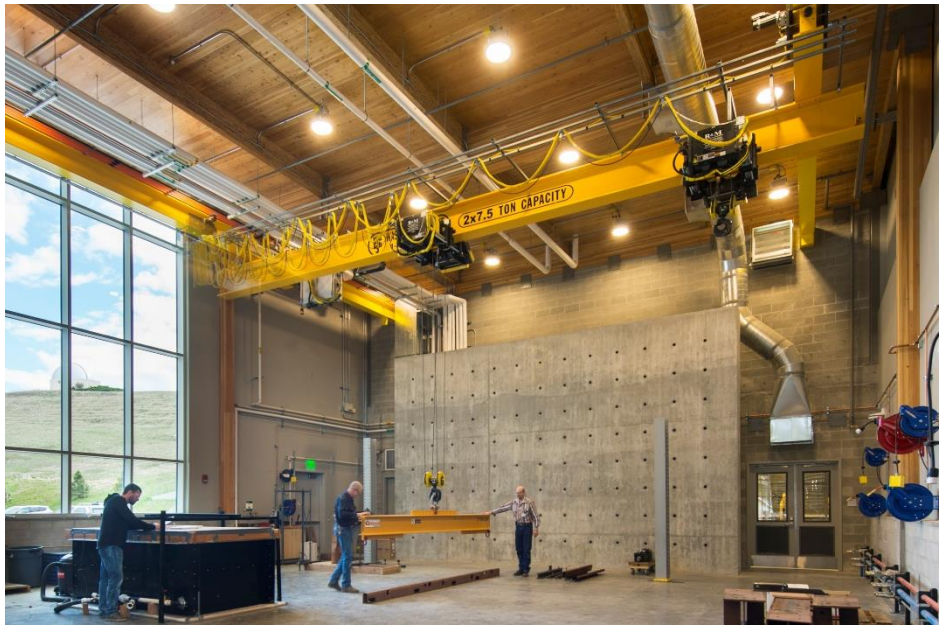
The Programs - **Engineering**

Electrical Engineering

Bio - Engineering

Mechanical Engineering

Civil Engineering



STEM Center
Indian River State College
Donadio and Associates

The Programs – **Other STEM Disciplines**

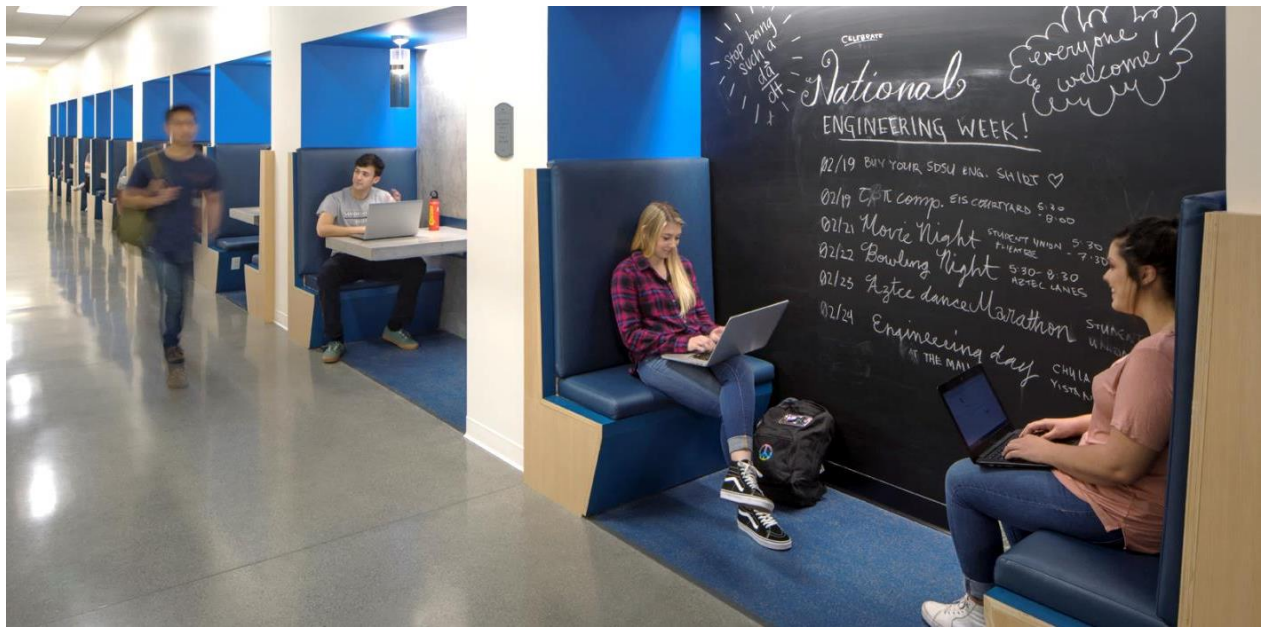
Allied Health

Robotics

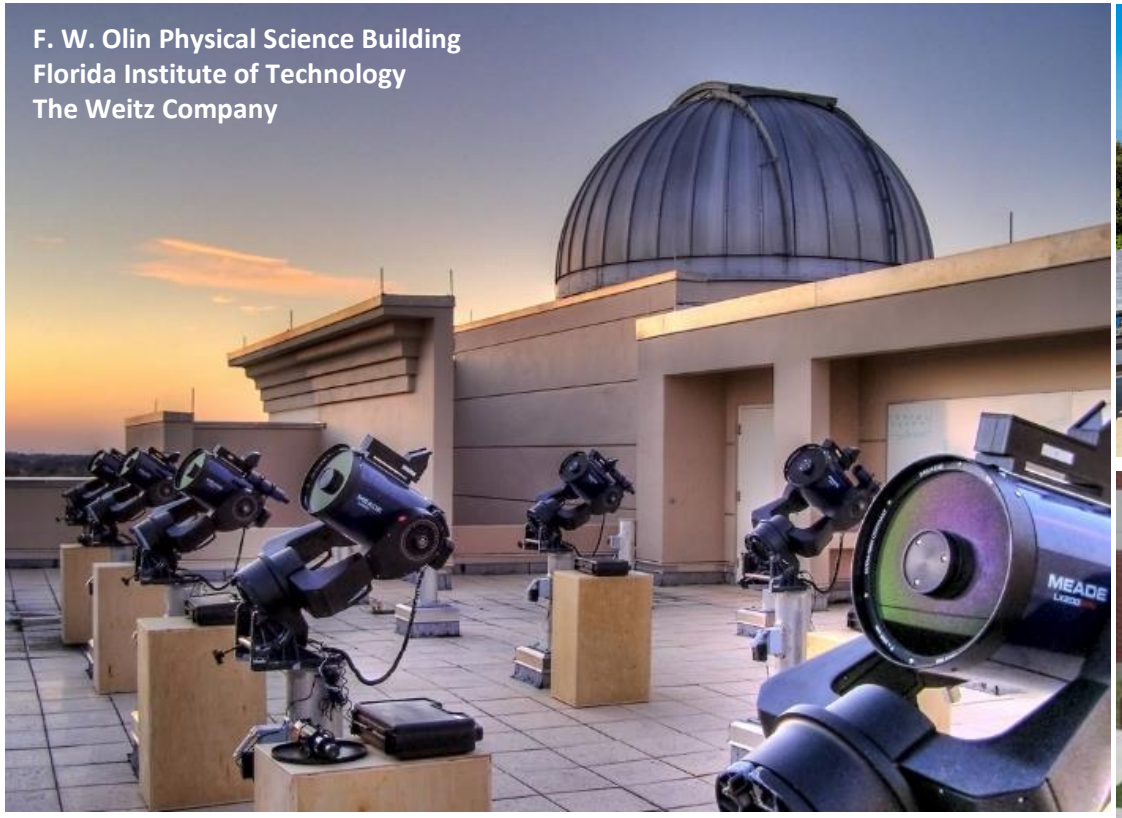
Environmental Sciences

Computer Science

The Places – **Formal & Informal**

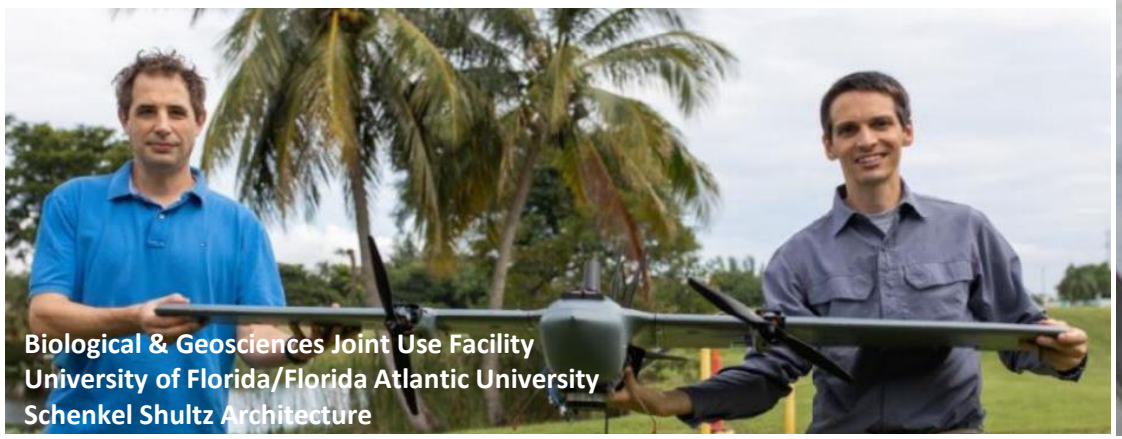


The Places – **Outdoor Spaces**



F. W. Olin Physical Science Building
Florida Institute of Technology
The Weitz Company

Research Laboratory II
Florida Atlantic University Harbor Branch
PGAL



Biological & Geosciences Joint Use Facility
University of Florida/Florida Atlantic University
Schenkel Shultz Architecture

The People – **Students, Faculty, Staff, Community, Outreach**

Developing STEM Communities

Heiser Natural Science Addition
New College of Florida
Harvard Jolly Architecture

Importance of ‘Curb Appeal’

Recruitment & Retention

FAU Harbor Branch
PGAL

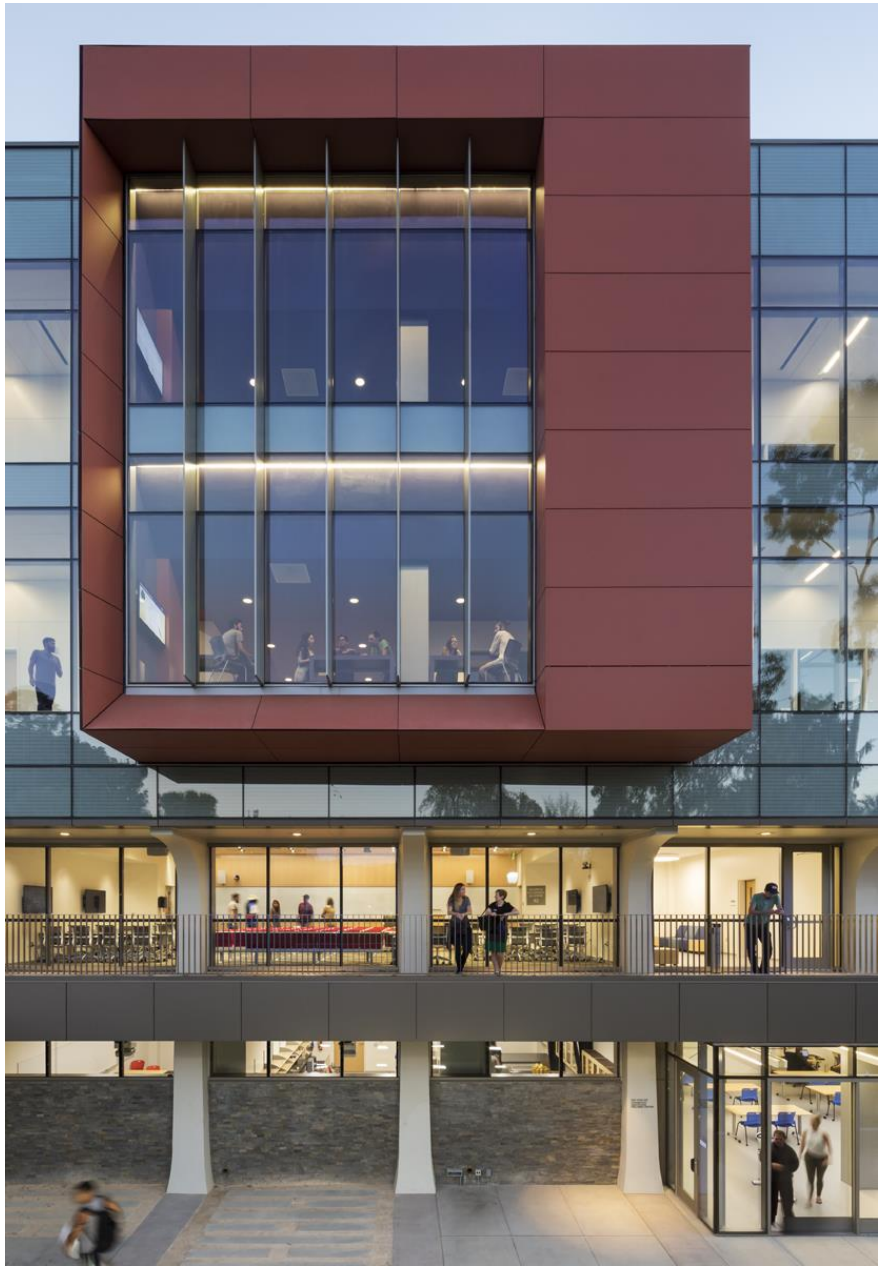
University of Miami Frost Institute for Chemistry and Molecular Science
Harvard Jolly Architecture

Palm Beach State College
Leo A Daly

FAU STEM/Life Sciences Research Facility
PGAL

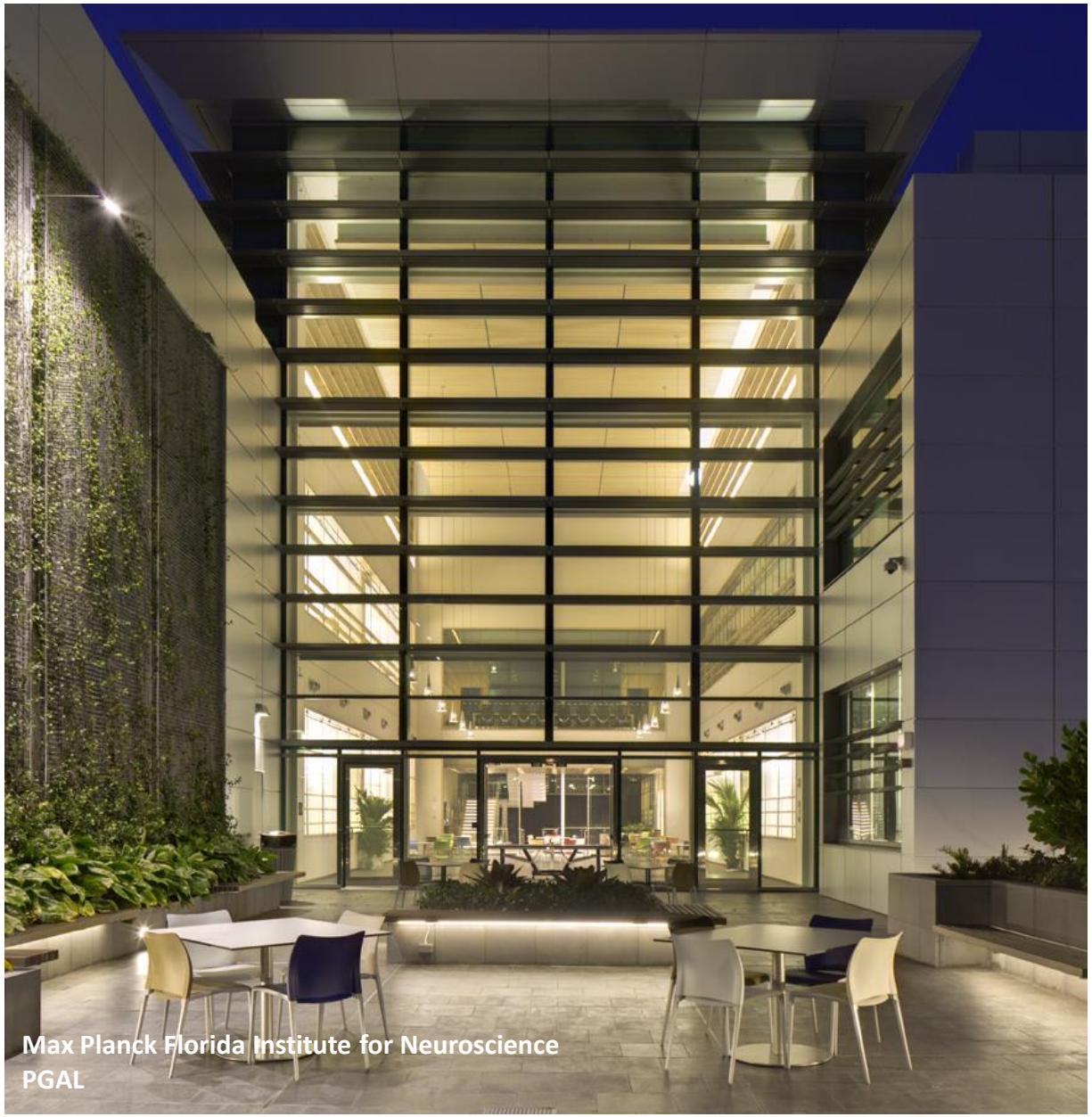
Importance of ‘Curb Appeal’ - Renovations

Recruitment & Retention



Importance of ‘Curb Appeal’ - Campus Landmarks

Recruitment & Retention



Max Planck Florida Institute for Neuroscience
PGAL

Heiser Addition – New College of Florida
Harvard Jolly Architecture

Active Learning in Teaching Laboratories – **Chemistry**

Engaged, Active & Applied Learning

Florida SouthWestern State College
RG Architects

Active Learning in Teaching Laboratories – **Physics**

Engaged, Active & Applied Learning

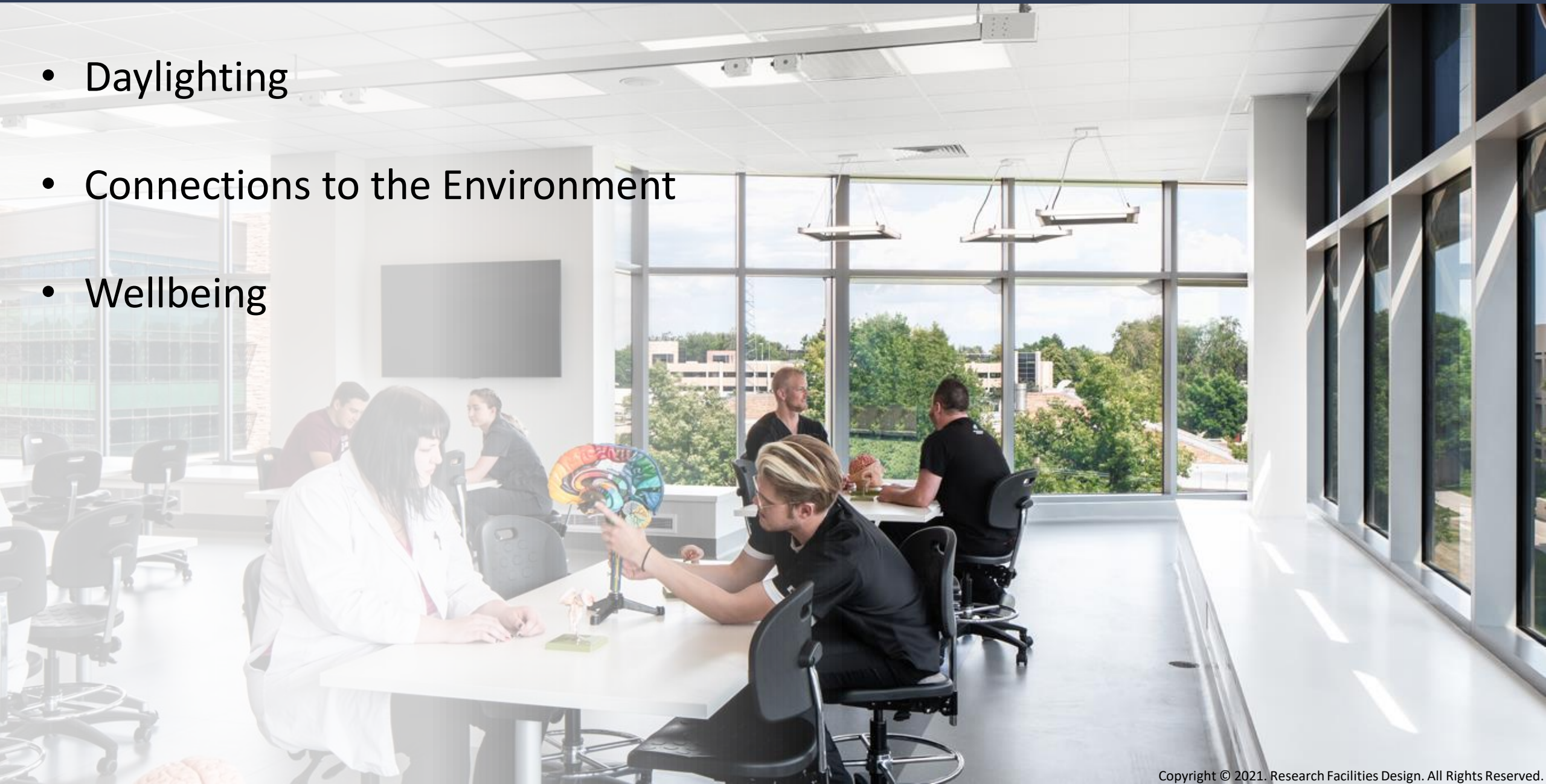
Active Learning in Teaching Laboratories – **Engineering**

Entire Building as a Learning Environment

Engaged, Active & Applied Learning

Transparency - to **Exterior**

- Daylighting
- Connections to the Environment
- Wellbeing



Transparency - from **Corridors**

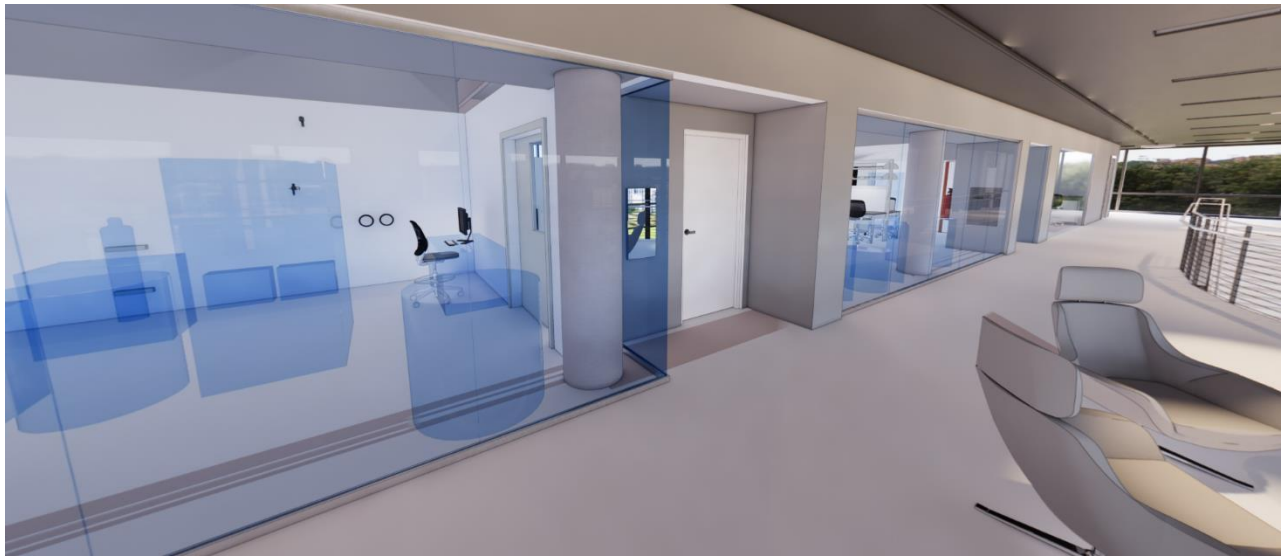
Transparency, Connections & Extended Learning

Florida SouthWestern State College
RG Architects

Indian River State College
Donadio and Associates

Transparency - from **Corridors**

Transparency, Connections & Extended Learning



Frost Institute of Chemistry and Molecular Science
University of Miami
Harvard Jolly Architecture

Transparency - **Between Spaces**

Transparency, Connections & Extended Learning

Connections – **Vertical Hubs of Activity**

Extended Learning – **Scientific Art**

Indian River State College
Donadio and Associates

Presentation Outline

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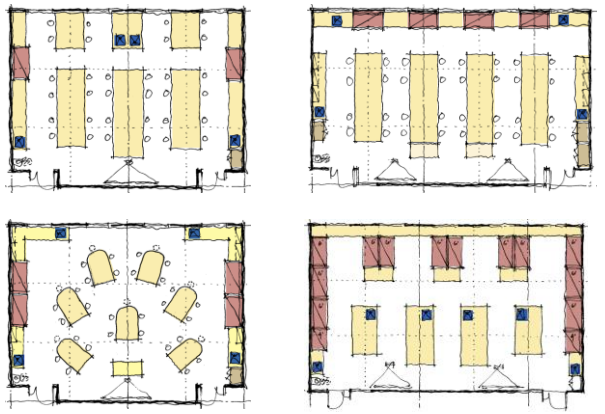
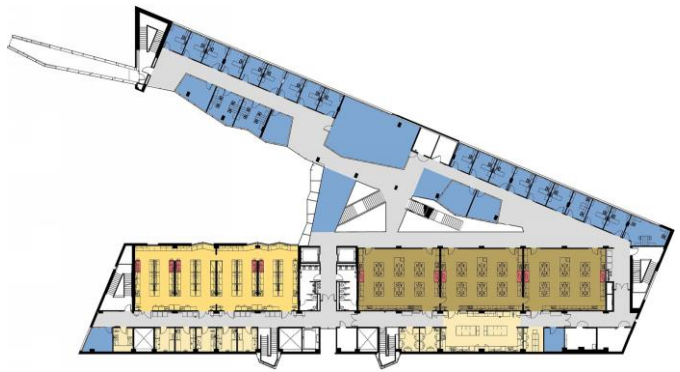
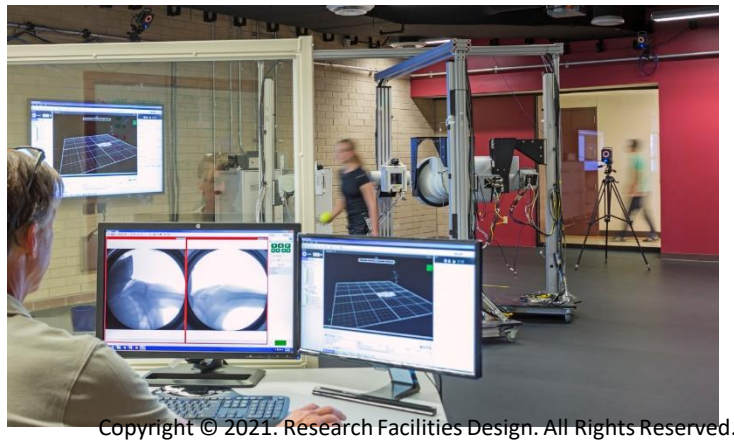
  - Research & Project Laboratories
- Innovation & Maker Spaces
- Benchmarking & Metrics
- Key Takeaways







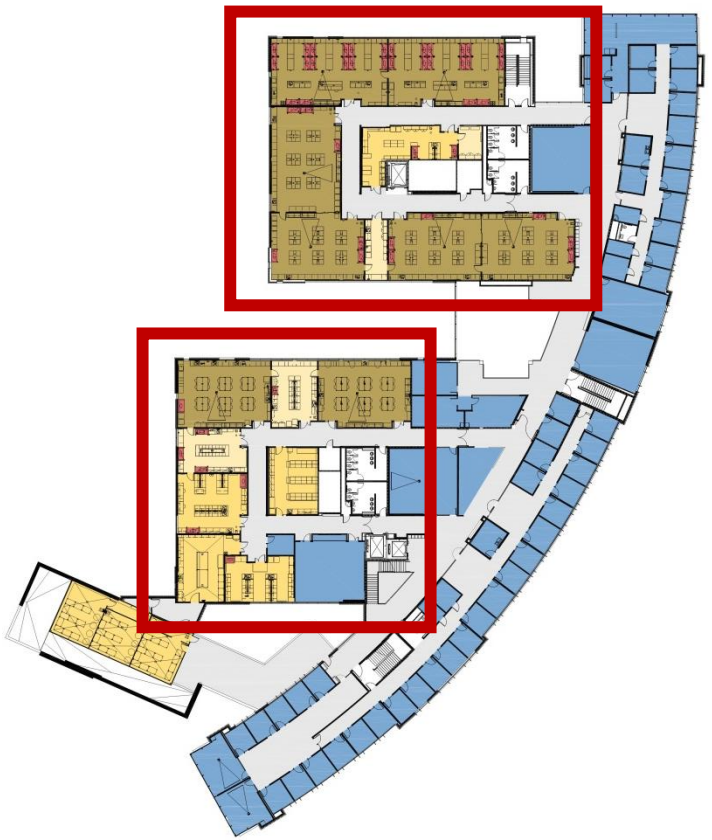
Organized by Building Systems

Building Planning Considerations

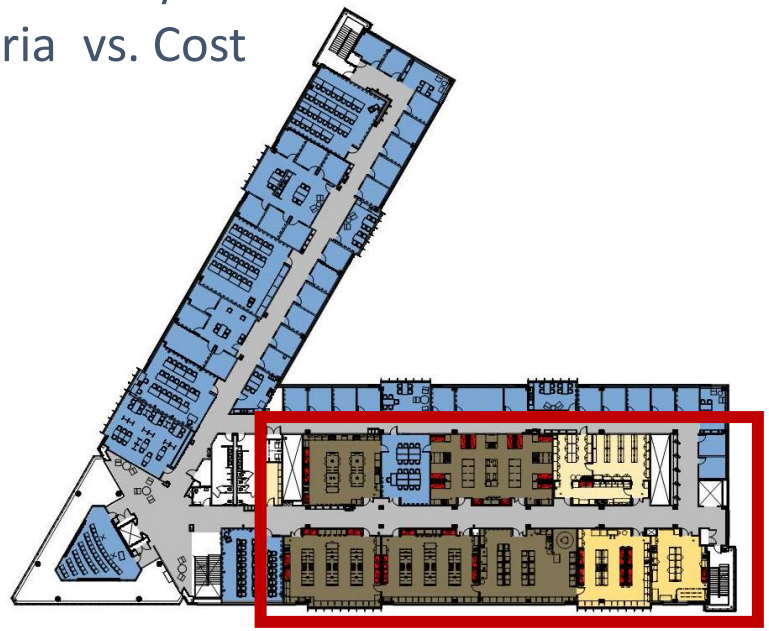
Energy Efficiency Planning Overlay

- HVAC – 100% Exhaust vs. Recirculated Air / Natural Ventilation
- Structural System – Vibration Criteria vs. Cost
- Piped Service Distribution

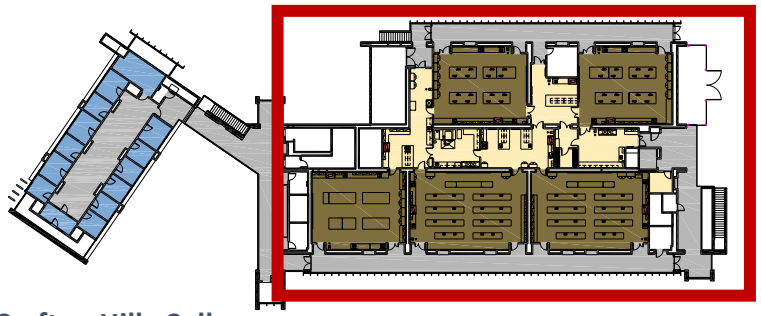
Teaching Labs
Research Labs
Support Labs
Office / Classroom



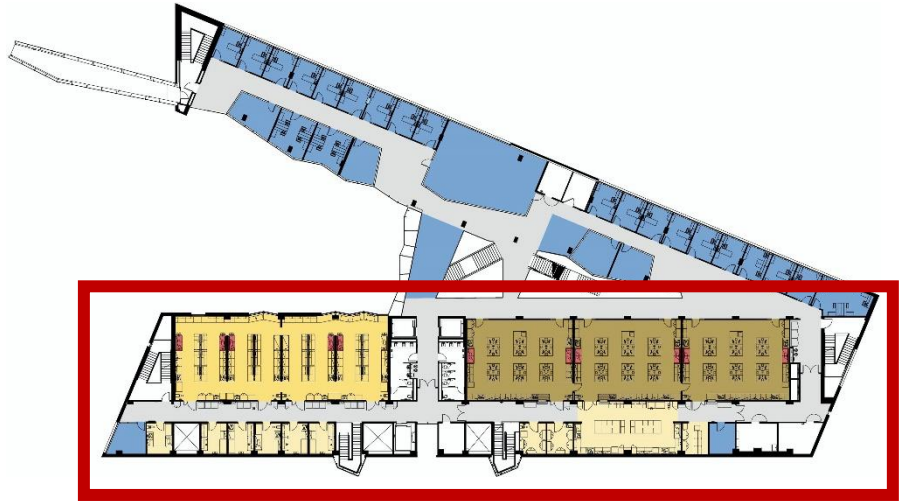
Weber State University



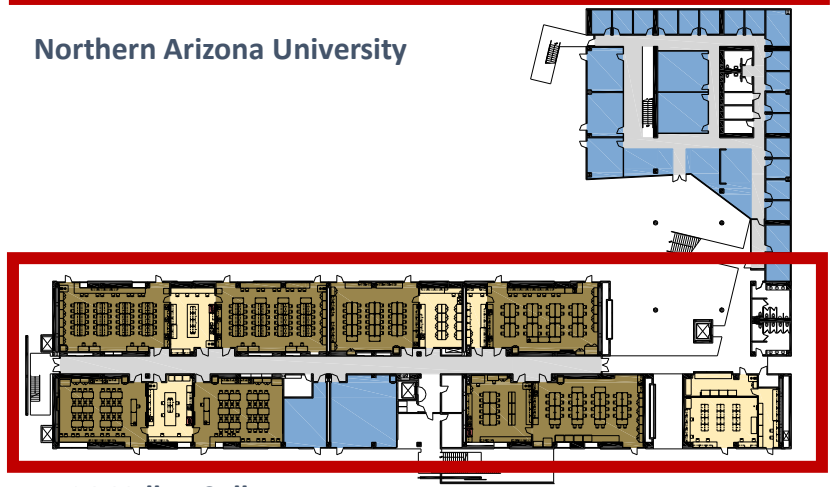
Augsburg College



Crafton Hills College



Northern Arizona University



LA Valley College

Organized by Program Function

Building Planning Considerations

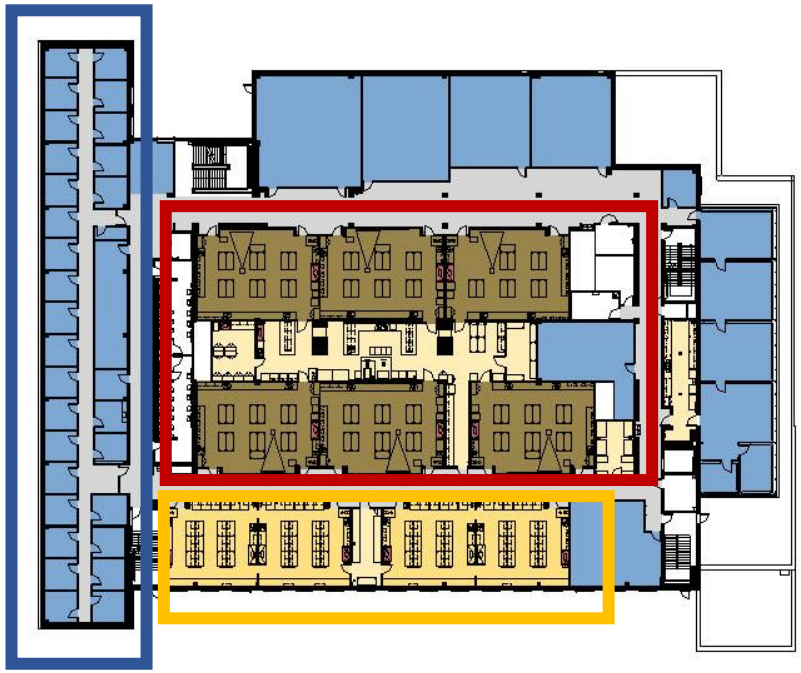
Zoned by Space Type

- Teaching Laboratories
- Research Laboratories
- Offices / Classrooms

Teaching Labs
Research Labs
Support Labs
Office / Classroom

Valparaiso University

University of Washington - Bothell



Grand Valley State University

Northern Arizona University

Southern Nazarene University

Organized by Neighborhoods

- Clusters of Teaching Labs, Research Labs, and Offices
- Shared use of Lab Support by Teaching and Research
- “Soft” Learning Spaces

Teaching Labs
Research Labs
Support Labs
Office / Classroom

Gustavus Adolphus College

Marshall University

Structure, Floor Heights & Vibration

- Steel vs. Concrete Frame – Floor Assembly Depth
- Floor to Floor Heights – MEP Distribution
- Trend Toward Flat Slab Concrete

Structural Systems for 30 Recent Projects:

- 39% Concrete Frame with shear wall lateral bracing
- 58% Steel Frame with steel frame lateral bracing
- 3% Timber construction in select functional areas

2011 – 2015	**Floor – to – Floor**	2016 – Beyond
5%	**14’-0”**	**14%**
14%	**14’-6”**	**32%**
24%	**15’-0”**	**30%**
38%	**15’-6”**	**10%**
19%	**16’-0” +**	**14%**

STRUCTURES & MATERIALS ENGINEERING BLDG
University of California, San Diego
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 16’ - 0”
Level 2 - R: 14’ - 6”

PHYSICS & NANOTECHNOLOGY BUILDING
University of Minnesota
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 16’ - 0”
Level 2 - R: 16’ - 0”

SANDLER NEUROSCIENCES CENTER 19A
University of California, San Francisco
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 20’ - 0”
Level 2 - R: 15’ - 0”

HEALTH SCIENCE BIOMED RESEARCH BLDG 2
University of California, San Diego
Concrete Frame/Shear Wall
Floor to Floor Heights: Level B: 21’ - 0”
Level 1 - R: 17’ - 0”

MATERIALS SCIENCE & ENGINEERING BLDG
University of California, Riverside
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 20’ - 0”
Level 2 - R: 15’ - 4”

CLEAN TECHNOLOGY LABORATORY BLDG
Washington State University
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 16’ - 0”
Level 2 - R: 16’ - 0”

SCIENCE & ENGINEERING BUILDING 2
University of California, Merced
Steel Frame/Braced Frame
Floor to Floor Heights: Level B: 18’ - 0”
Level 1 - R: 15’ - 0”

ENGINEERING VI PHASE I
University of California, Los Angeles
Concrete Frame/Shear Wall
Floor to Floor Heights: Level B - 1: 18’ - 0”
Level 2 - R: 15’ - 6”

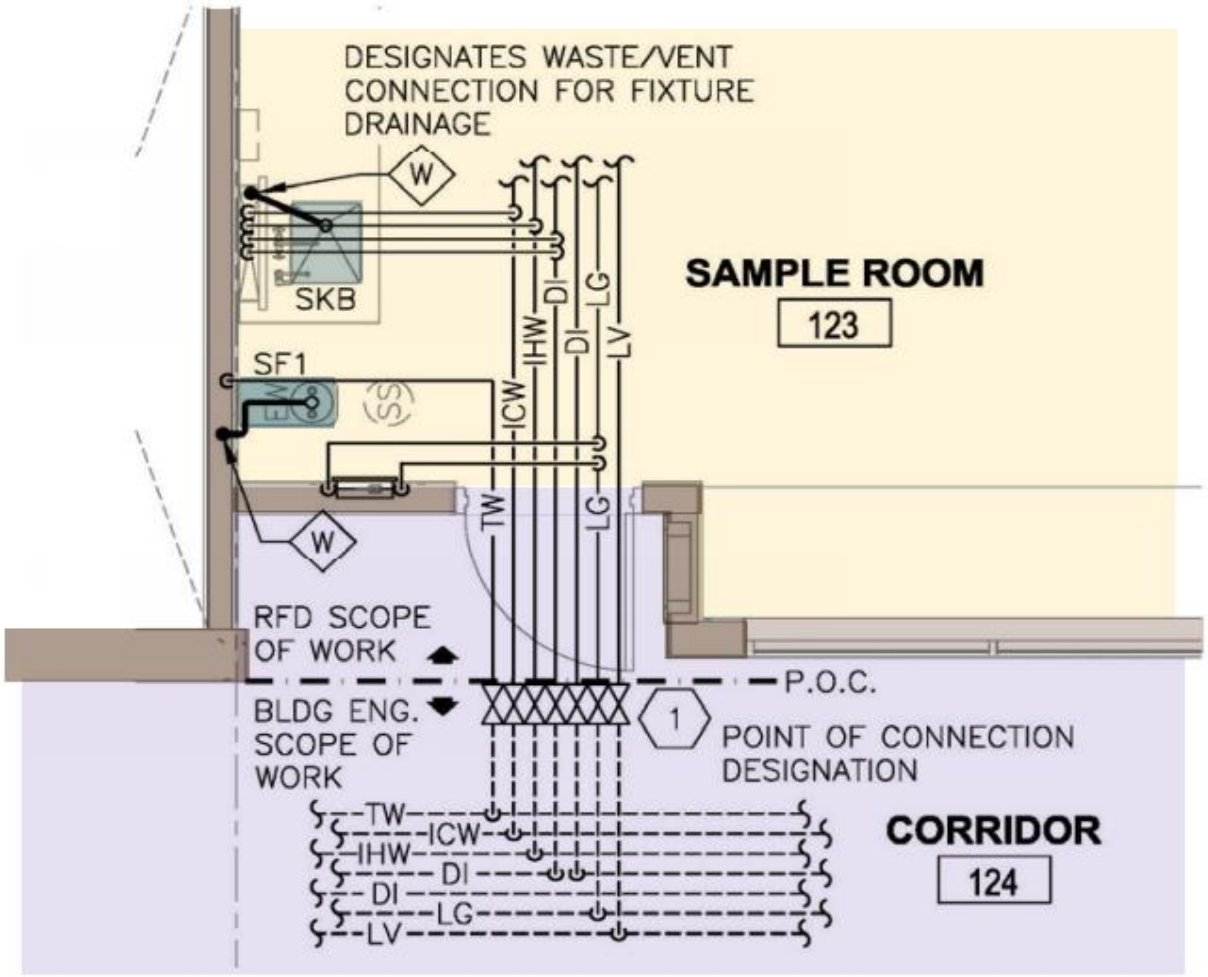
ENGINEERING RESEARCH BUILDING
University of Texas, Arlington
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 16’ - 0”
Level 2 - R: 16’ - 0”

INTERDISCIPLINARY SCI & ENGINEERING BLDG
University of Delaware
Concrete Frame/Shear Wall
Floor to Floor Heights: Level 1: 16’ - 0”
Level 2 - R: 16’ - 0”

Structure, Floor Heights & Vibration

Concrete Frame + Flat Slab

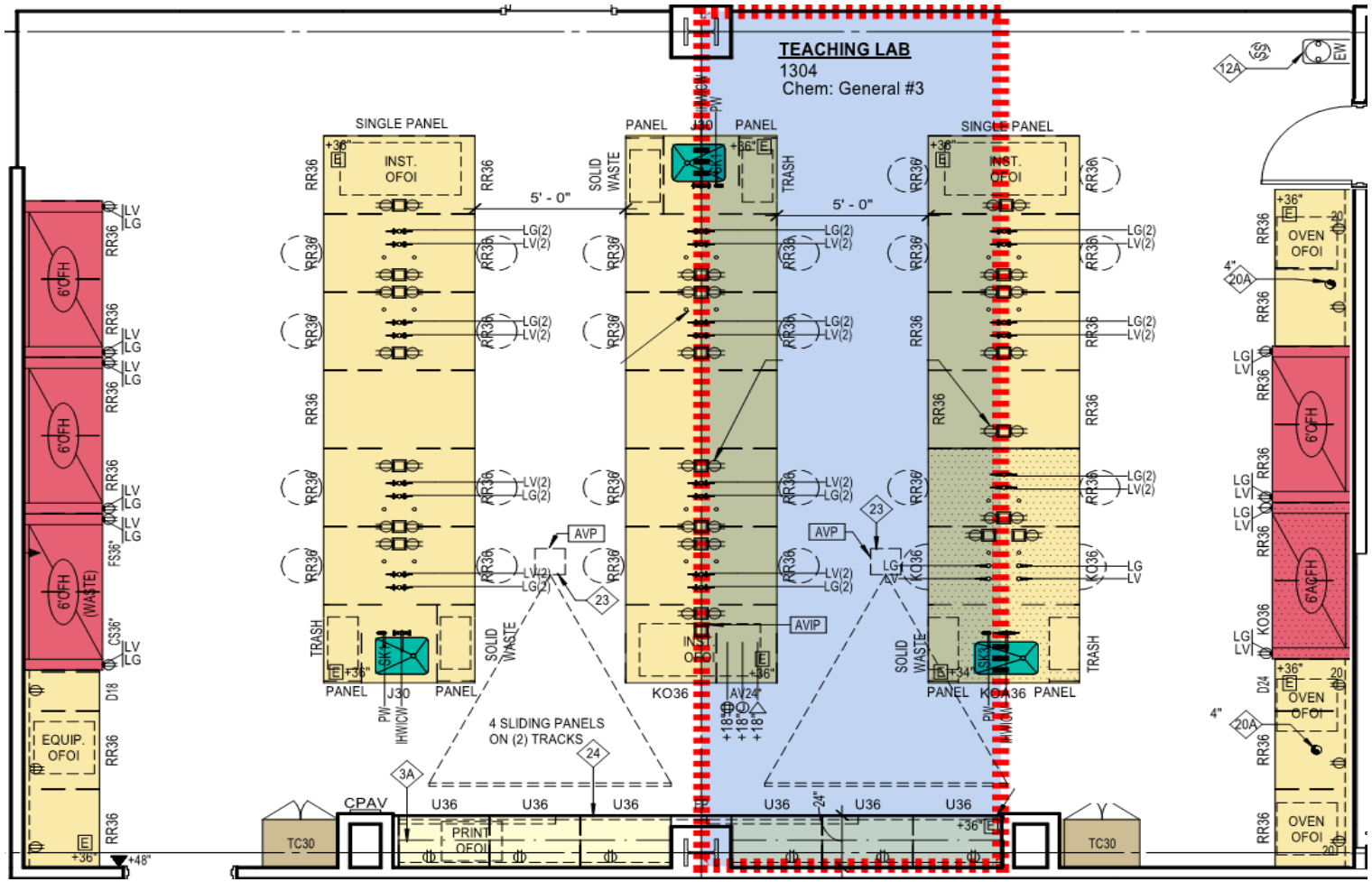
- Reduced Floor to Floor Heights
- Economy of Installation
- Ease of Renovations



Laboratory Planning Module

Building Planning Considerations

- Basic Planning Module Getting Deeper – 30’ to 33’ Deep
- Two Way Module
- Engineering Labs Benefit from Wider Modules



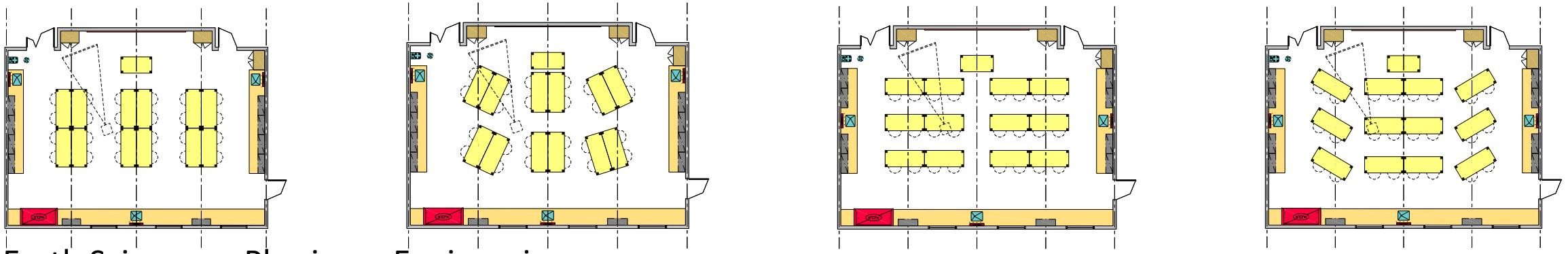
2011 – 2015	Private	2016 – Beyond
20%	10’-0”	5%
0%	10’-4”	0%
50%	10’-6”	50%
30%	10’-8”	20%
0%	11’-0”	25%

2011 – 2015	Public	2016 – Beyond
0%	10’-0”	0%
17%	10’-4”	0%
75%	10’-6”	82%
0%	10’-8”	9%
8%	11’-0”	9%

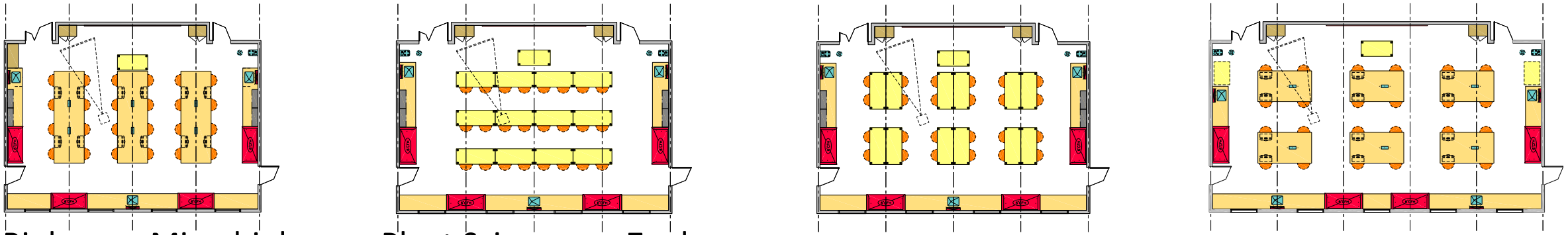
2011 – 2015	Comm. College	2016 – Beyond
30%	10’-0”	0%
0%	10’-4”	0%
60%	10’-6”	81%
0%	10’-8”	6%
10%	11’-0”	13%

Traditional Laboratory Layouts

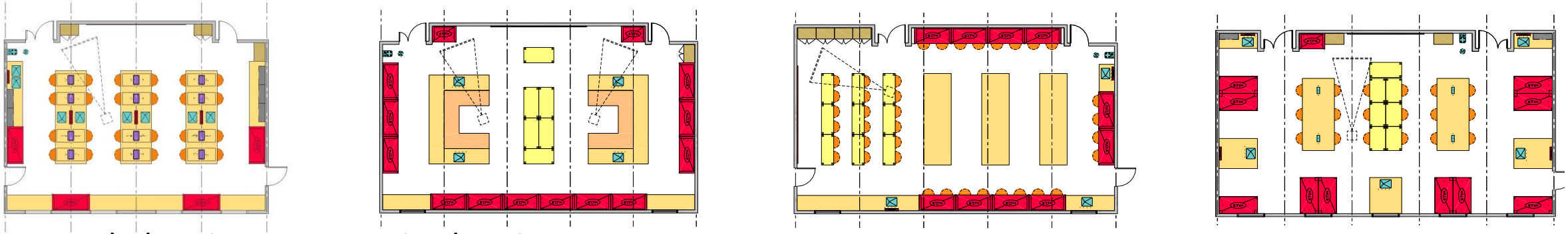
Science Learning Laboratories



Earth Science - Physics - Engineering



Biology - Microbiology - Plant Sciences - Zoology



General Chemistry - Organic Chemistry

Laboratory Design Trends – **Greater Flexibility**

Science Learning Laboratories

Evolving Teaching Laboratory Layouts – **Organic Chemistry Example**

Small, Medium, Large

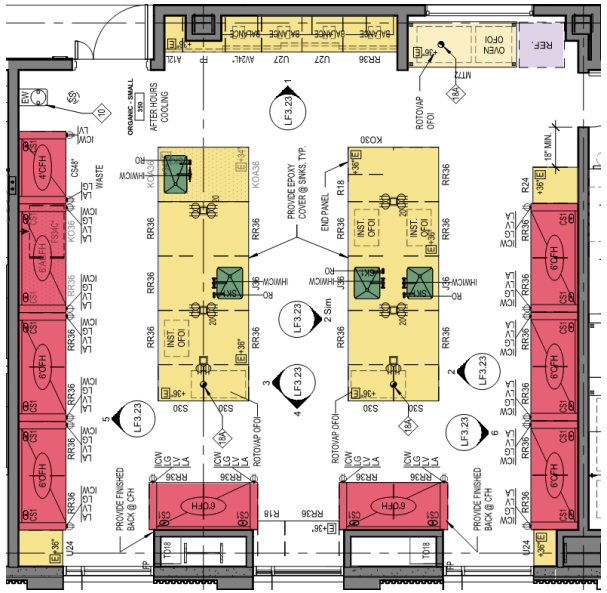
#1 16 Students in **945 nsf** (8 CFHs)
59.0 nsf / Student

#2 16 Students in **975 nsf** (8 CFHs)
61.0 nsf / Student

#3 20 Students in **1,260 nsf** (10 CFHs)
63.0 nsf / Student

#4 24 Students in **1,665 nsf** (12 CFHs)
69.4 nsf / Student

#1



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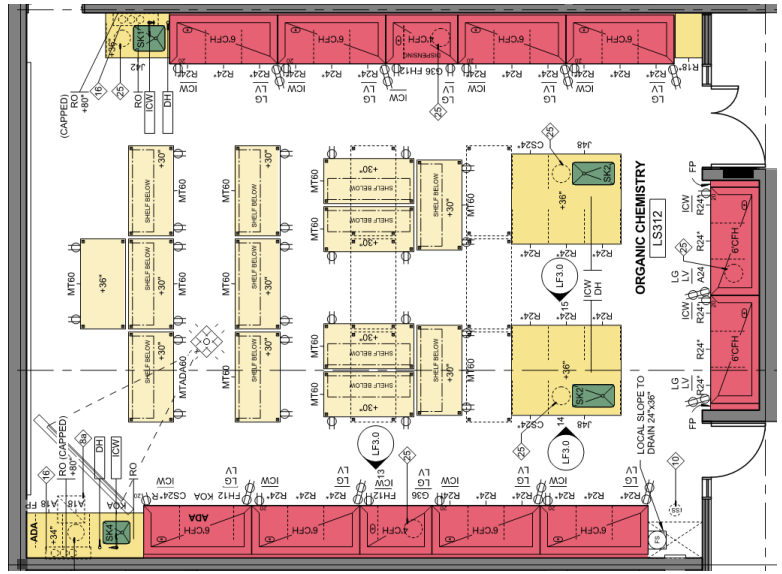

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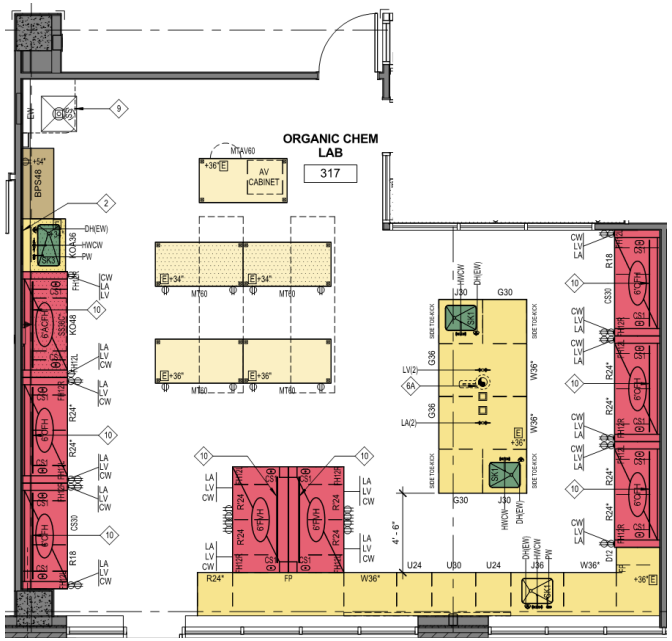

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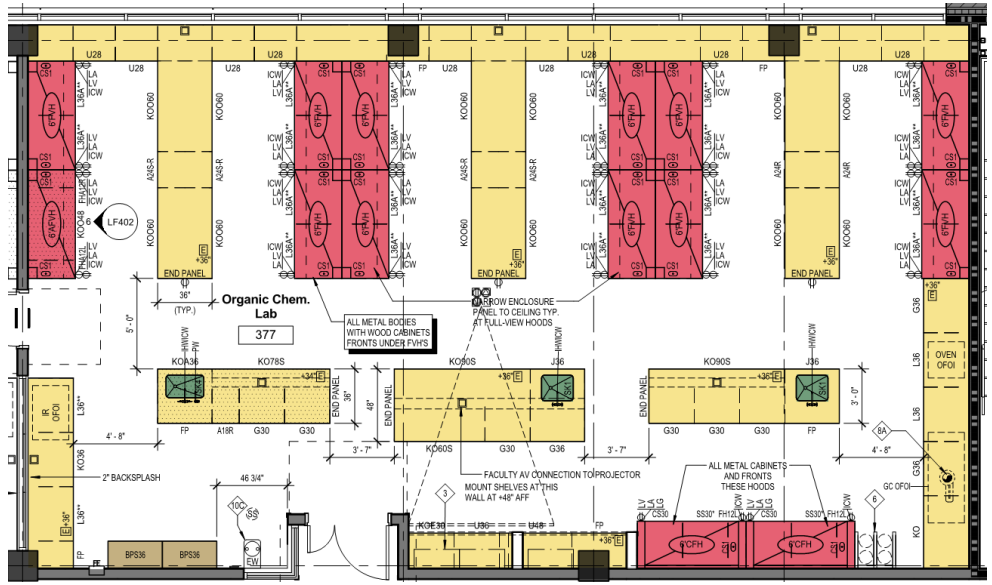


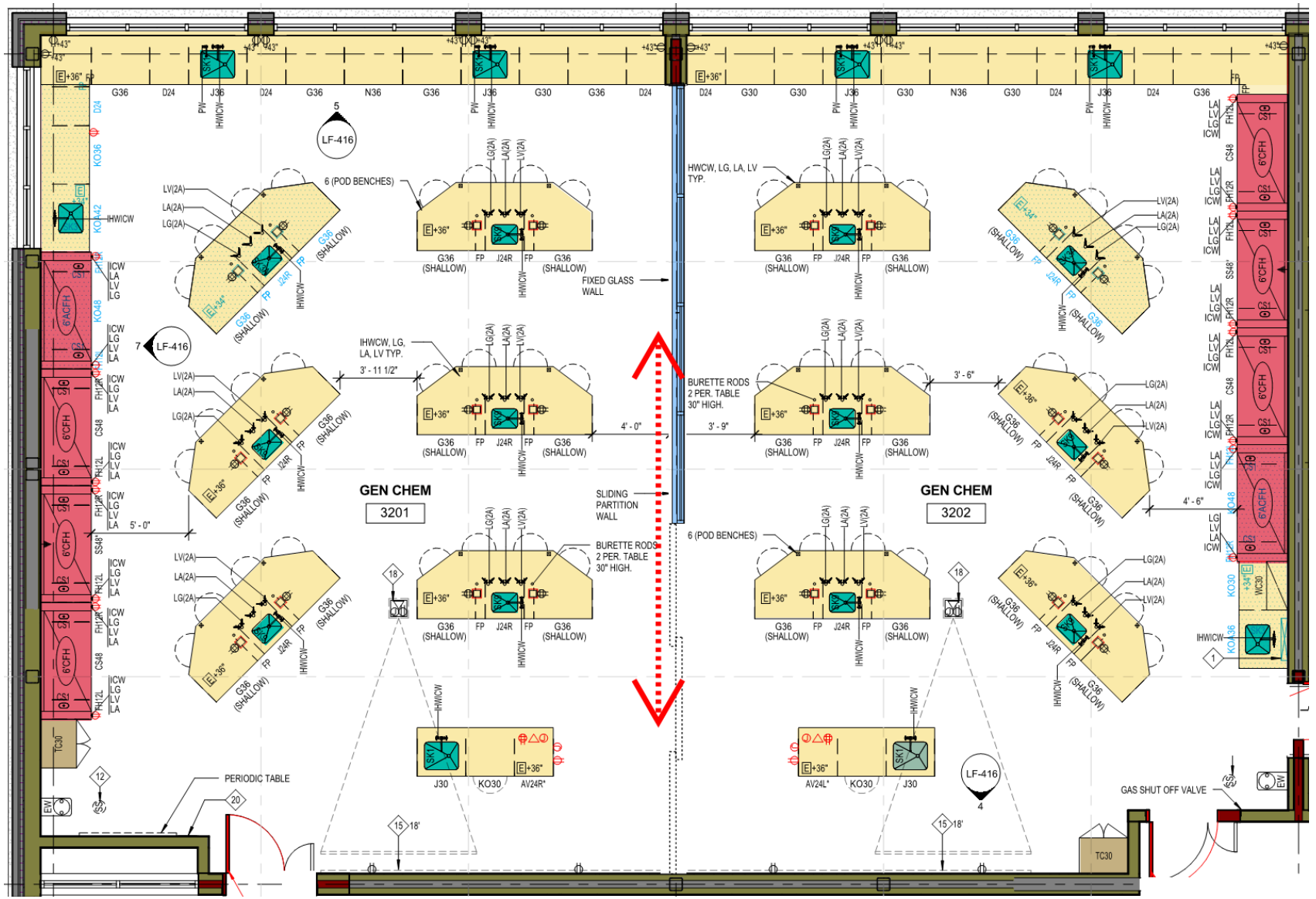
Laboratory Design Trends – **Paired Teaching Laboratories**

Individual Lab Configuration – 1,320 nsf

- 24 Students each
- 1 Faculty each
- Sliding Glass Partition

Studio Lab Configuration – 2,640 nsf

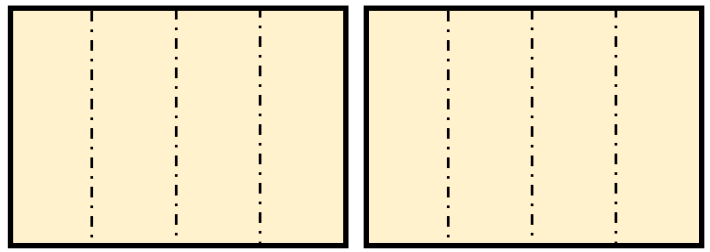
- 48 Students
- 1 Faculty + 2 TAs



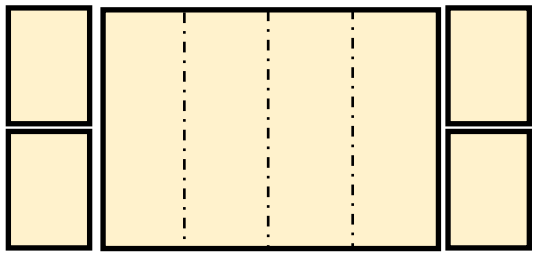
Laboratory Design Trends – **Paired Teaching Laboratories**

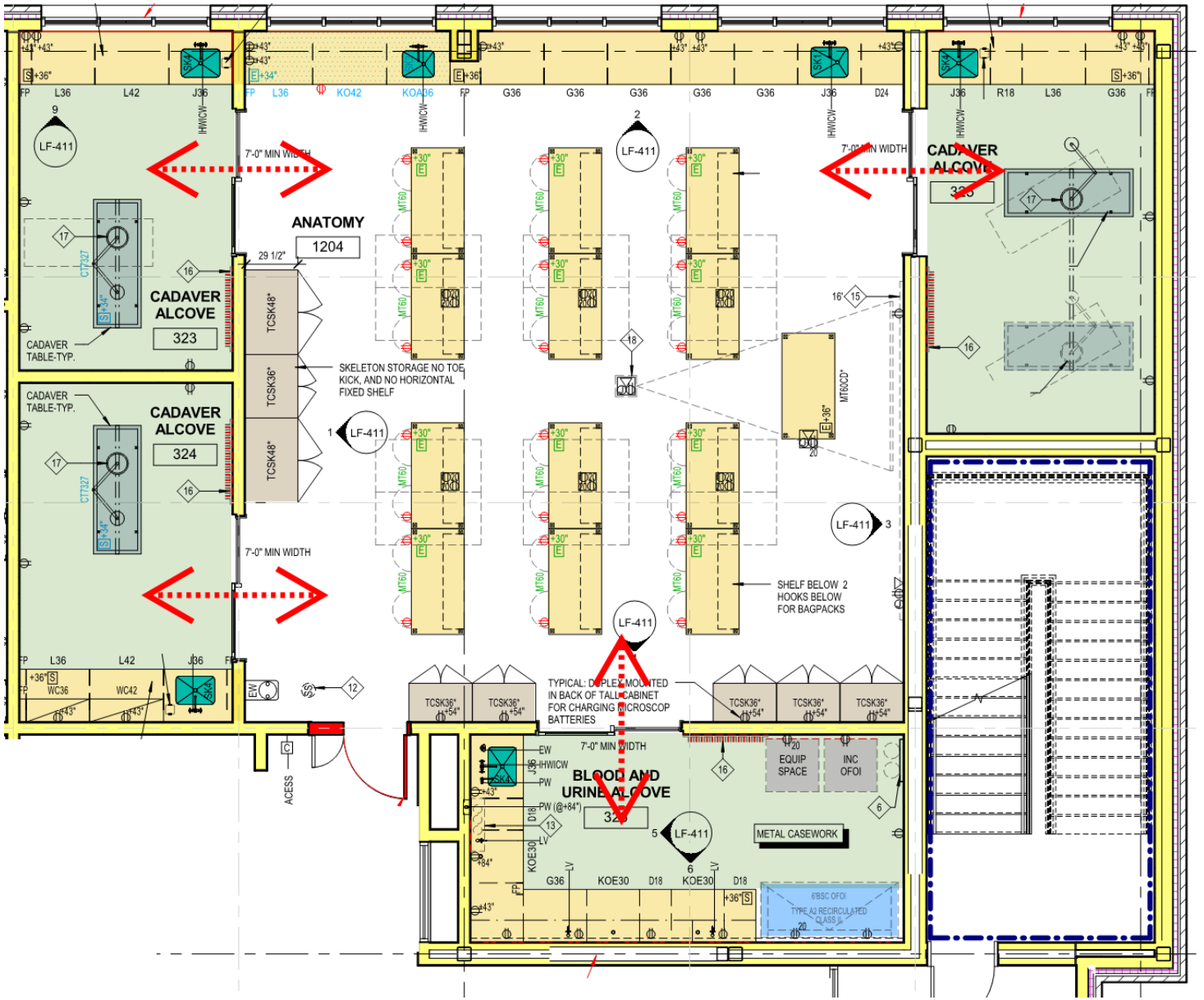
Laboratory Design Trends – **Multi-Use Teaching Laboratories**

- 2 labs at 1,320 nsf each = **2,640 nsf**



- Single Lab = 1,320 nsf + Alcoves = 660 nsf
- Total Area = **1,980 nsf**





Laboratory Design Trends – **Multi-Use Teaching Laboratories**

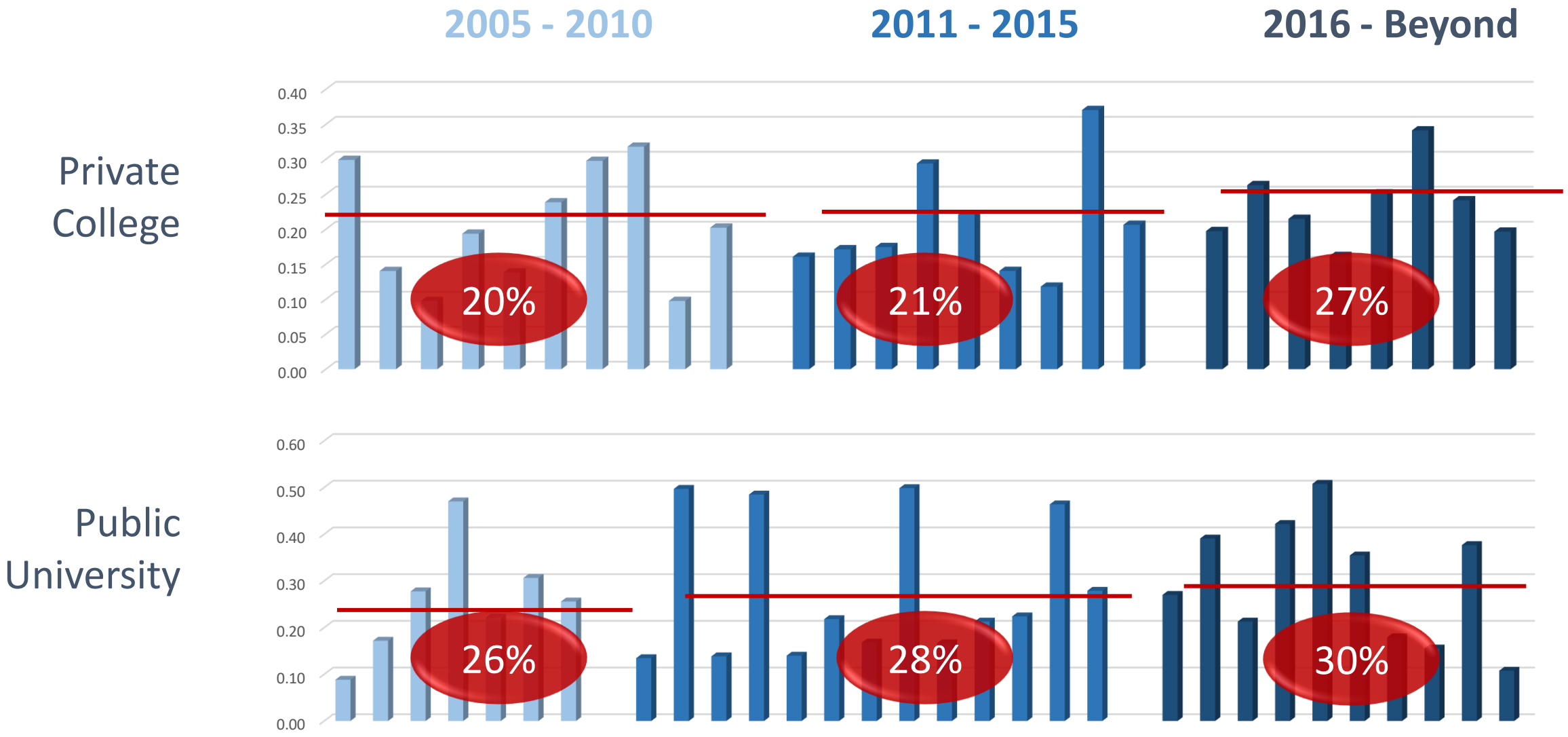
Laboratory Design Trends – **Engineering Fluids Lab Example**

- Equipment Scale Lab Sizing
- Metrics Less Useful
- Teaching Zone Variable

Laboratory Design Trends – **Engineering Project Labs**

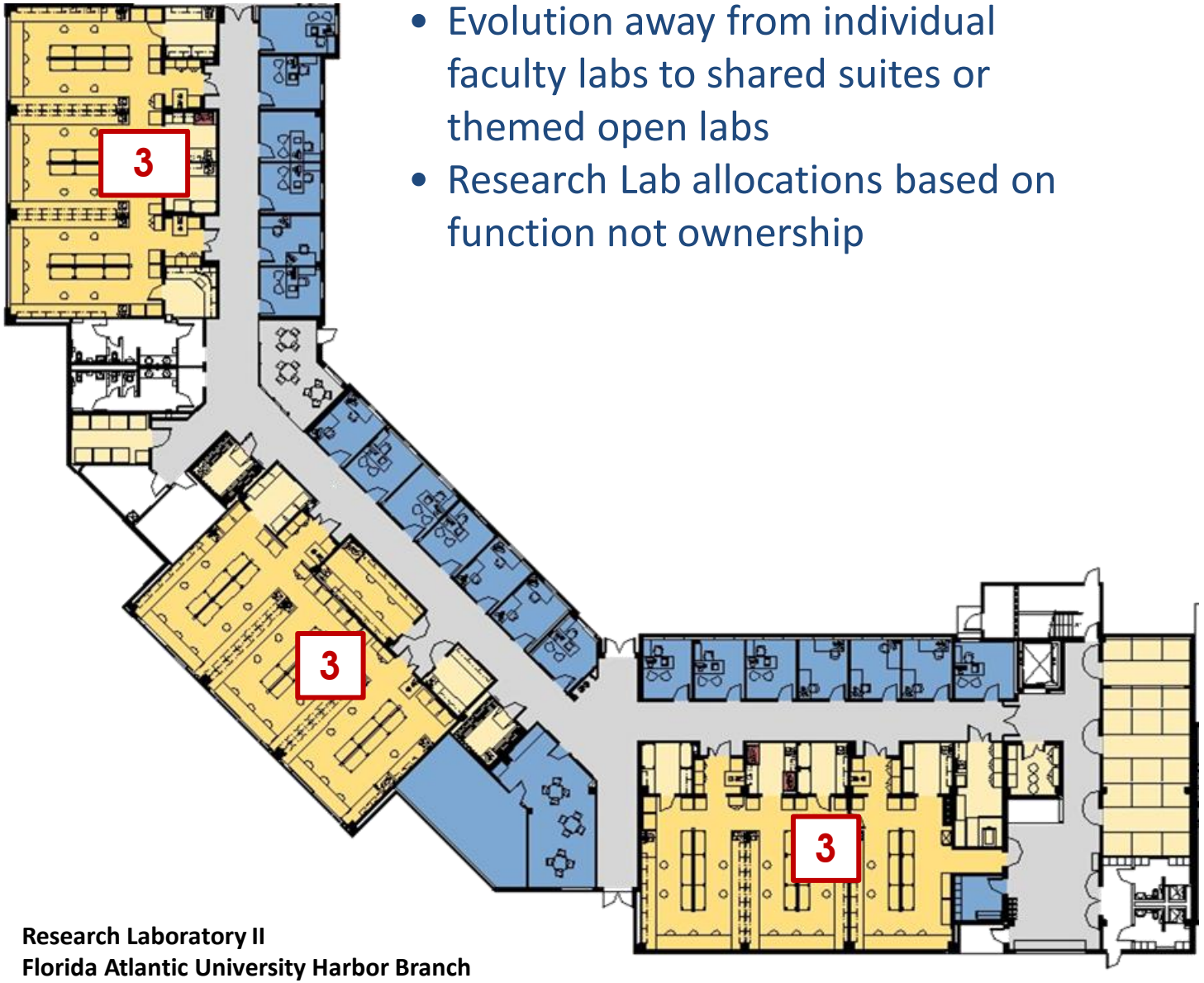
Research Accommodations – Metrics

Research Area / Teaching + Research + Support



Research Accommodations

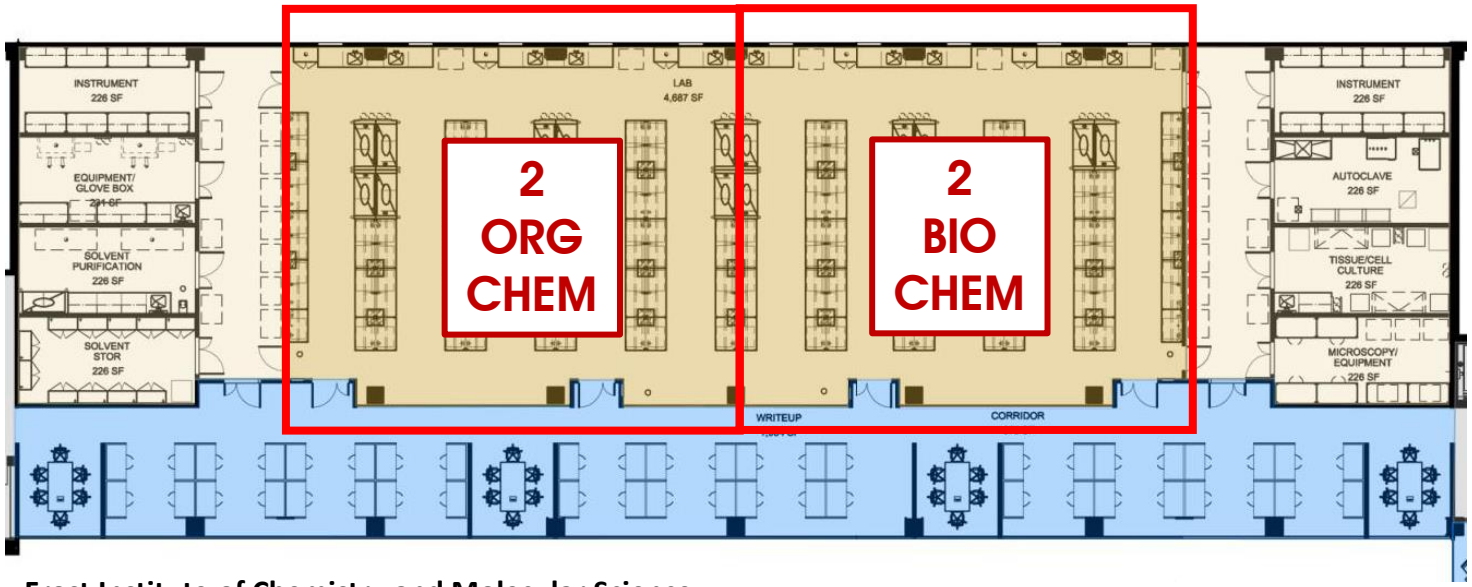
- Evolution away from individual faculty labs to shared suites or themed open labs
- Research Lab allocations based on function not ownership



Research Laboratory II
Florida Atlantic University Harbor Branch
PGAL

Research Accommodations

- Evolution away from individual faculty labs to shared suites or themed open labs
- Research Lab allocations based on function not ownership



Frost Institute of Chemistry and Molecular Science
University of Miami
Harvard Jolly Architecture

Undergraduate Research – **Student Desks & Flexible Benches**

Undergraduate Research Accommodations – **Leveraged Research**

- Modest dedicated Research allocation during the academic year
- Coupled with Teaching Laboratory for extended use during the summer
- Shared Laboratory Support Space in between

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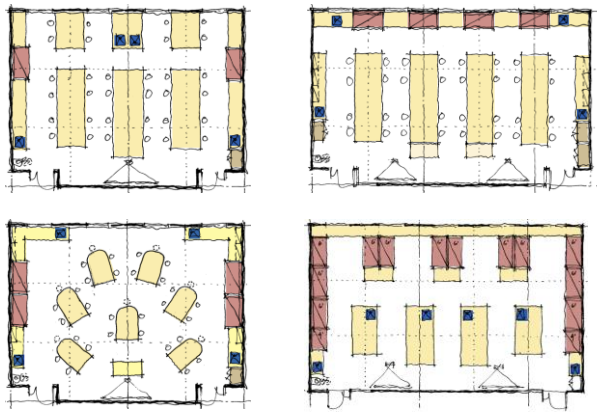
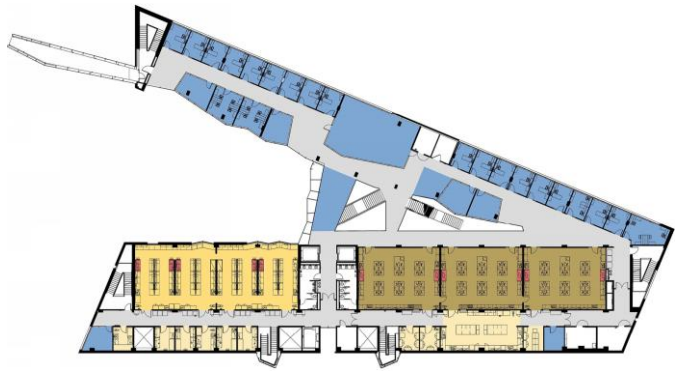
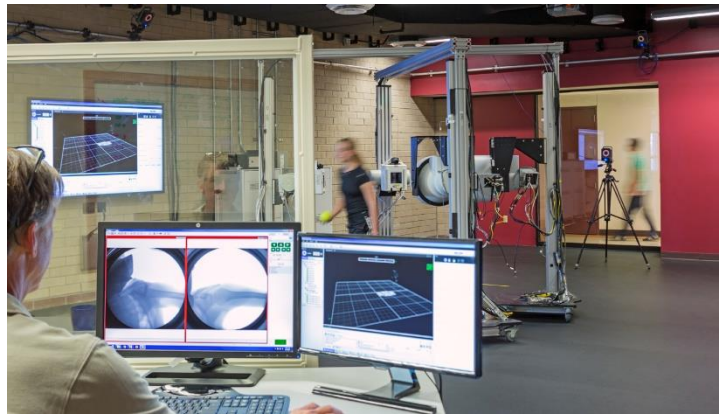
- Considerations for STEM Environments
  - STEM Communities
  - Recruitment & Retention
  - Engaged, Active & Applied Learning
  - Transparency, Connections & Extended Learning
- Planning Trends for STEM
  - Building Planning Considerations
  - Active Learning Laboratories
  - Research & Project Laboratories
- **Innovation & Maker Spaces**
- Benchmarking & Metrics
- Key Takeaways







Maker Space Types & Users

Hands-On Learning

Maker Spaces Variations:

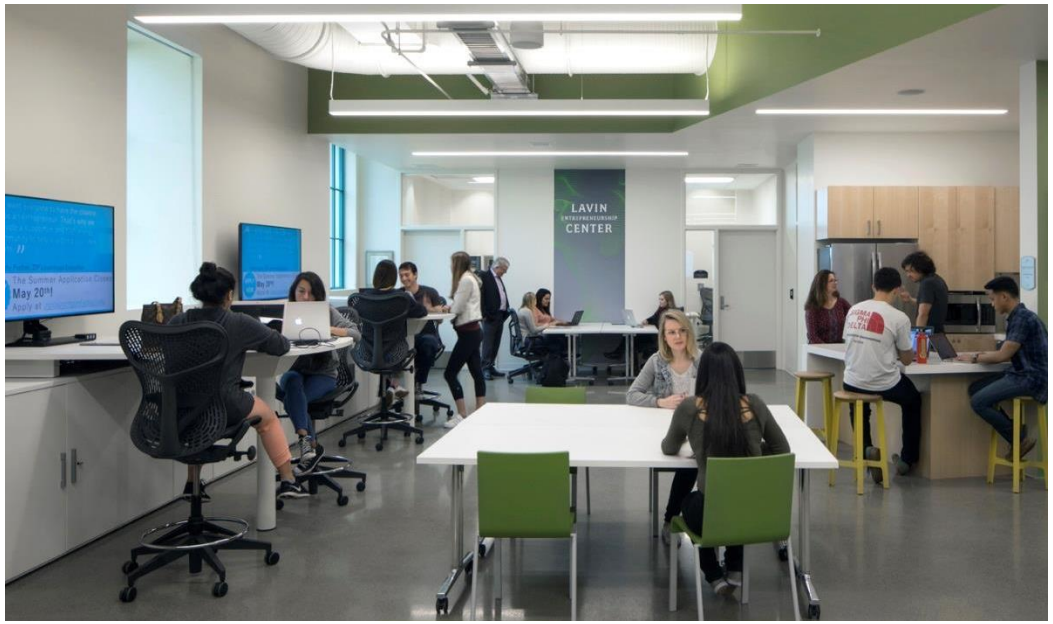
- Ideation & Visualization Labs
- Lightweight Tools & Materials Spaces
- Prototyping Labs
- Large Scale Shops
- Project Assembly Labs

Maker Spaces Users:

- Scheduled Design Courses
- Senior Project / Capstone Teams
- Clubs & Competitions
- Entrepreneurial Incubator Projects
- Non-STEM Students & Outreach

Design & Ideation Spaces

Hands-On Learning



Maker ‘Light’

Hands-On Learning

Fabrication and Shops

Large, Expensive Equipment:

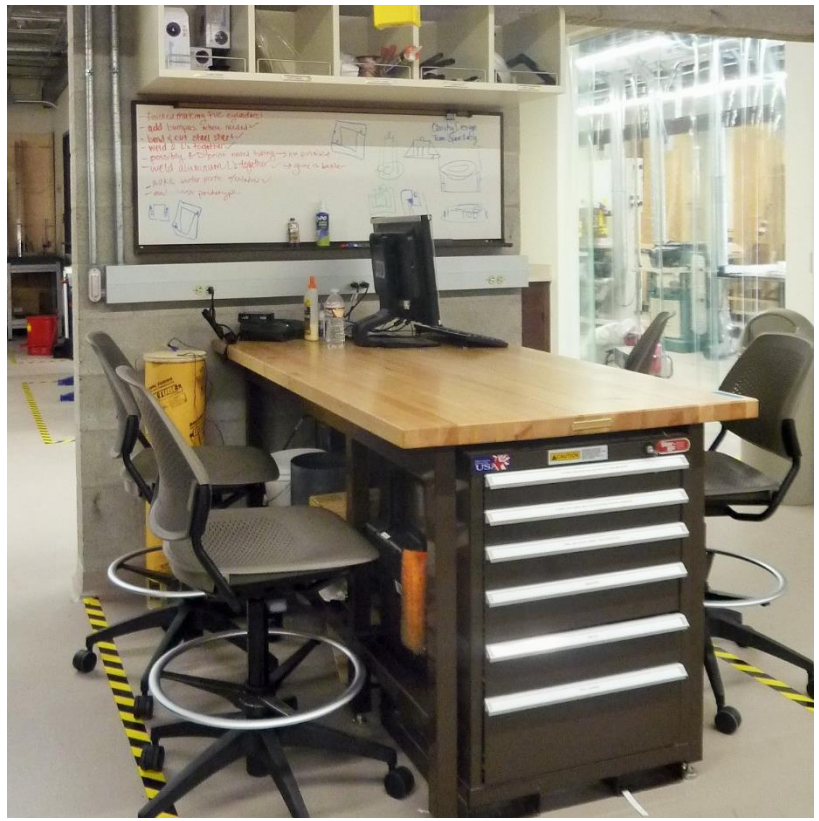
- Woodworking
- Machining
- Composites
- CNC

Project & Assembly

Hands-On Learning

Project Space

- Student Benches
- Work & Tool Stations
- Student Storage
- Open Floor Space



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- **Benchmarking & Metrics**
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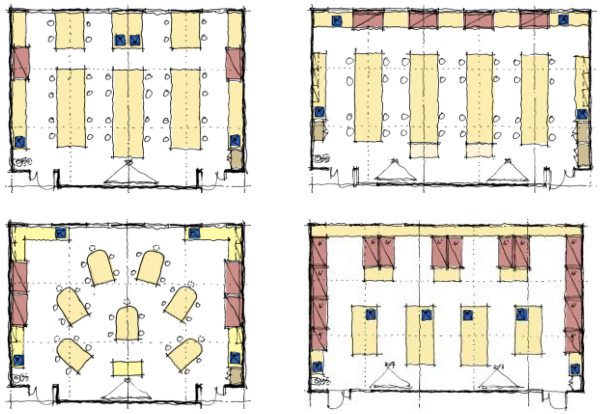
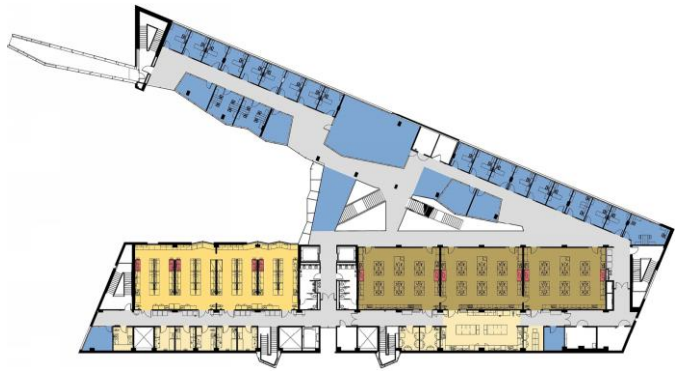
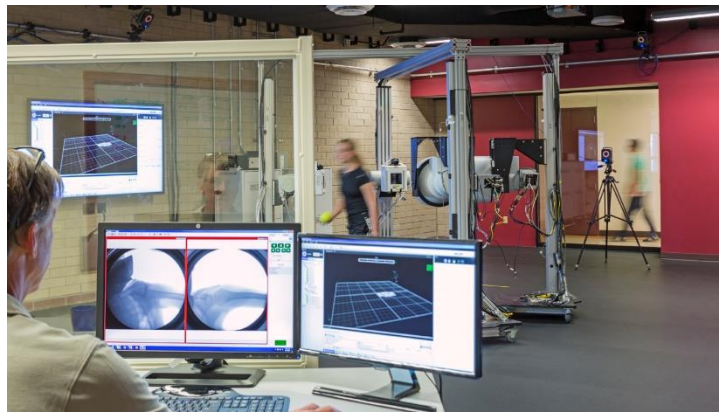
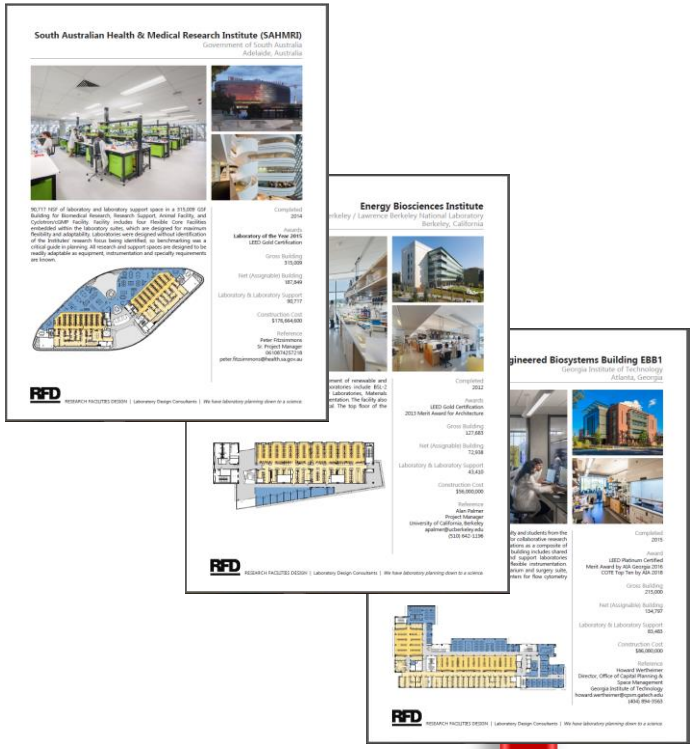


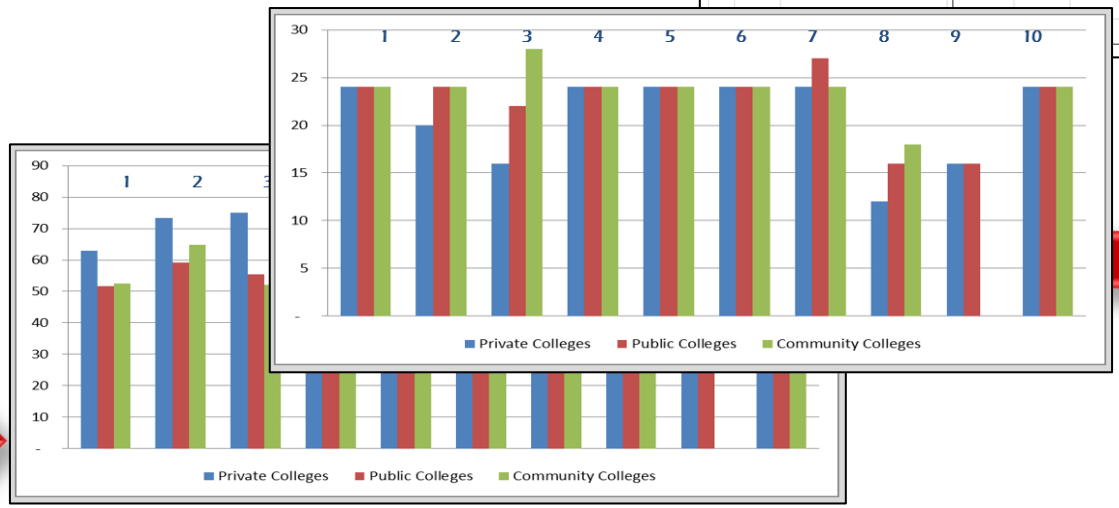




Benchmarking Application to Your Project

- Use as a ‘Guide’ not a ‘Predictor’
- Align with Similar Projects
- Checks and Balances





ROOM LIST / SPACE TABULATION

Overall Space Summary

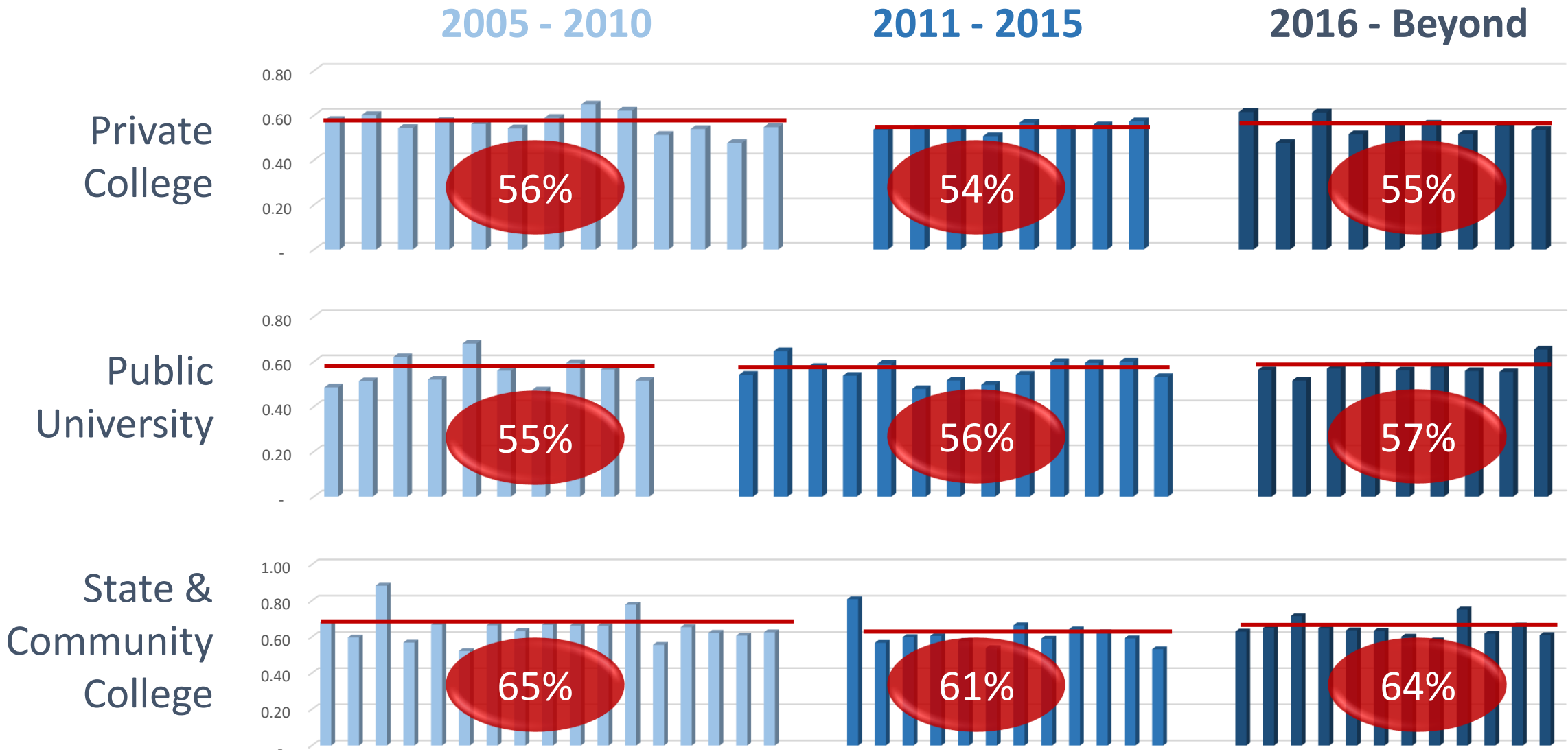
	Department	Option "A" - Reduce PI's March 27, 2012 Lab	Support	Office	Other	Total	Delta	Option "B" - Reduce All March 27, 2012 Lab	Support	Office	Other	Total	Delta
1	College of Science	13,740	8,400	13,390	2,050	37,580	-13,360	20,310	12,390	15,990	2,250	50,940	0
		15	38%					23	38%				
		108						162					
2	College of Engineering	12,690	7,665	8,550	1,600	30,505	-12,035	19,260	11,130	10,350	1,800	42,540	0
		15	38%					23	37%				
		108						162					
3	Core Facilities	0	4,830	0	0	4,830	0	0	4,830	0	0	4,830	0
4	Vivarium	0	31,350	0	0	31,350	0	0	31,350	0	0	31,350	0
5	Building Facilities	0	3,150	0	6,800	9,950	0	0	3,150	0	6,800	9,950	0
	Total ASF	26,676	55,396	21,940	10,450	114,462	-25,395	39,940	62,851	26,340	10,850	139,981	0
	Assumed Net/Gross Ratio					0.57						0.57	
	Estimated Total Building Area					200,810						245,580	

Construction Cost/GSF by Type of Space	Laboratory + Support	Core Functions	Vivarium		Office/Admin + Conference
Estimated Construction Cost	$400	$400	$500		$225
				$73,496,053	

Construction Cost/GSF by Type of Space	Laboratory + Support	Core Functions	Vivarium		Office/Admin + Conference
	$400	$400	$500		$225
		$366		$89,843,421	

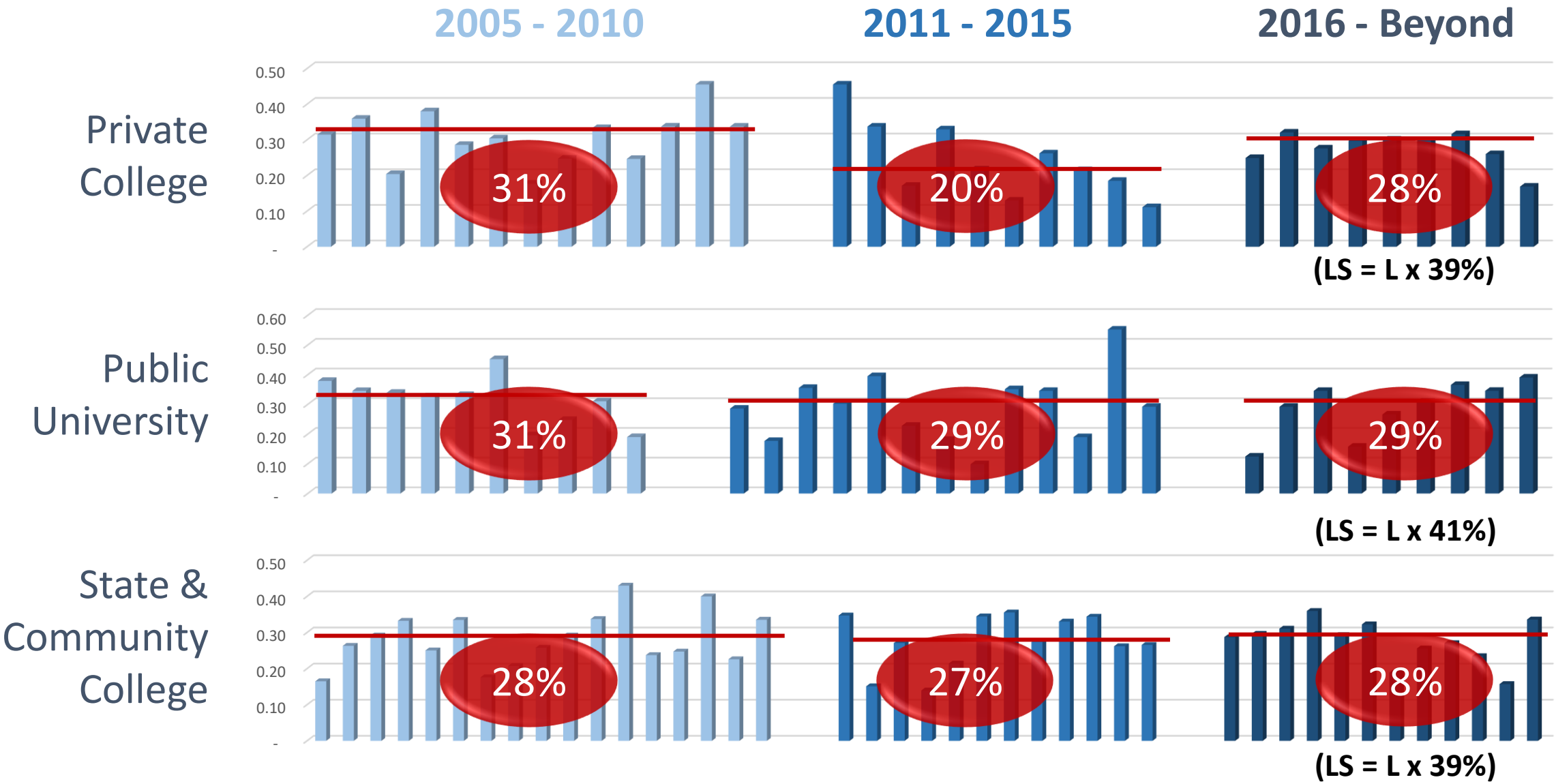
Net / Gross Building Efficiency Ratio

Total Net SF / Total Gross SF



Laboratory Support Area Ratio

Lab Support / Lab + Lab Support



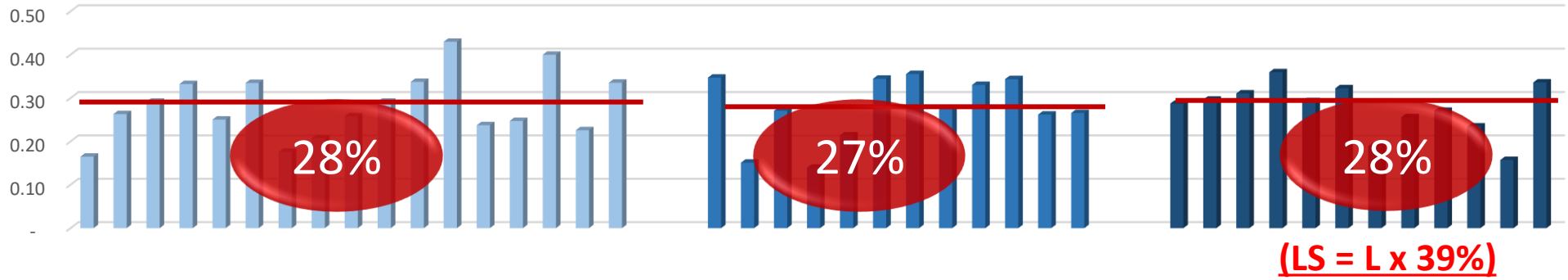
Laboratory Support Area Ratio

Lab Support / Lab + Lab Support

Example:

- 10 teaching labs x 1,320 NSF each
- 13,200 NSF teaching lab area
- **13,200 x 39% = 5,148 NSF laboratory support space over and above the teaching lab space**

State & Community College



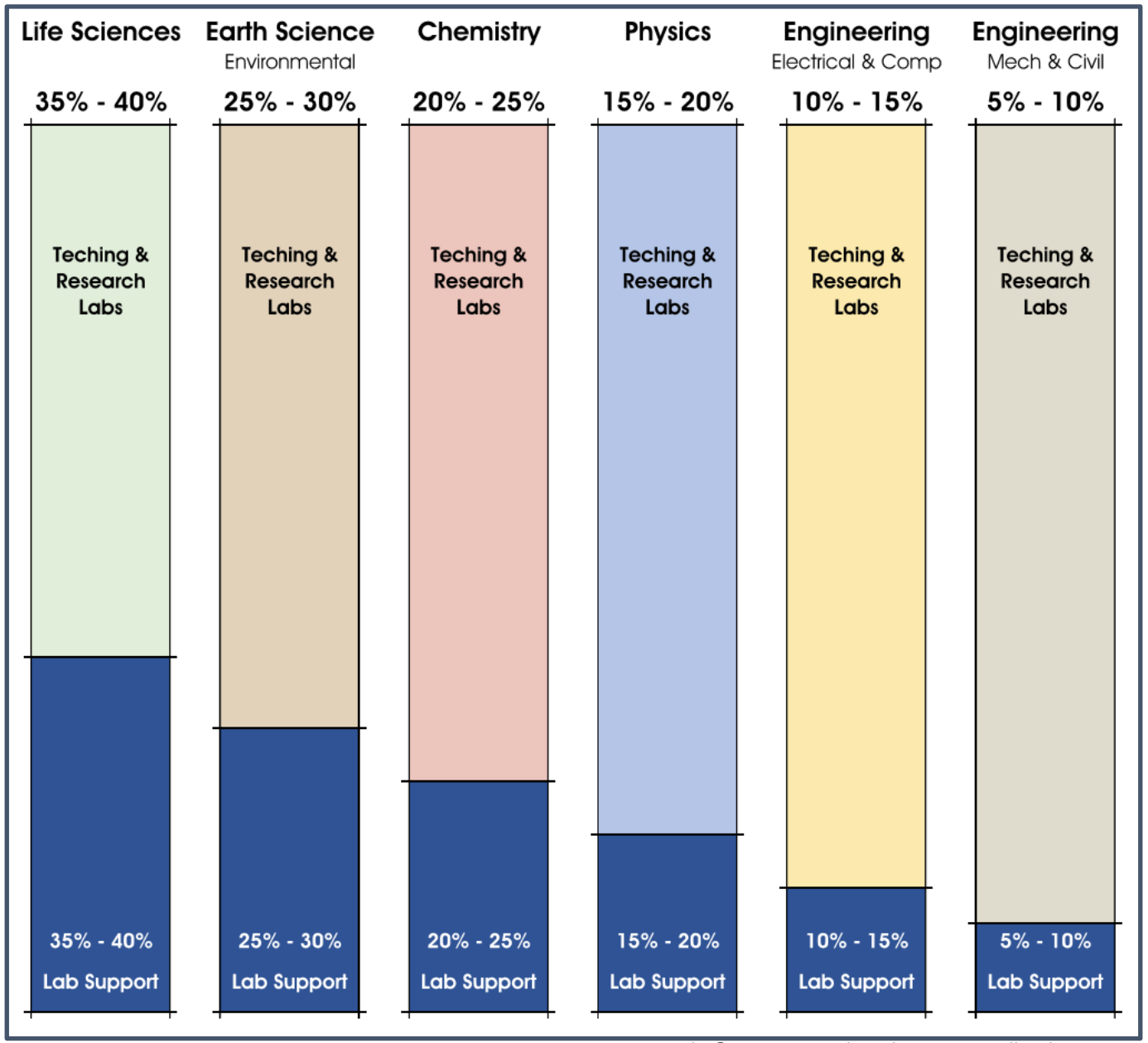
Laboratory Support Area Ratio

Lab Support / Lab + Lab Support

- Lab Support Ratios vary significantly by Discipline
- Life Sciences have much higher Lab Support Ratios
- Engineering facilities have much lower Lab Support Ratios
- Chemistry & Physics somewhere in between

Why is lab support important?

- Can help make laboratory space more flexible and efficient
- Helps recruit & retain faculty & staff
- Improves equipment usable life & functionality
- Can support work force training
- Supports transfer students' knowledge base
- Improves student experience

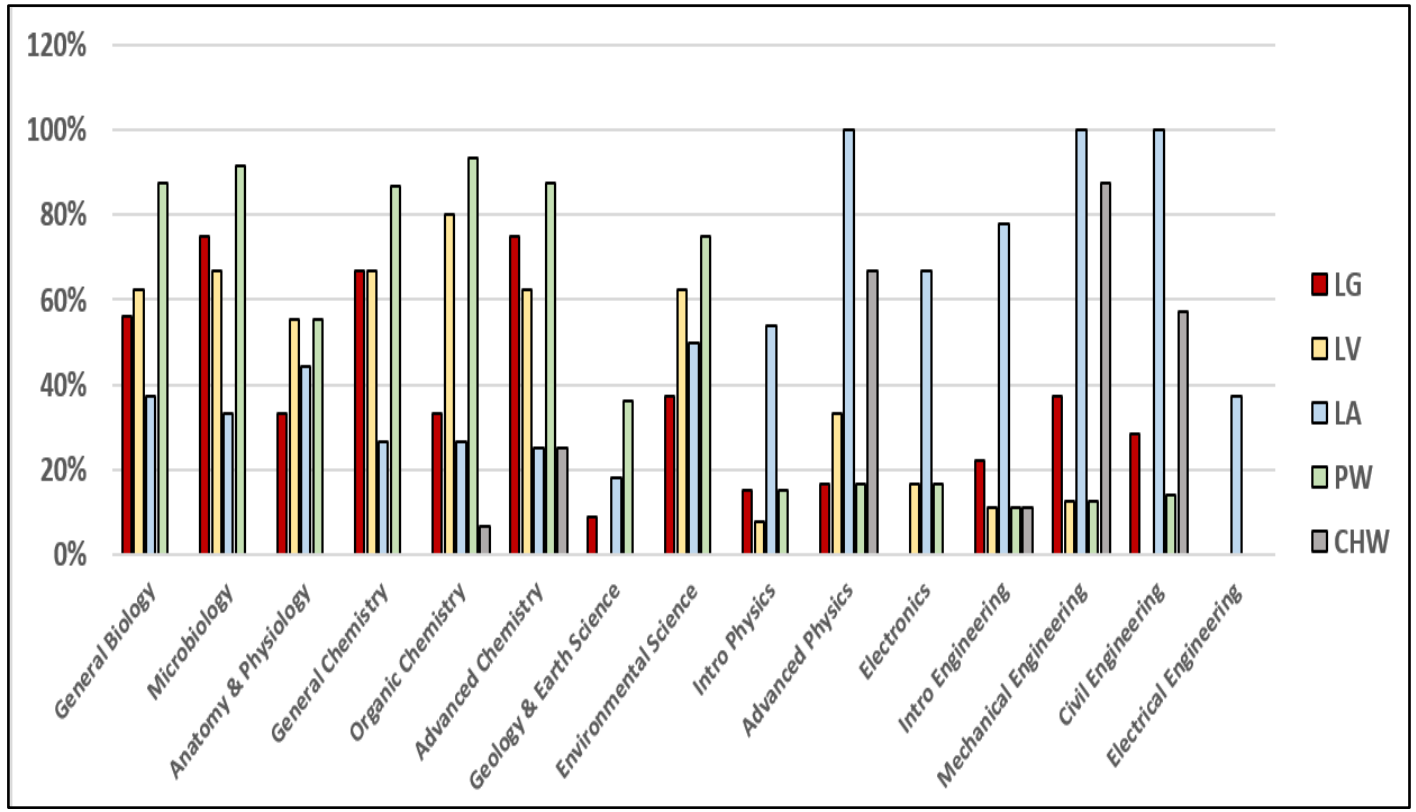


STEM Teaching Laboratory Piped Services

- Overall decreasing density of piped services
- Purified Water and Lab Vacuum are still common in Biology and Chemistry
- High density of Compressed Air in Engineering Labs – much less in other disciplines
- Reduction in use of Natural Gas for Sustainability, Safety and Cost Reasons

2015 – Current Piped Services Distribution

2015 - Current	LG	LV	LA	PW	CHW
General Biology	56%	63%	38%	88%	0%
Microbiology	75%	67%	33%	92%	0%
Anatomy & Physiology	33%	56%	44%	56%	0%
General Chemistry	67%	67%	27%	87%	0%
Organic Chemistry	33%	80%	27%	93%	7%
Advanced Chemistry	75%	63%	25%	88%	25%
Geology & Earth Science	9%	0%	18%	36%	0%
Environmental Science	38%	63%	50%	75%	0%
Intro Physics	15%	8%	54%	15%	0%
Advanced Physics	17%	33%	100%	17%	67%
Electronics	0%	17%	67%	17%	0%
Intro Engineering	22%	11%	78%	11%	11%
Mechanical Engineering	38%	13%	100%	13%	88%
Civil Engineering	29%	0%	100%	14%	57%
Electrical Engineering	0%	0%	38%	0%	0%



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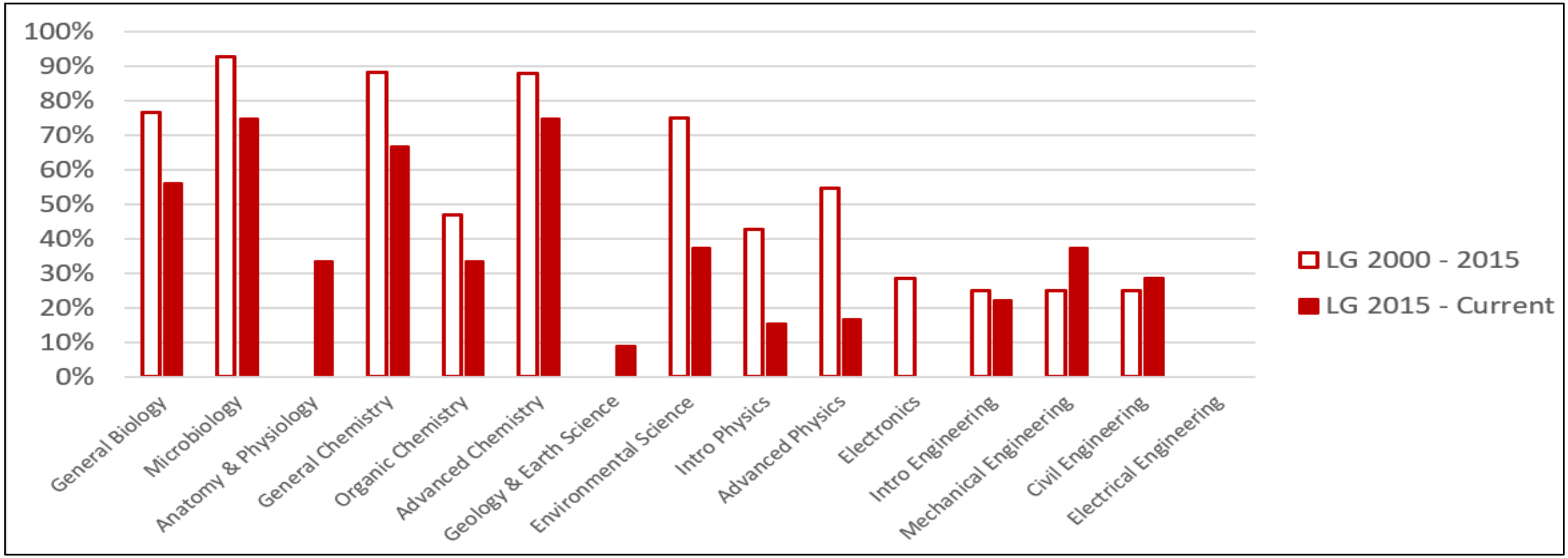
Comparison - Natural Gas Reductions in Teaching Labs



Laboratory Ventilation Air

Almost Always Recirculating Air:

- Computer Sciences
- GIS
- Astronomy

Sometimes Recirculating Air:

- Physics
- Engineering
- Geology
- Earth Science

Almost Always Once - Through Air:

(Minimum Make-up Air)

- Maker Spaces
- Shops
- Mechanical & Civil Engineering

Always Once - Through Air:

(Required Elevated Air Change Rates)

- Chemistry
- Organic Chemistry
- Anatomy & Physiology
- Biology

Laboratory Ventilation Air

Recirculating Air:

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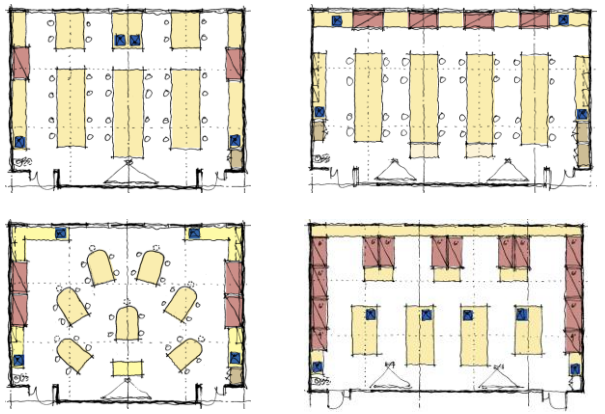

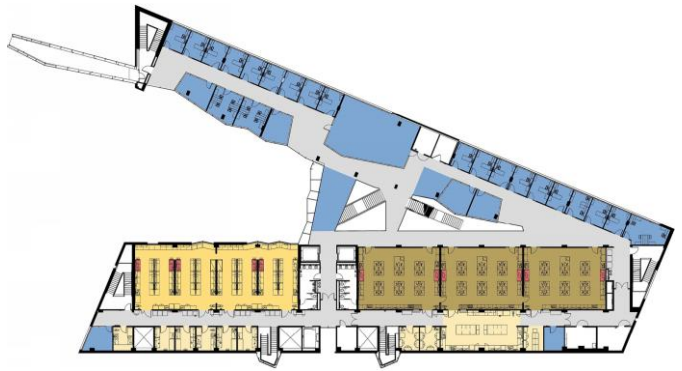

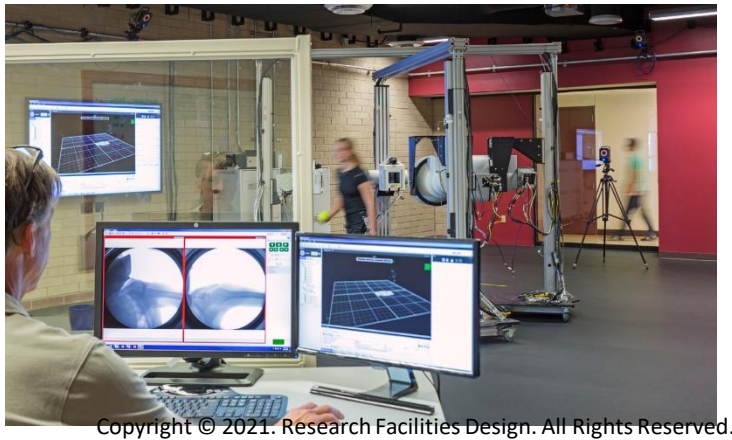

Key Takeaways

1. ***Extend your STEM Community***
   Focus on the People –
   Students, Faculty, Outreach

2. ***Connect your Learning Environments***
   Clusters & Multi-use Neighborhoods
   Engage Future STEM Learners

3. ***Learn from others but identify and celebrate what is unique about YOU.***

Key Takeaways

4. STEM can be 'Magic'!!

Questions / Discussion

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