TRADELINE

UNIVERSITY FACILITIES for the SCIENCES & ADVANCED TECHNOLOGY

November 8th & 9th, 2021

Scottsdale, Arizona

Forum 'D':
Next-Generation Science & Technology Facilities
Trends, Planning & Metrics

SEAN TOWNE, FAIA, LEED AP
Principal

JORGE GARCIA, AIA
Laboratory Consultant

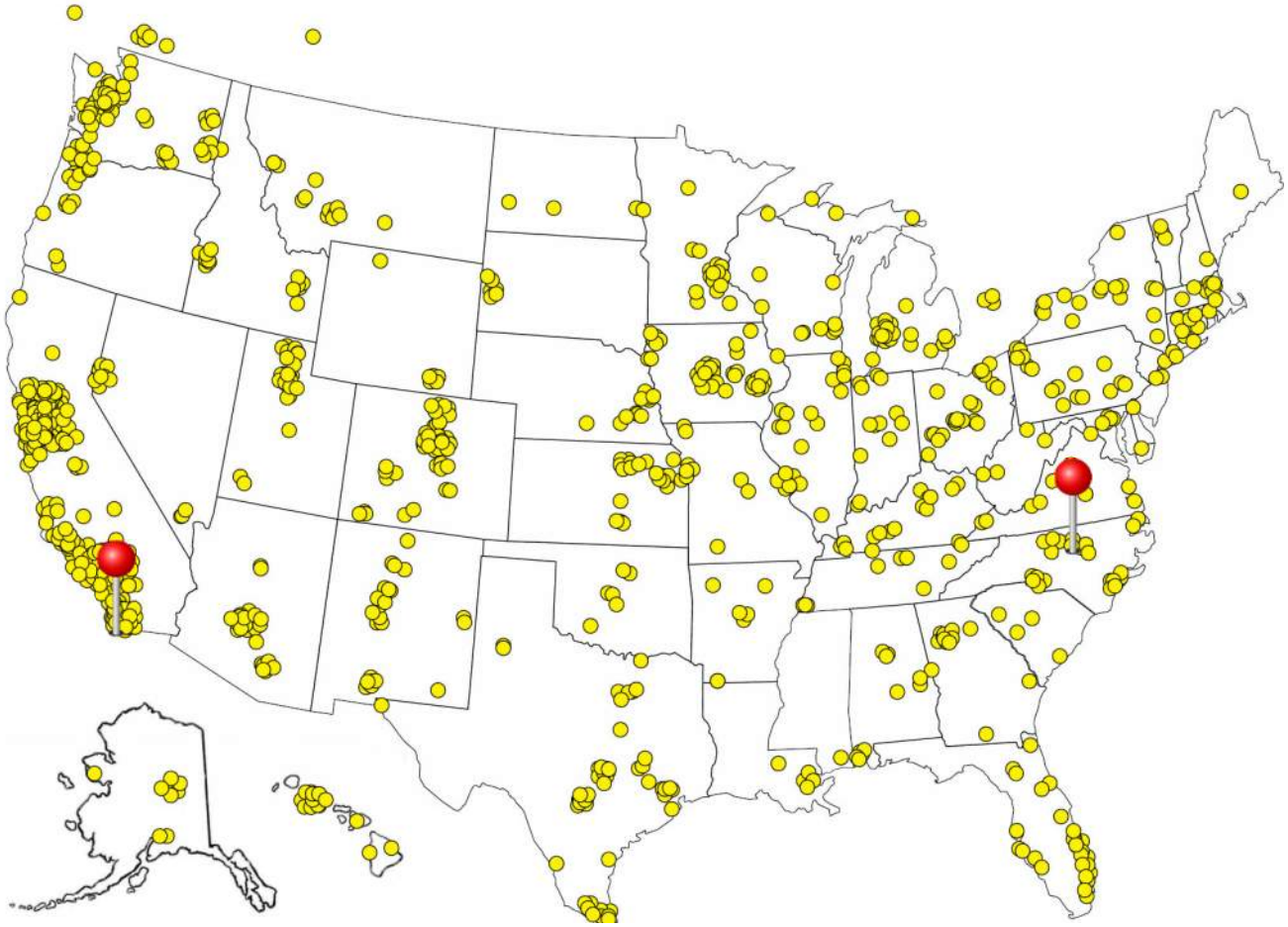
MICHAEL DAVISON, AIA
Laboratory Consultant

RESEARCH FACILITIES DESIGN

What is our perspective?

Laboratory Programming & Design Consultants

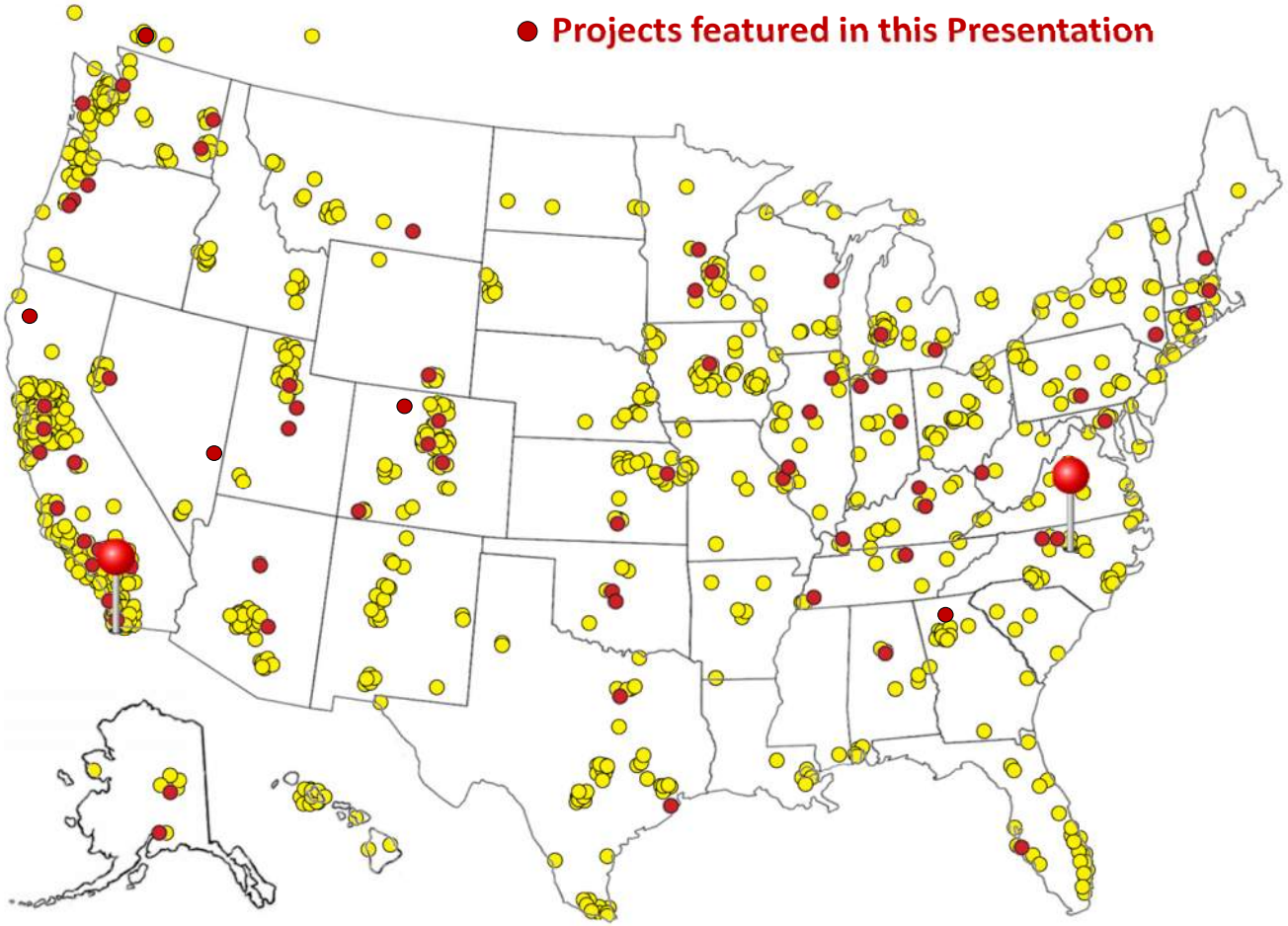
- Architects, Engineers, Designers, & Technical Support Staff
- Focused 100% on Planning & Design of Laboratories
- Collaborated with more than 480 Architectural Firms
- More than 1,200 Projects in 50 states throughout the U.S., Canada, Australia, United Kingdom, Asia & Middle East
- 450 College and University Clients
- 90 Million GSF of Building Space
- $23 Billion Construction Value



What is our perspective?

Laboratory Programming & Design Consultants

- Architects, Engineers, Designers, & Technical Support Staff
- Focused 100% on Planning & Design of Laboratories
- Collaborated with more than 480 Architectural Firms
- More than 1,200 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

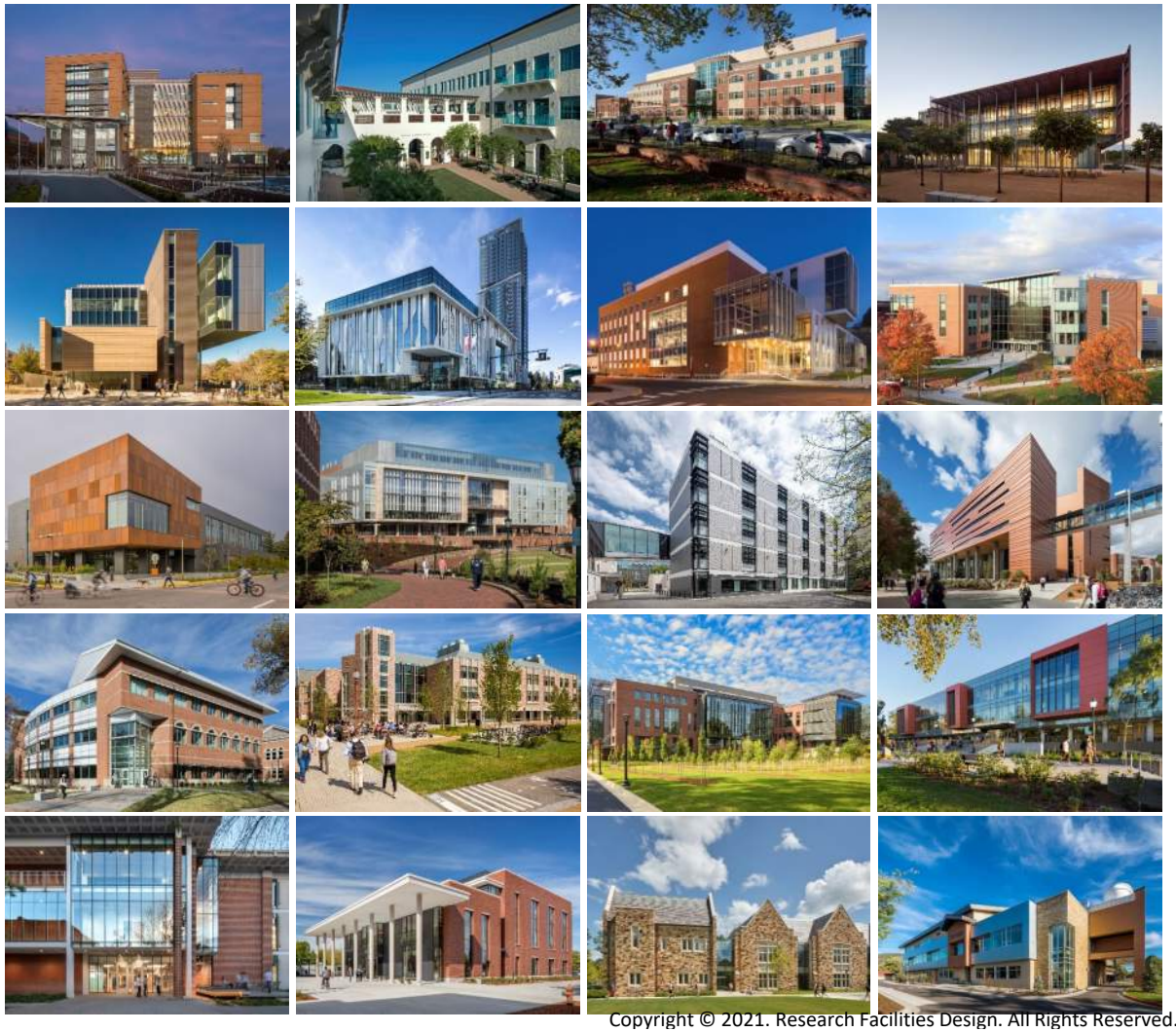


What is our perspective?

As Laboratory Design Consultants, RFD has Collaborated with more than 400 Architectural Design Partners in our 35+ year practice.

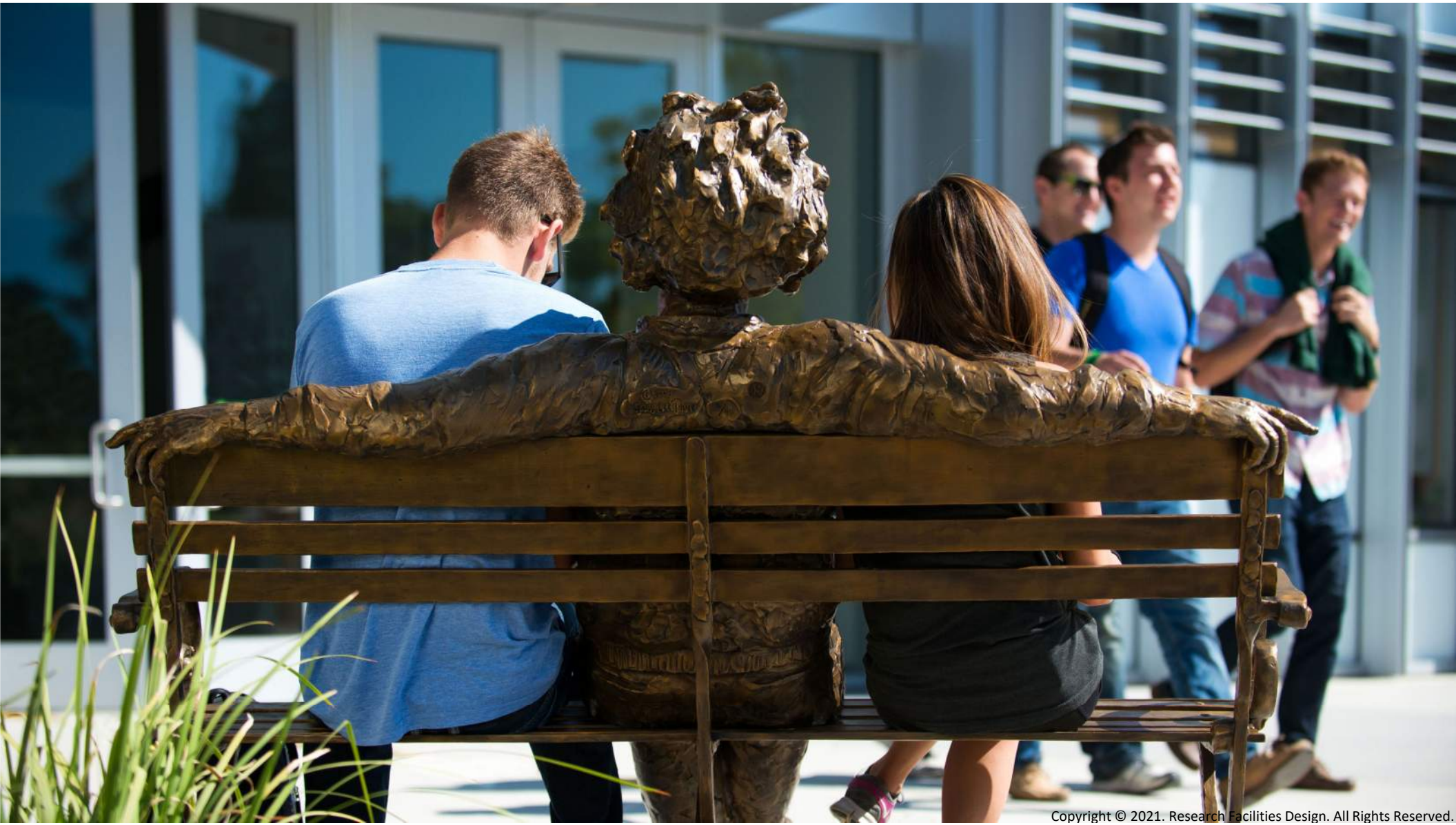
Architects for Projects Featured in this Presentation include:

- A&E
- AC Martin
- Acton Ostry
- Ayers Saint Gross
- Anderson Mason Dale
- Architekton
- Barber McMurry Architects
- Bolin Cywinski Jackson
- BSA Life Structures
- Cooper Carry Architects
- Dekker Perich Sabatini
- Dewberry Architects
- Grimshaw Architects
- H+K Architects
- Harvard Jolly
- Hacker
- Hanbury
- Hastings & Chivetta
- HGA
- Holly Street Studio
- Hord Coplan Macht
- Kieran Timberlake
- Lake Flato Architects
- Lionakis
- LMN Architects
- Mahlum Architects
- Miller Hull
- Moore Ruble & Yudell
- Morphosis
- OPN Architects
- PGAL
- PGAV
- RATIO Architects
- Revery Architecture
- RDG
- Richard + Bauer
- Shepley Bulfinch
- SmithGroup JJR
- SOM
- SRG Partnership
- Steinberg Hart
- Upland Design Group
- VCBO Architecture
- Zimmer Gunsul Frasca



Presentation Outline

1) **Considerations for Science & Technology Facilities**
   - » Learning & Research Communities
   - » Recruitment & Retention
   - » Engaged, Active & Applied Learning
   - » Transparency, Connections & Extended Learning
2) **Planning Trends for Science & Technology**
   - » Building Planning Considerations
   - » Active Learning Laboratories
   - » Undergraduate Research & Project Laboratories
3) **Innovation, Maker & Advanced Manufacturing Spaces**
4) **Benchmarking & Metrics**
5) **The 'Tradeline Three'**



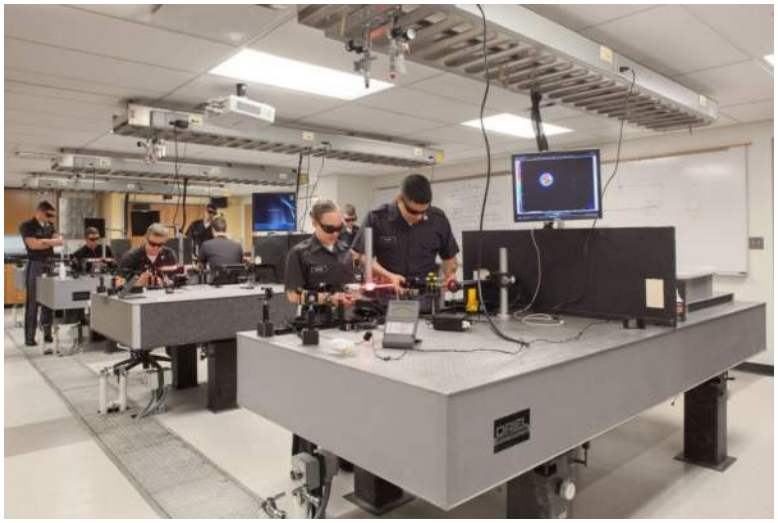
Extending Communities for Science & Technology

- ✓ **PROGRAMS** for Science & Technology
- ✓ **PLACES** for extended learning
- ✓ **PEOPLE** that broaden your community
- ✓ **PARTNERSHIPS** that build industry connections

The Programs – Basic Sciences

Chemistry

Physics



Biology

Earth Sciences

The Programs – Engineering

Electrical Engineering

Bio - Engineering

Mechanical Engineering

Civil Engineering

The Programs – Other STEM Disciplines

Allied Health

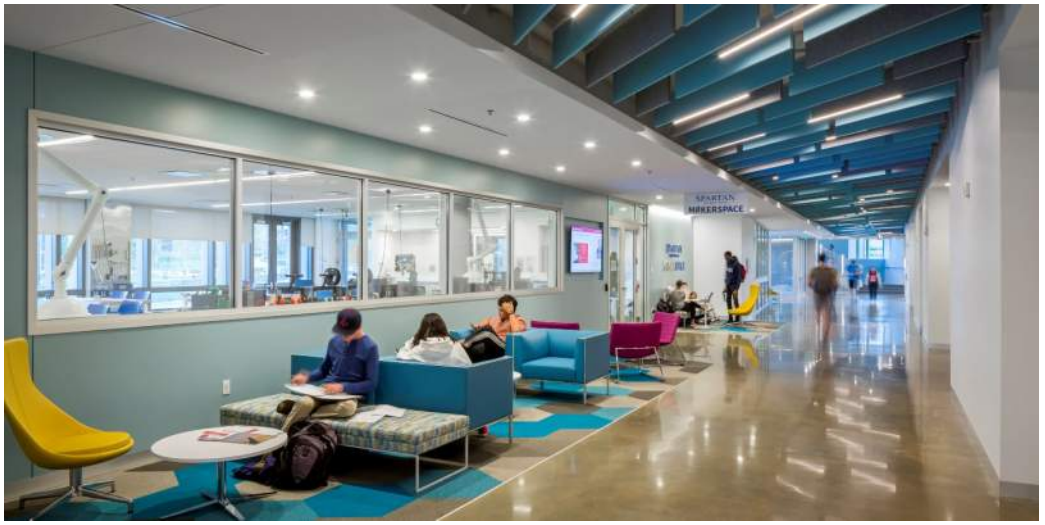
Robotics

Environmental Sciences

Computer Science

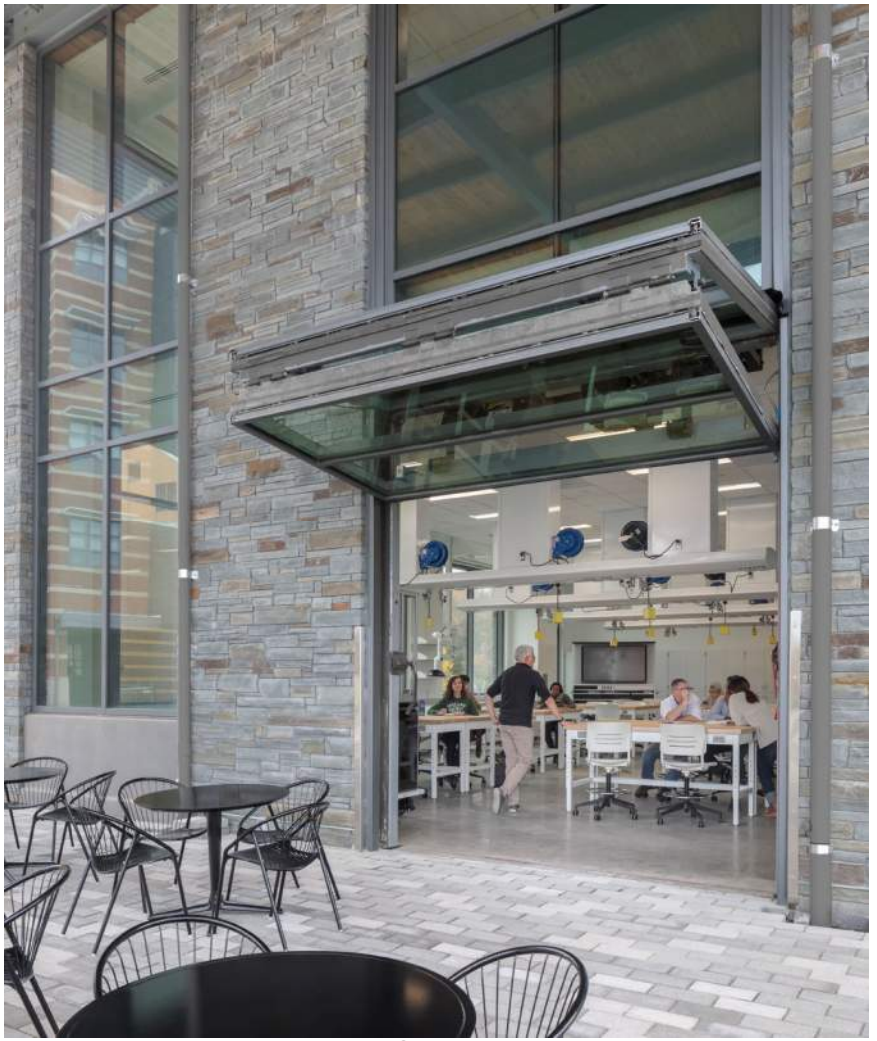
Developing Communities

The Places – Formal & Informal



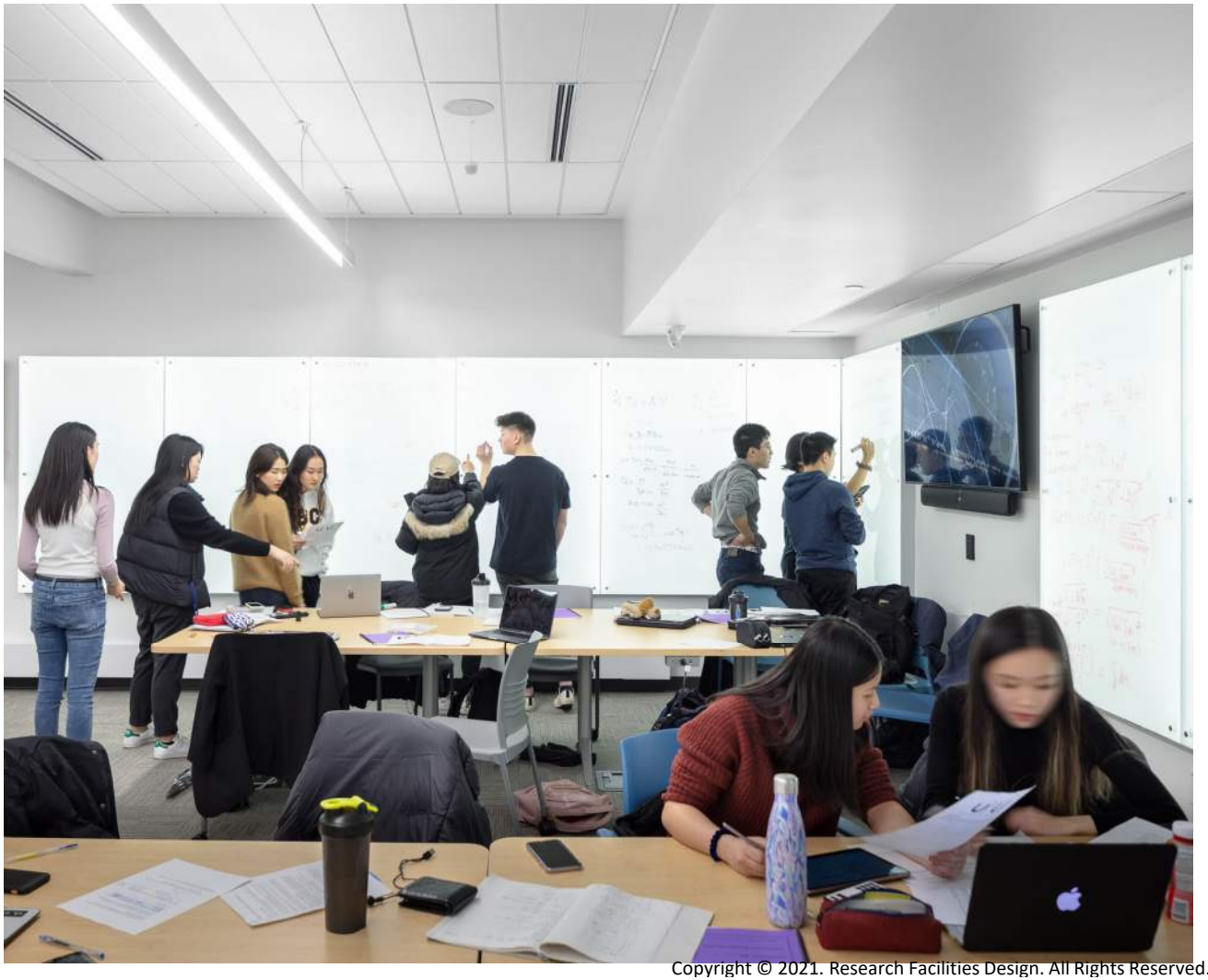
Developing Communities

The Places – Outdoor Spaces



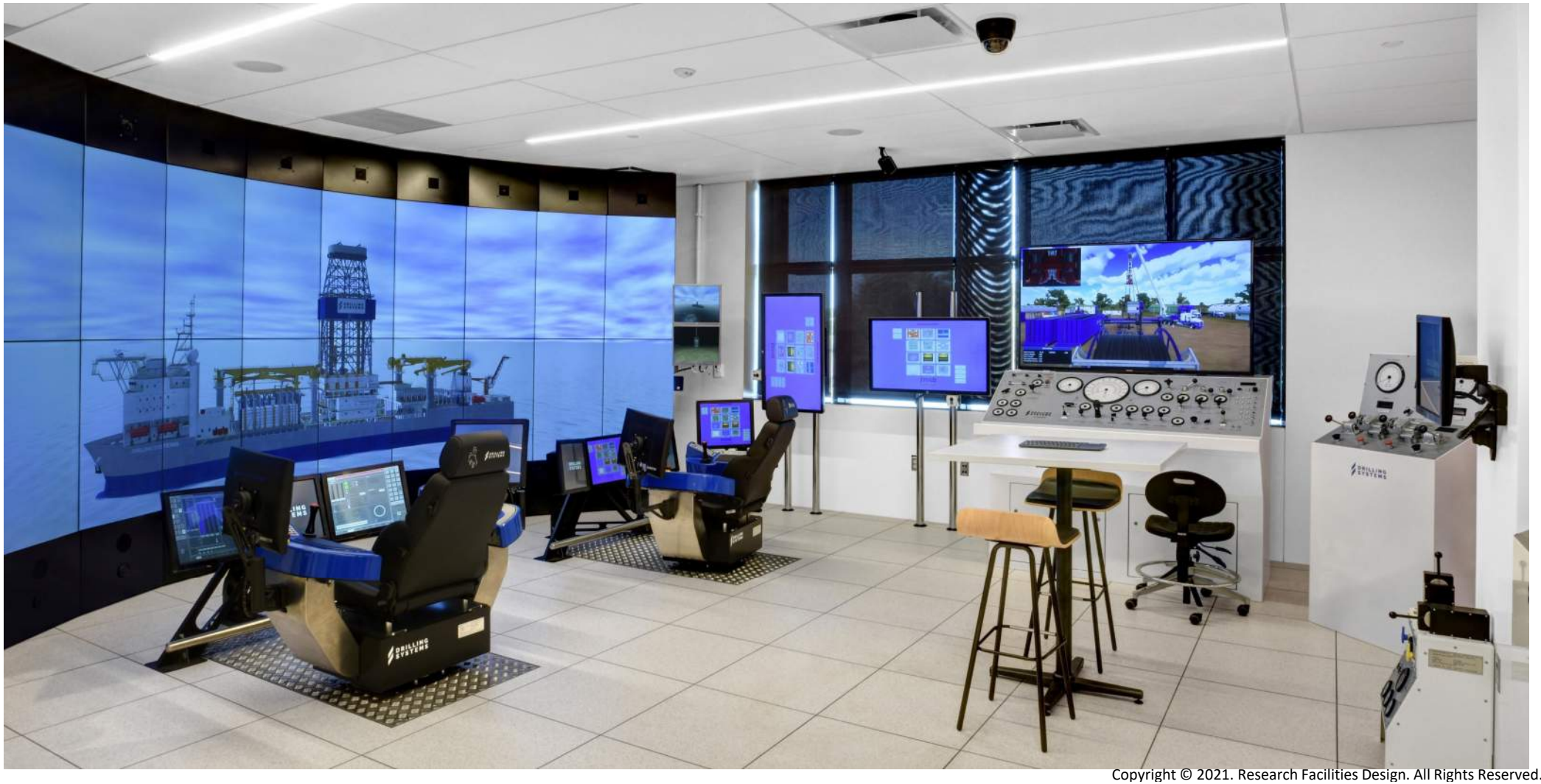
Developing Communities

The People – Students, Faculty, Staff



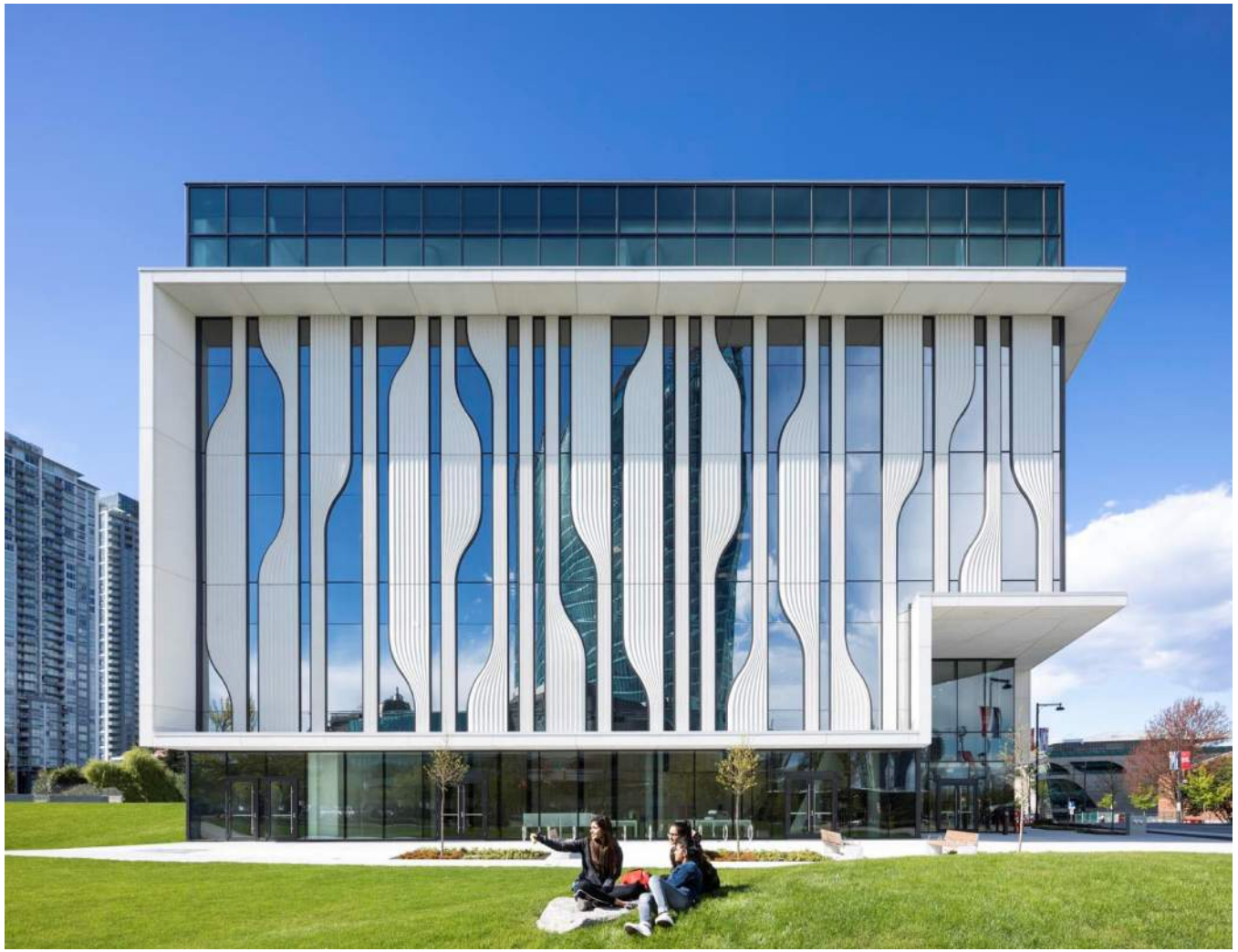
Developing Communities

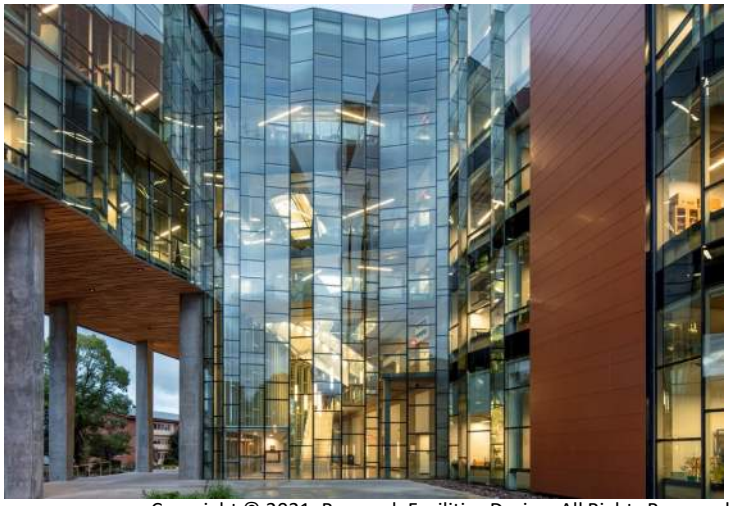
The People – Partnerships, Outreach



Recruitment & Retention

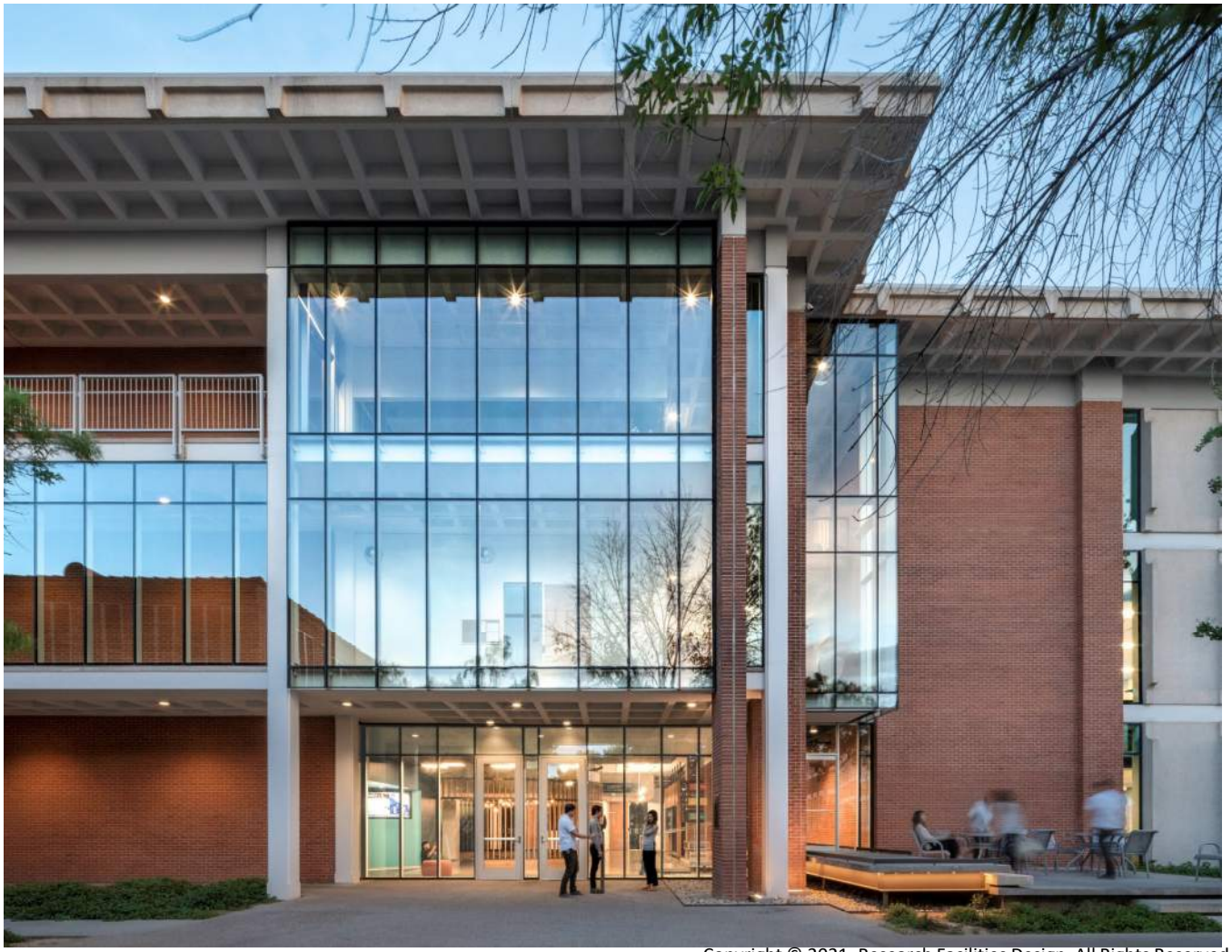
Importance of ‘Curb Appeal’





Recruitment & Retention

Importance of ‘Curb Appeal’ – Renovations

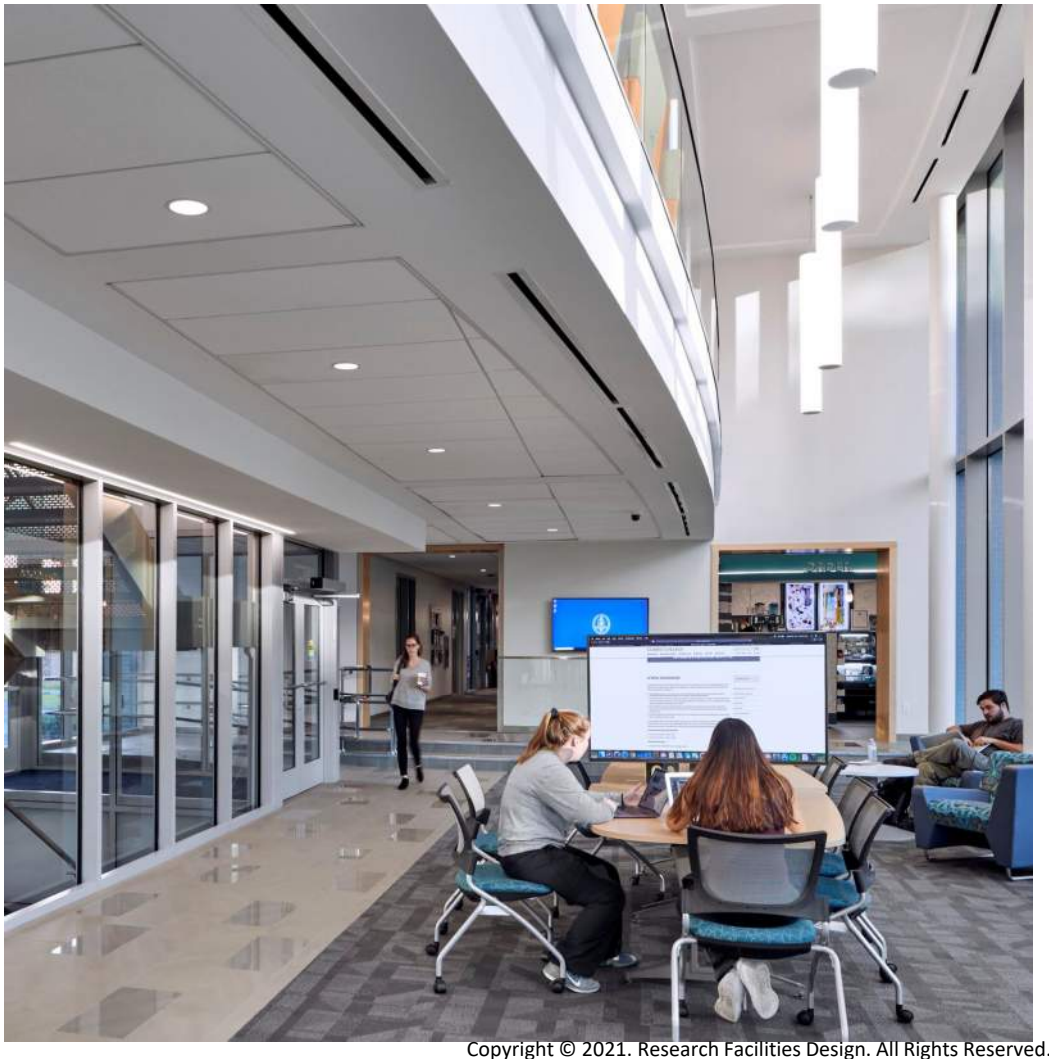


Recruitment & Retention

Importance of ‘Curb Appeal’ – Campus Landmarks

Recruitment & Retention

Student Life Amenities - Food, Caffeine, Daylight & Wi-Fi

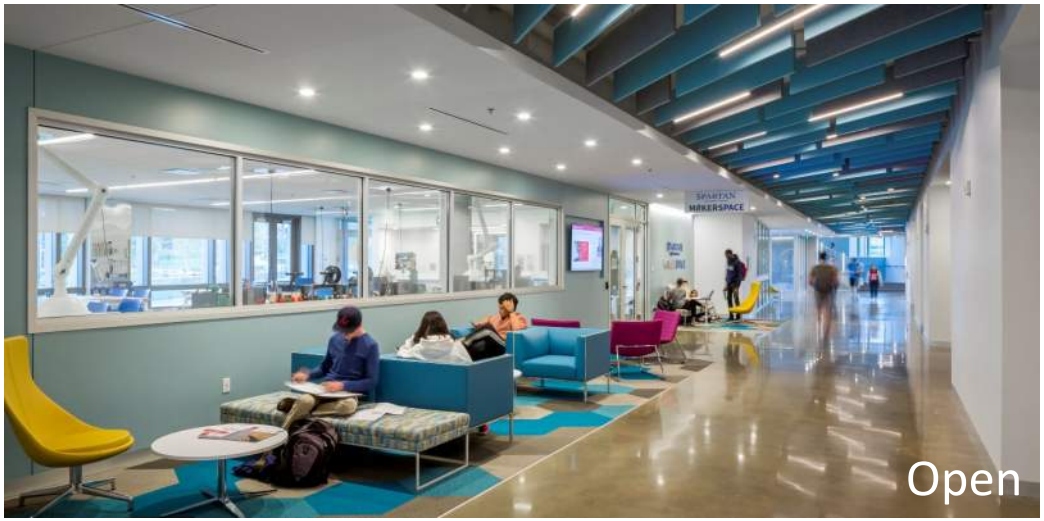


Engaged, Active & Applied Learning

Entire Building as a Learning Environment

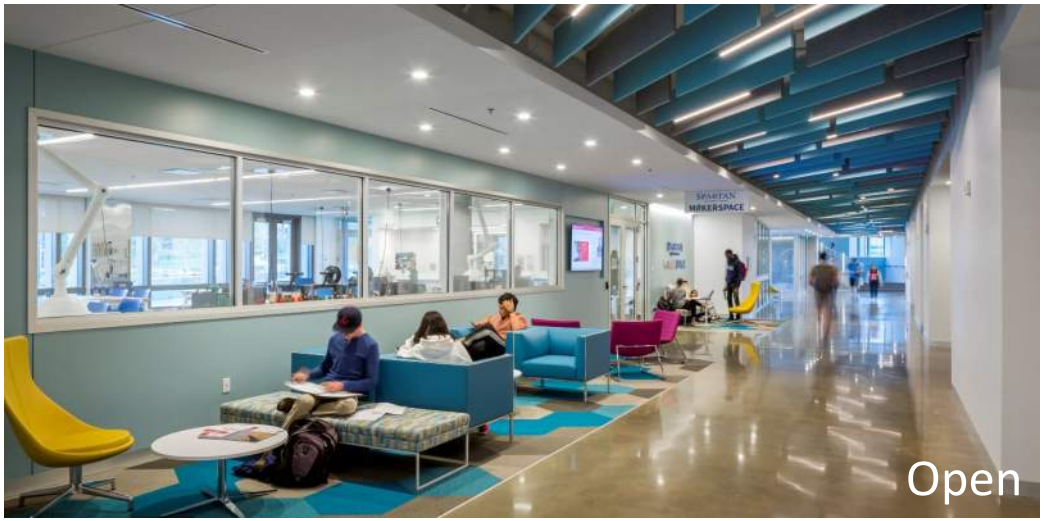
Engaged, Active & Applied Learning

Entire Building as a Learning Environment



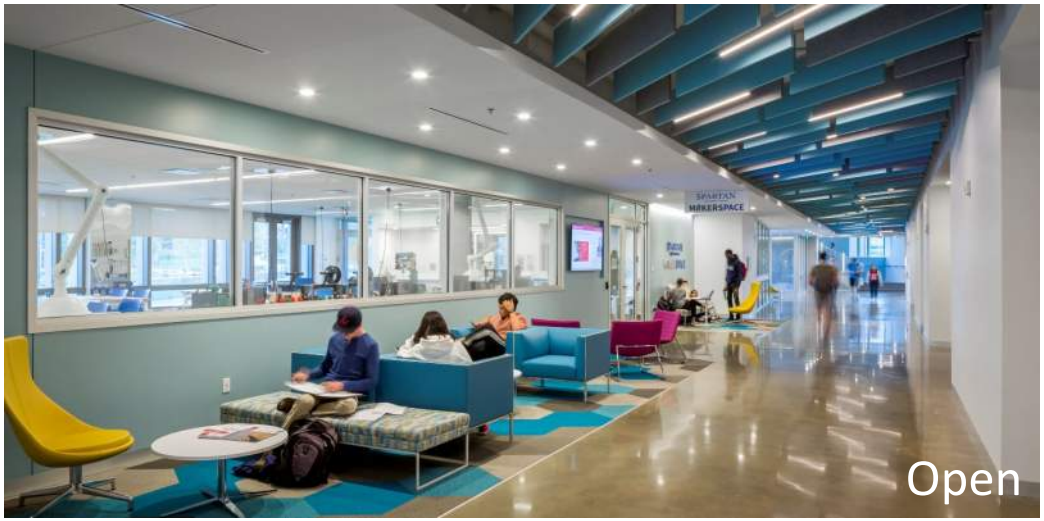
Engaged, Active & Applied Learning

Entire Building as a Learning Environment



Engaged, Active & Applied Learning

Entire Building as a Learning Environment



Engaged, Active & Applied Learning

Entire Building as a Learning Environment – Flexible

Engaged, Active & Applied Learning

Entire Building as a Learning Environment – Flexible

Engaged, Active & Applied Learning

Entire Building as a Learning Environment – Flexible

Engaged, Active & Applied Learning

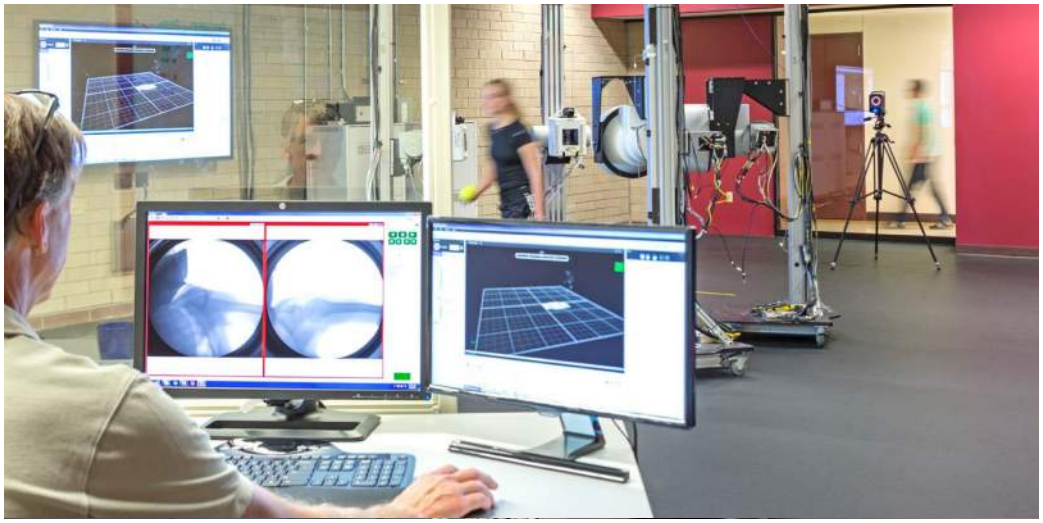
Entire Building as a Learning Environment – Flexible

Engaged, Active & Applied Learning

Active Learning in Labs – Discovery & Problem Solving

Engaged, Active & Applied Learning

Applied Learning in Labs – Projects & Research



Transparency, Connections & Extended Learning

Transparency – to Exterior

Transparency, Connections & Extended Learning

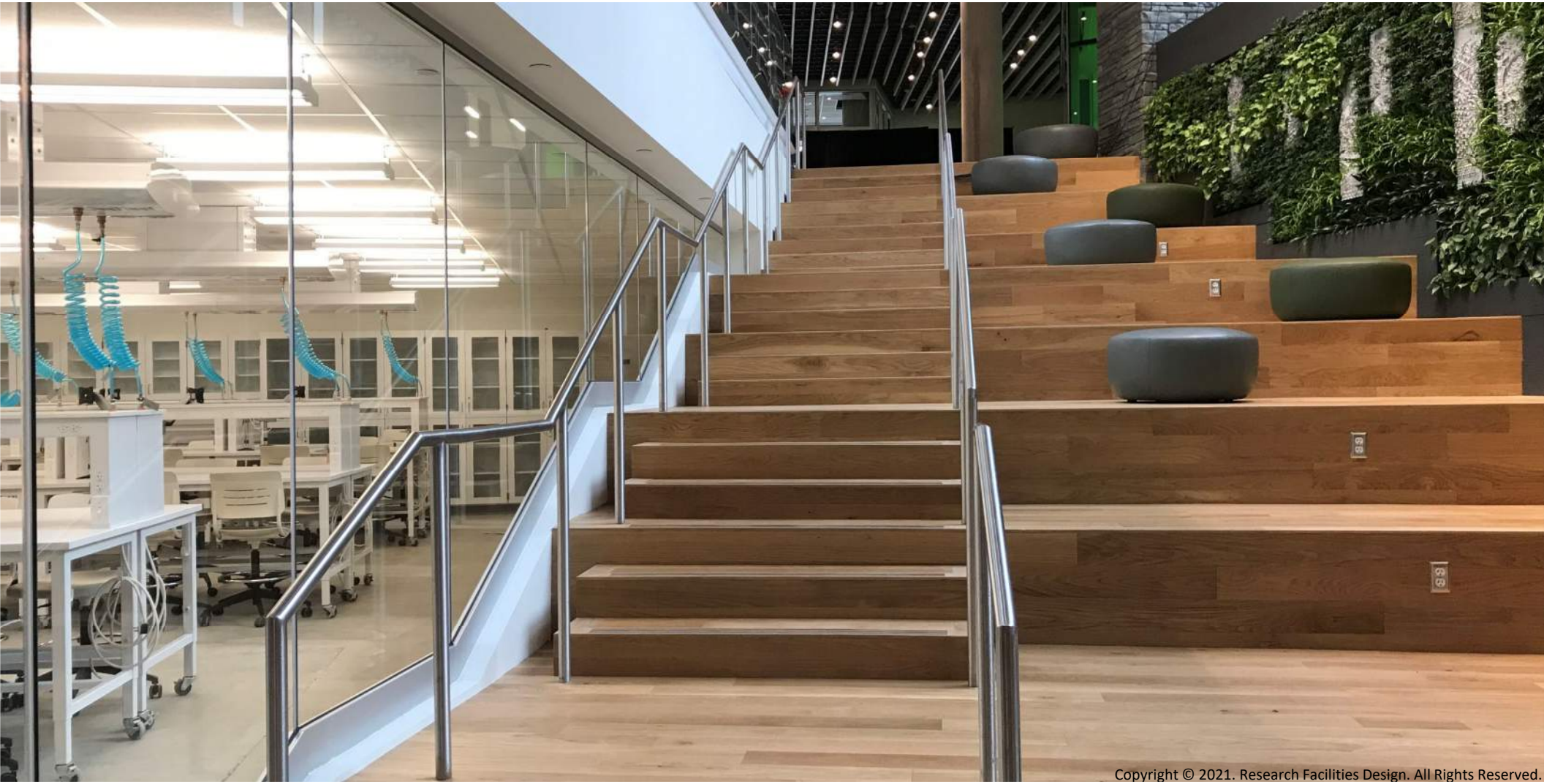
Transparency – to Exterior

- Daylighting
- Connections to the Environment
- Wellbeing

Transparency, Connections & Extended Learning

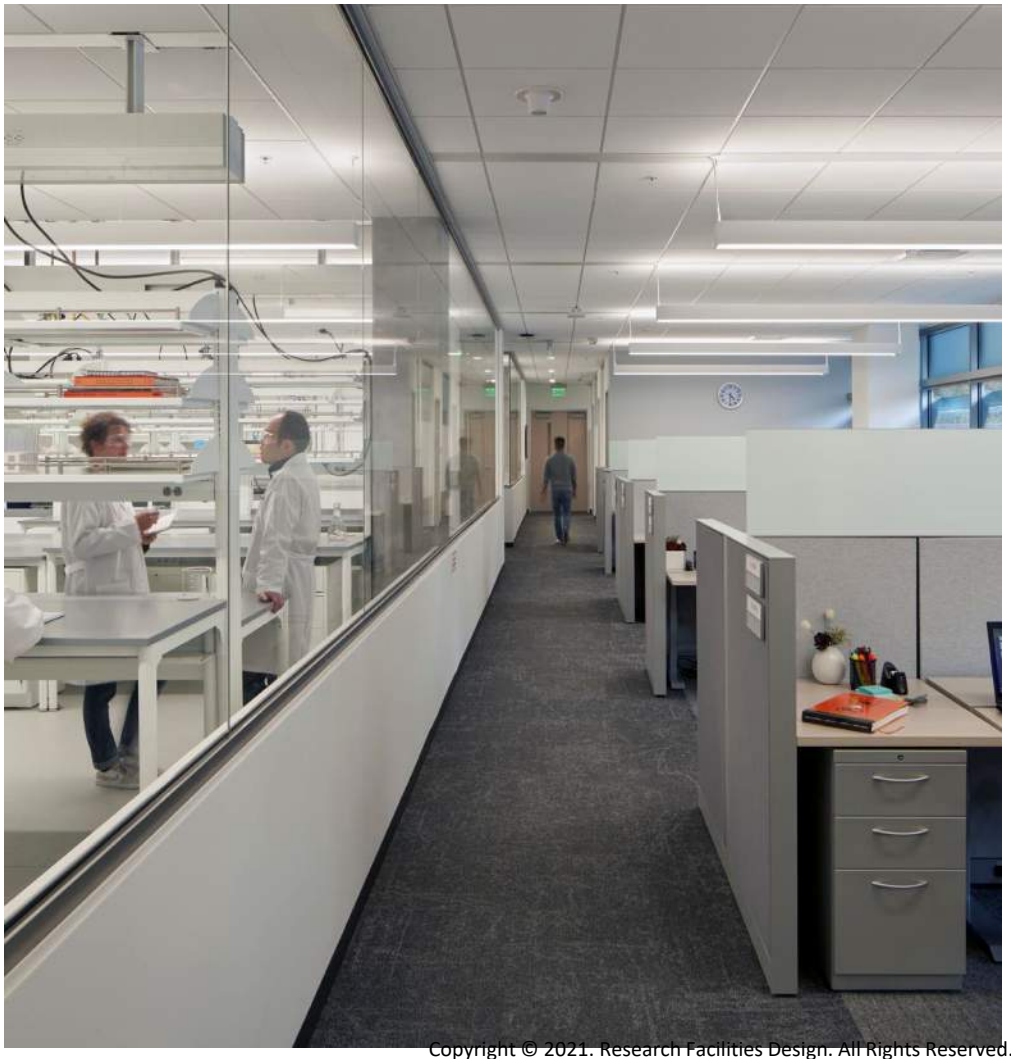
Transparency – from Corridors

Transparency – from Corridors



Transparency, Connections & Extended Learning

Transparency – Between Spaces

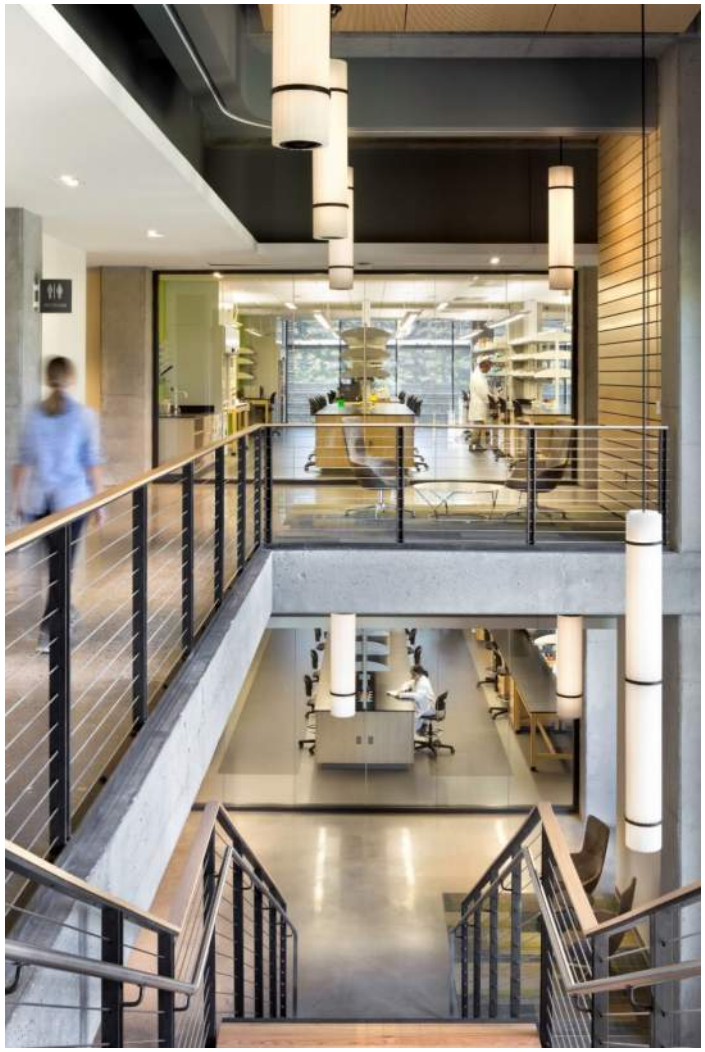


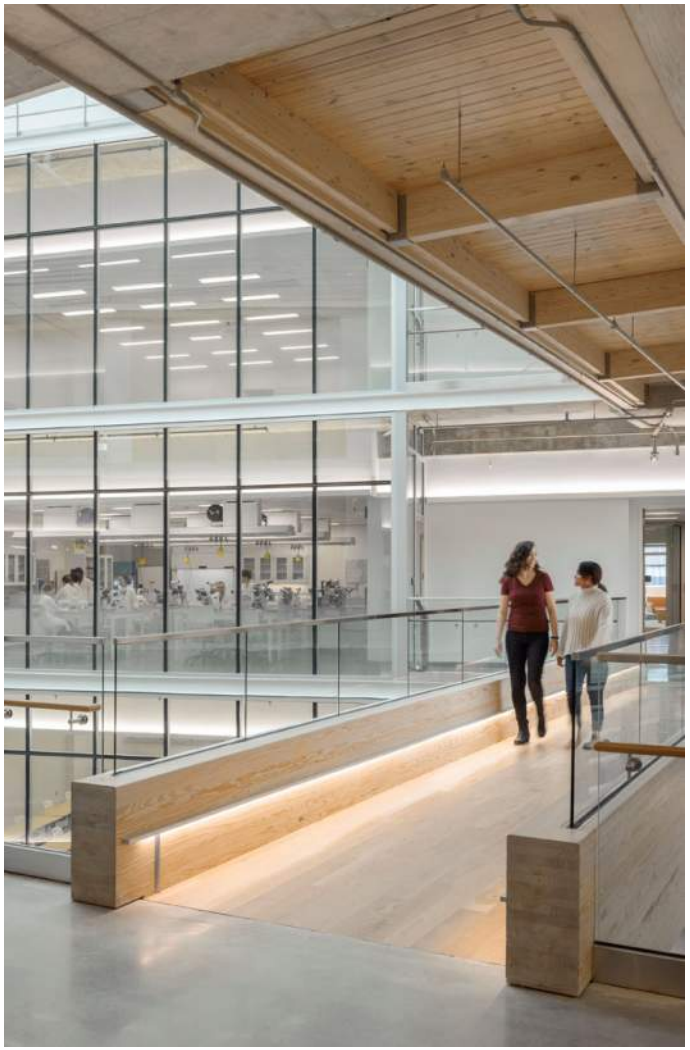
Transparency, Connections & Extended Learning

Transparency – Between Spaces

Transparency, Connections & Extended Learning

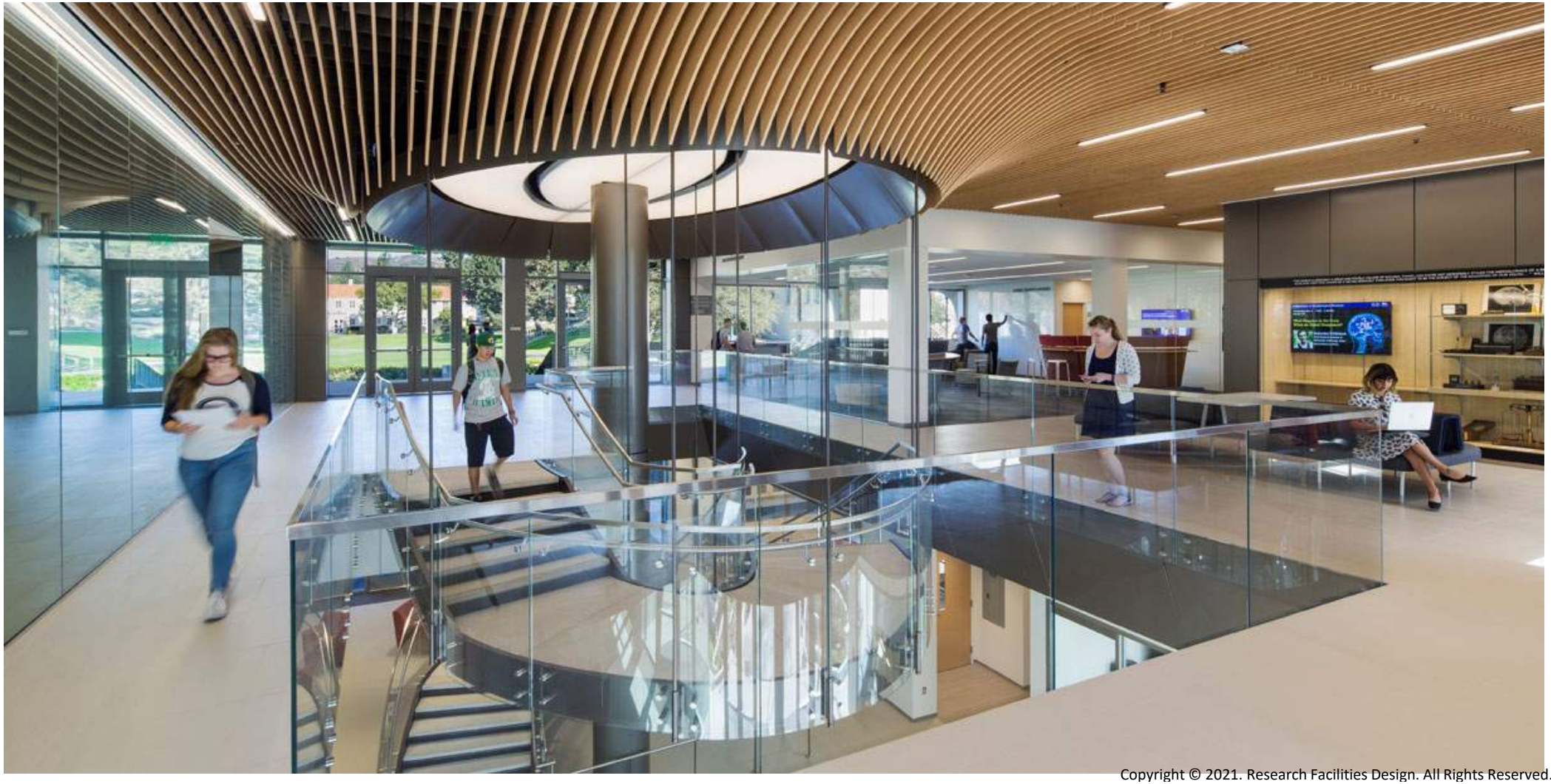
Transparency – Between Floors





Transparency, Connections & Extended Learning

Connections – Hub of Activity



Transparency, Connections & Extended Learning

Extended Learning – STEM on Display

Transparency, Connections & Extended Learning

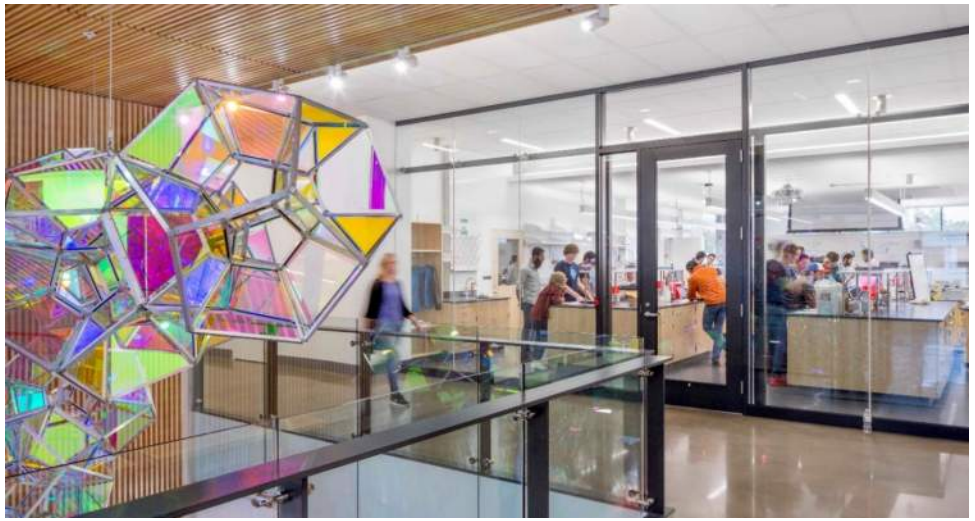
Extended Learning – STEM on Display

Transparency, Connections & Extended Learning

Extended Learning – Scientific Art

Transparency, Connections & Extended Learning

Extended Learning – Scientific Art



Presentation Outline

1) Considerations for Science & Technology Facilities
   - » Learning & Research Communities
   - » Recruitment & Retention
   - » Engaged, Active & Applied Learning
   - » Transparency, Connections & Extended Learning

2) **Planning Trends for Science & Technology**
   - » Building Planning Considerations
   - » Active Learning Laboratories
   - » Undergraduate Research & Project Laboratories

3) Innovation, Maker & Advanced Manufacturing Spaces

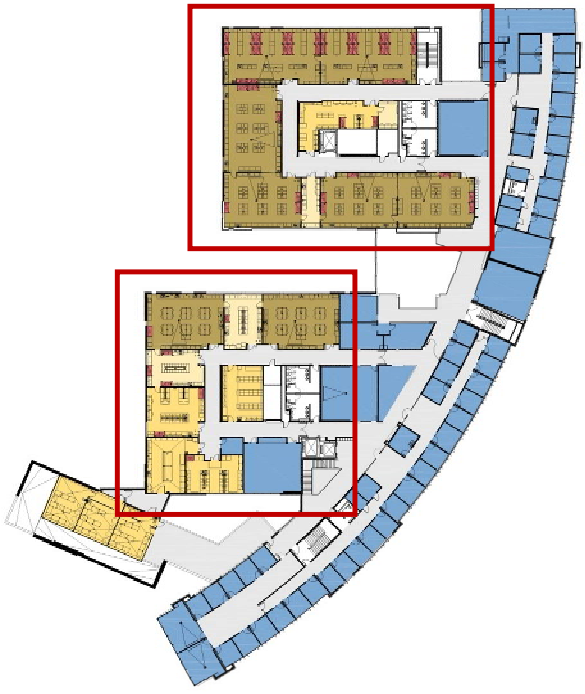
4) Benchmarking & Metrics

5) The 'Tradeline Three'

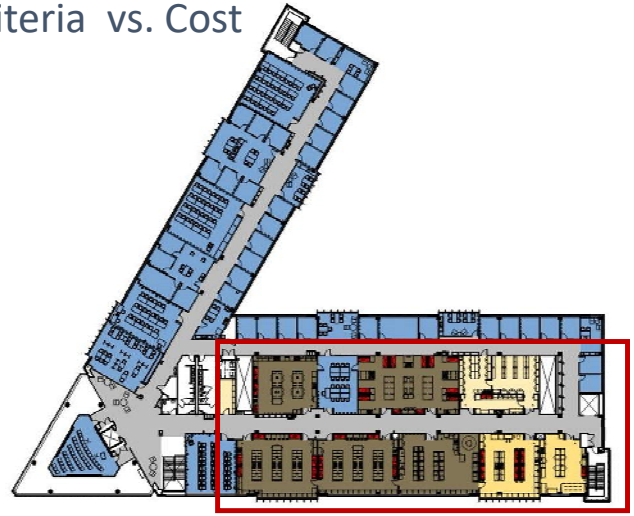
Building Planning Considerations | Organized by Building Systems

Energy Efficiency Planning Overlay

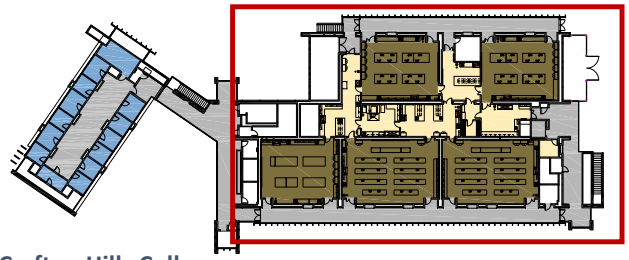
- HVAC – 100% Exhaust vs. Recirculated Air / Natural Ventilation
- Structural System – Vibration Criteria vs. Cost
- Piped Service Distribution



Weber State University

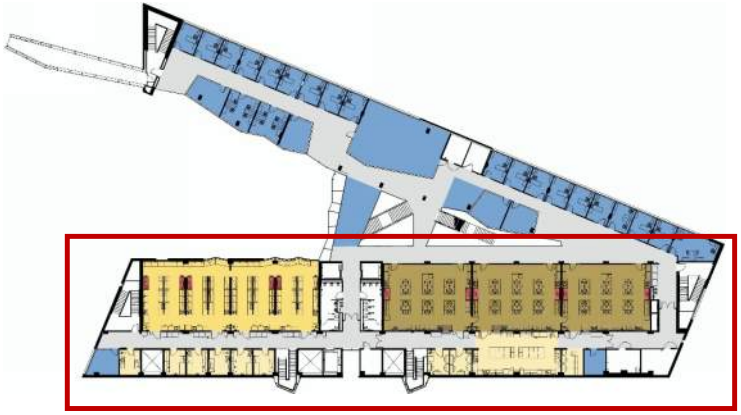


Augsburg College

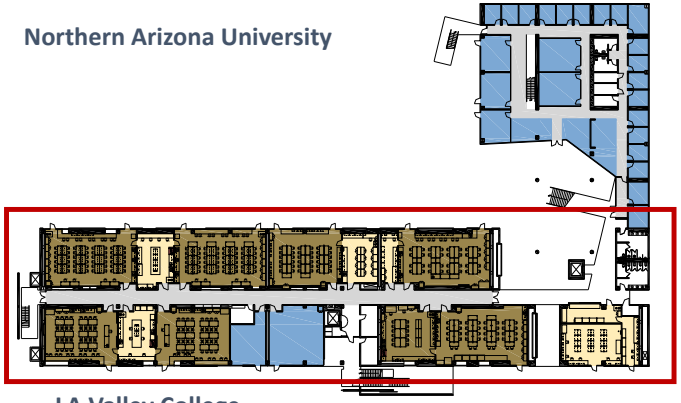


Crafton Hills College

Teaching Labs
Research Labs
Support Labs
Office / Classroom



Northern Arizona University



LA Valley College

Building Planning Considerations | Organized by Program Function

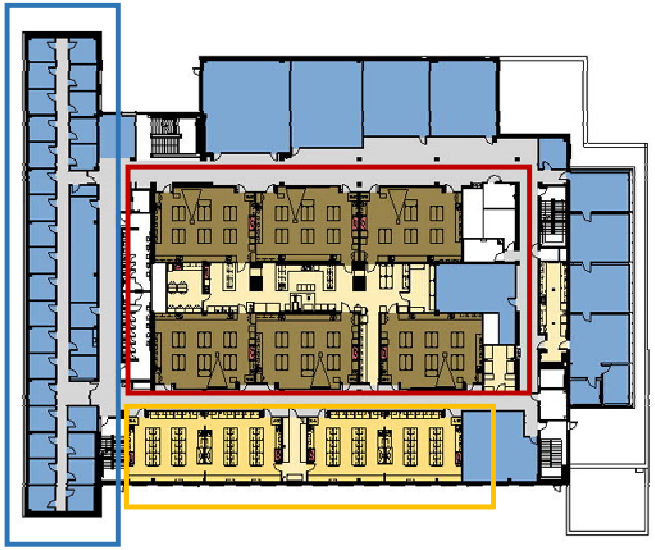
Zoned by Space Type

- 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

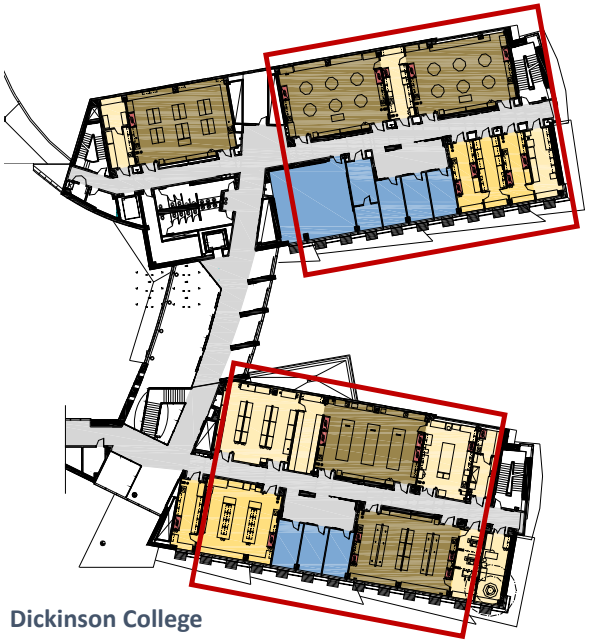
Southern Nazarene University

Building Planning Considerations | Organized by Neighborhoods

- Neighborhoods 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

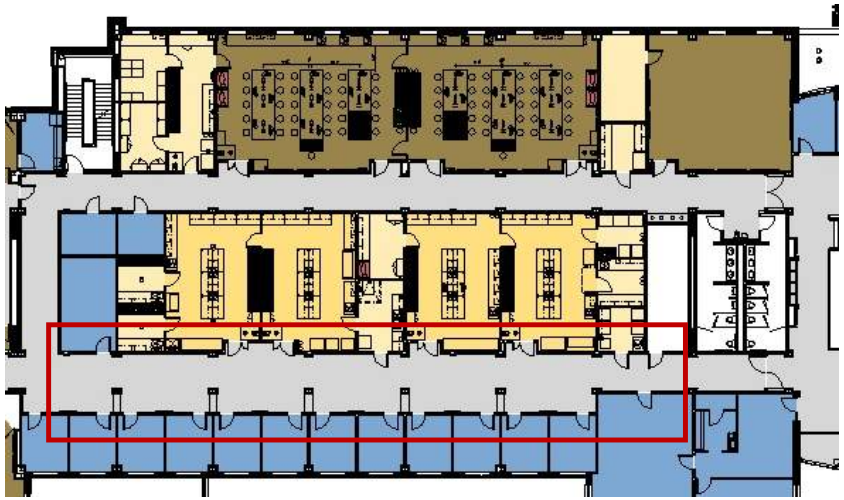
Gustavus Adolphus College

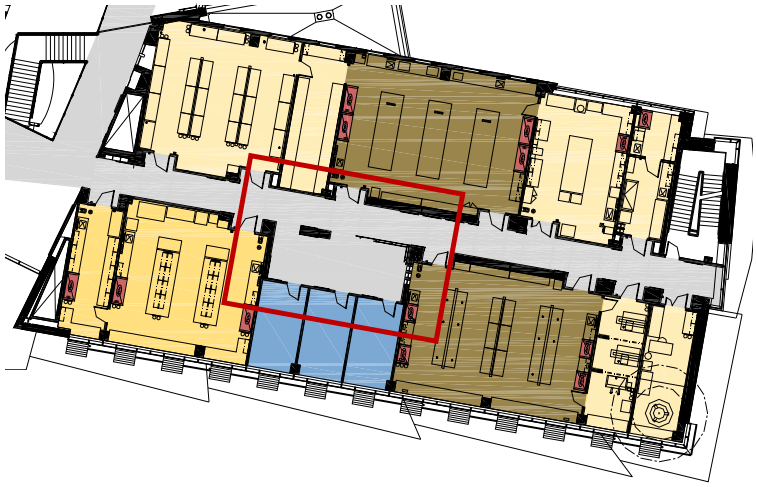


Dickinson College

Building Planning Considerations

Organized by Neighborhoods

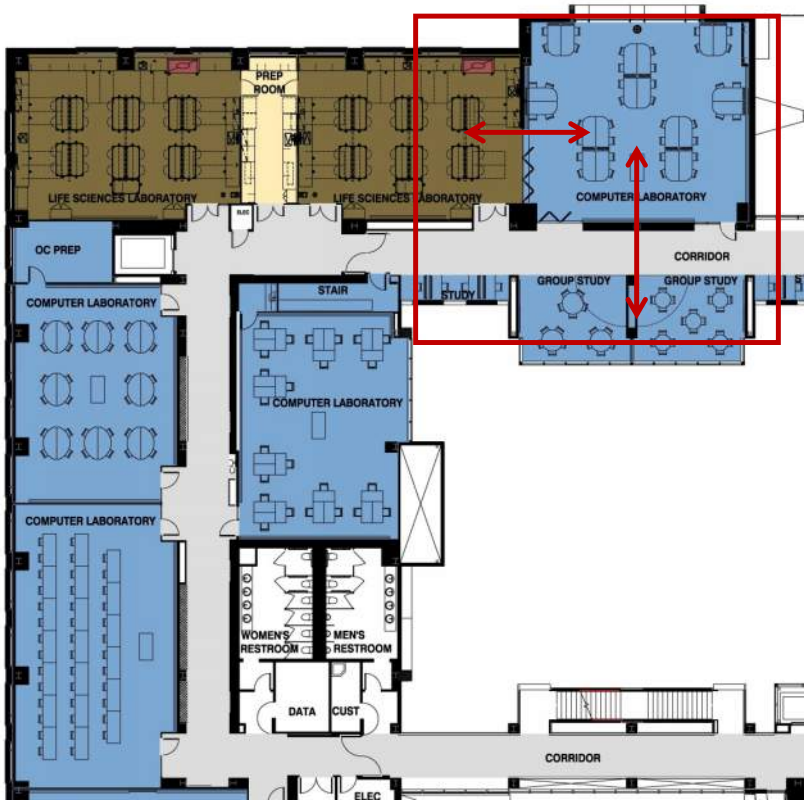




Building Planning Considerations

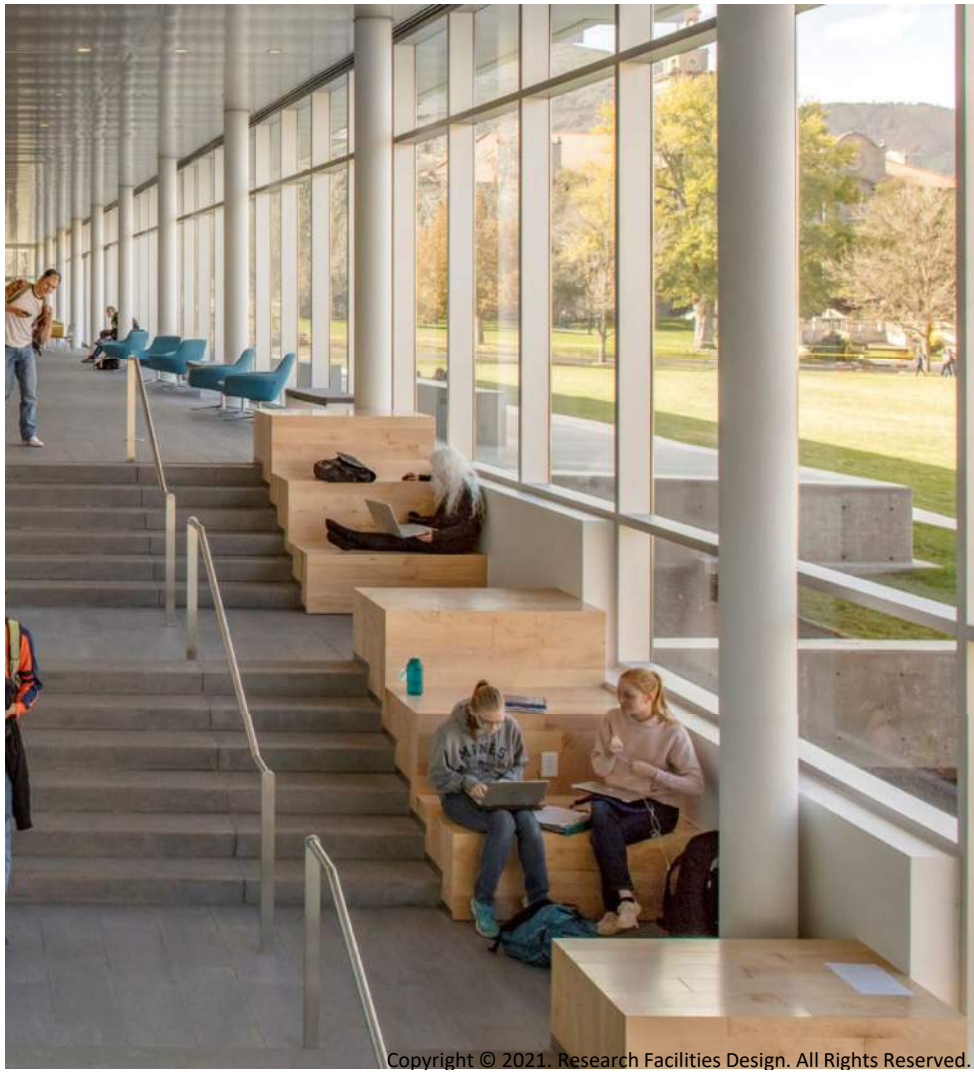
Organized by Neighborhoods

- Teaching Labs
- Technology Access
- Informal Collaboration



- Multiple “Street Level” Direct Outside Access Points
- Slab-on-Grade for Vibration
- Service & Large Equipment Access
- Vertical Transition through Site

- Multiple “Street Level” Direct Outside Access Points
- Slab-on-Grade for Vibration
- Service & Large Equipment Access
- Vertical Transition through Site



Building Planning Considerations | Structure, Floor Heights & Vibration

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

	Steel	Concrete	Timber
Community College	93%	7%	0%
4-Year Public/ Private	52%	44%	4%
R-1 Research	32%	62%	6%

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"

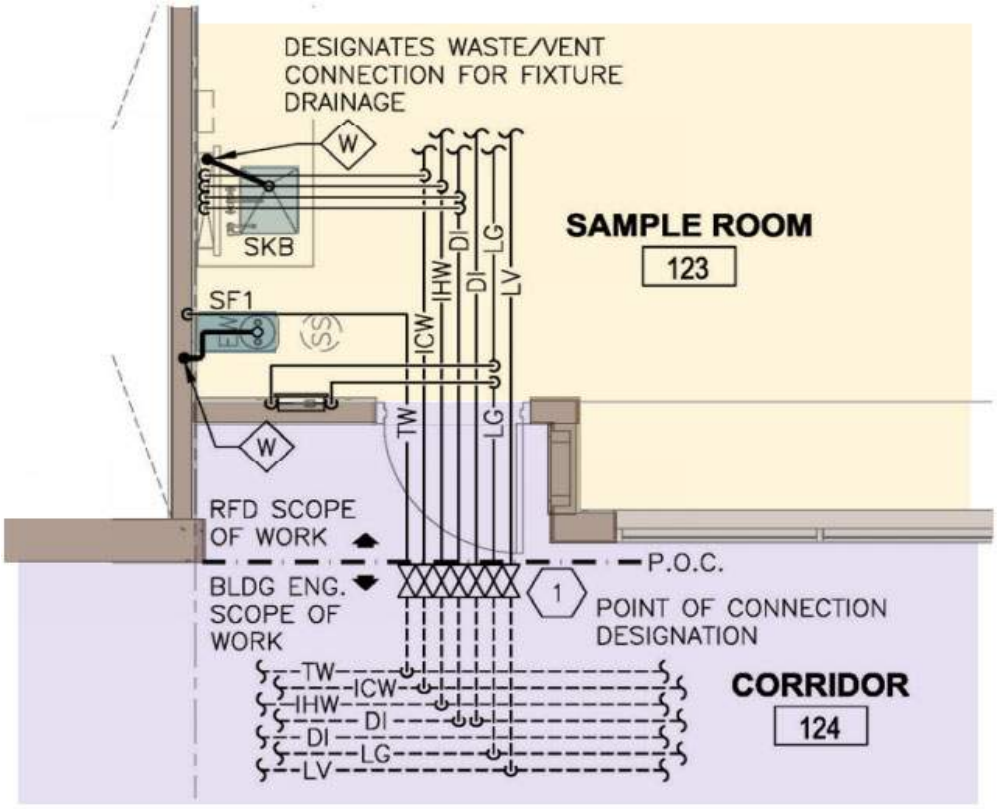
ENGINEERING VI PHASE I
University of California, Los Angeles
Concrete Frame/Shear Wall
Floor to Floor Heights: Level B - 1: 18' - 0"
Level 2 - R: 15' - 6"

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"

Concrete Frame + Flat Slab

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



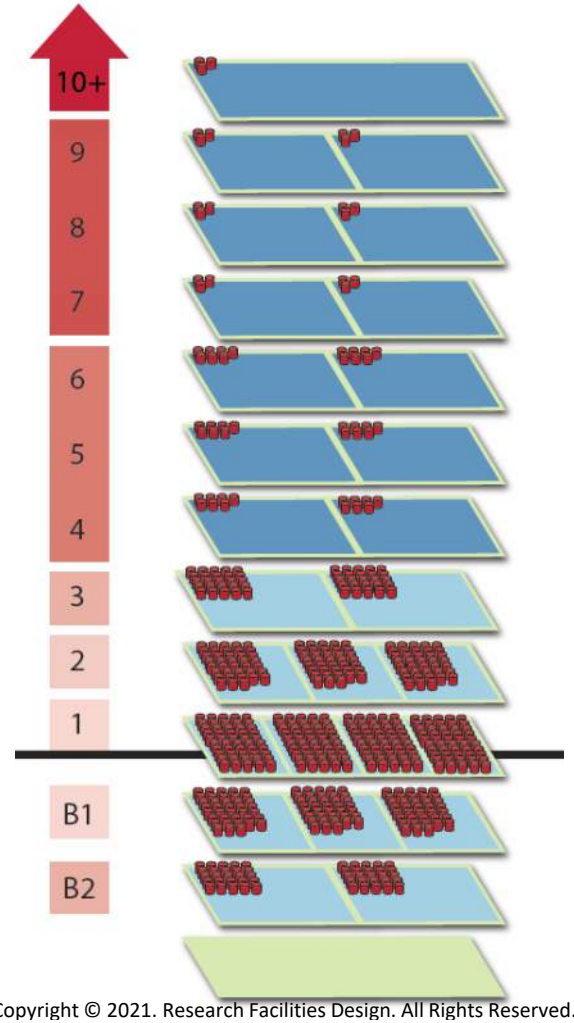
Building Planning Considerations

Hazardous Materials Management & Control Areas

- Materials Quantities
- Control Areas
- Laboratory Units
- Code Changes

2015 IBC - CONTROL AREAS Allowed within a Building & Percentage of Maximum Allowable Quantites per Control Area

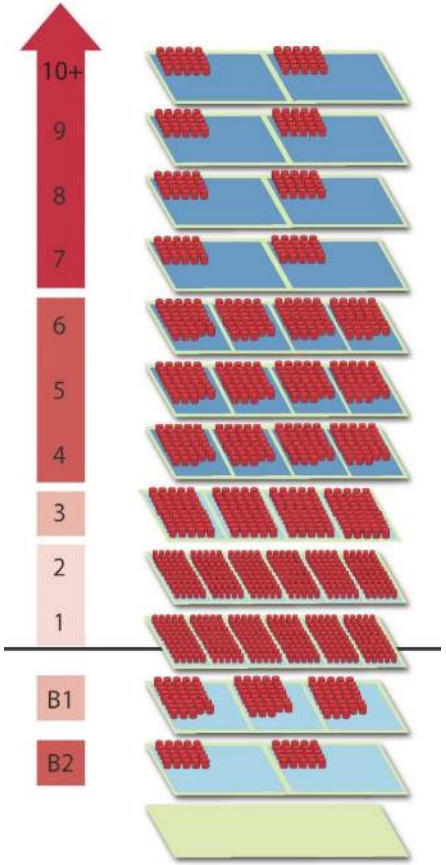
Floor	Maximum # of Control Areas per Floor	Percentage of Maximum Allowable Quantity per Control Area
10+	1	5%
9	2	5% | 5%
8	2	5% | 5%
7	2	5% | 5%
6	2	12.5% | 12.5%
5	2	12.5% | 12.5%
4	2	12.5% | 12.5%
3	2	50% | 50%
2	3	75% | 75% | 75%
1	4	100% | 100% | 100% | 100%
B1	3	75% | 75% | 75%
B2	2	50% | 50%
B3	0	0%



Higher Ed Lab Exception: Laboratory Suites → more materials allowed & more zones allowed

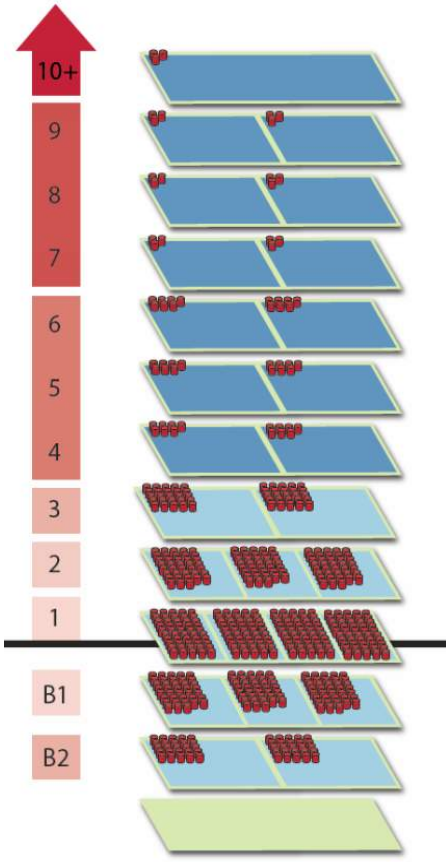
2018 IBC - Table 428.3
LABORATORY SUITES Allowed as "B" Occ. in a Building
& Percentage of Maximum Allowable Quantites per Control Area
Higher Education Laboratories

Floor	Maximum # of Lab Suites per Floor	Percentage of Maximum Allowable Quantity per Lab Suite
10	1	50% 50%
9	2	50% 50%
8	2	50% 50%
7	2	50% 50%
6	2	75% 75% 75% 75%
5	2	75% 75% 75% 75%
4	2	75% 75% 75% 75%
3	2	100% 100% 100% 100%
2	3	100% 100% 100% 100% 100% 100%
1	4	100% 100% 100% 100% 100% 100%
B1	3	75% 75% 75% 75%
B2	2	50% 50%
B3	0	0%



2018 IBC - Table 414.2.2
CONTROL AREAS Allowed within a Building
& Percentage of Maximum Allowable Quantites per Control Area

Floor	Maximum # of Control Areas per Floor	Percentage of Maximum Allowable Quantity per Control Area
10+	1	5%
9	2	5% 5%
8	2	5% 5%
7	2	5% 5%
6	2	12.5% 12.5%
5	2	12.5% 12.5%
4	2	12.5% 12.5%
3	2	50% 50%
2	3	75% 75% 75%
1	4	100% 100% 100% 100%
B1	3	75% 75% 75%
B2	2	50% 50%
B3	0	0%



Increasing scrutiny of manifolded exhaust systems

- Assumption of incompatible materials
- Formal or informal requirements for proof of compatibility
- Compatibility Report may be required

California Department of General Services · Division of the State Architect · Interpretation of Regulations Document

LAB FUME HOOD DUCT MANIFOLDING REQUIREMENTS **IR M-1**

References: Issued 03-10-11
California Code of Regulations (CCR) Title 24, Part 4: California Mechanical Code (CMC) 2007 and 2010 CMC, Chapter 5, Sections 505.1, 505.1.2, and 506.1

Discipline: Fire and Life Safety

This Interpretation of Regulations (IR) is intended for use by the Division of the State Architect (DSA) staff, and as a resource for design professionals, to promote more uniform statewide criteria for plan review and construction inspection of projects within the jurisdiction of DSA which includes State of California public elementary and secondary schools (grades K-12), community colleges, and state-owned or state-leased essential services buildings. This IR indicates an acceptable method for achieving compliance with applicable codes and regulations, although other methods proposed by design professionals may be considered by DSA.

This IR is reviewed on a regular basis and is subject to revision at any time. Please check the DSA web site for currently effective IRs. Only IRs listed in the document at http://www.dgs.ca.gov/dsa/Resources/IRManual.aspx at the time of plan submittal to DSA are considered applicable.

Purpose: This Interpretation of Regulations (IR) describes the options acceptable to Division of the State Architect (DSA) for lab fume hood duct manifolding.

Background: Some school science buildings are designed with multiple areas each containing multiple fume hoods. The issue of manifolding (combining exhaust streams into fewer ducts) fume hood units can be further compounded when there are multiple elevations or stories, and/or hazardous materials involved.

1. BASIC DESIGN REQUIREMENTS:

1.1 DSA will accept submittals that conform to the requirements of Title 24, Part4: California Mechanical Code, Sections 505 though 506.

1.1.1 **Ducts conveying flammable vapors, fumes, or dust out of the building:** Code language requires that the ducts go directly to the exterior without passing through any other space, unless the use of a rated shaft, continuous to the exterior, is provided.

1.1.2 **Separate and distinct systems:** Fume hood ducts may not be manifolded together, unless they are within the same space, and compatible by-products are being used in all of the ducts in question. See Section 2 of this IR for an exception to this requirement regarding incompatible materials.

1.1.3 **Recirculation not permitted:** Fume hood exhausts combined with general exhaust provides the potential for direct communication of by-products from the fume hoods which can then be circulated throughout the building. Therefore, environmental (general) exhaust air must not be connected by any manifold to any fume hood exhaust system, nor be allowed the potential to recirculate fume hood exhausts into occupied spaces.

2. Option

2.1 DSA will also accept, as an option to meeting the requirements of Sections 1.1.1 and/or 1.1.2 above, submittals conforming to the option described below. Conformance with code requirements described in Section 1.1.3 above is still mandatory.

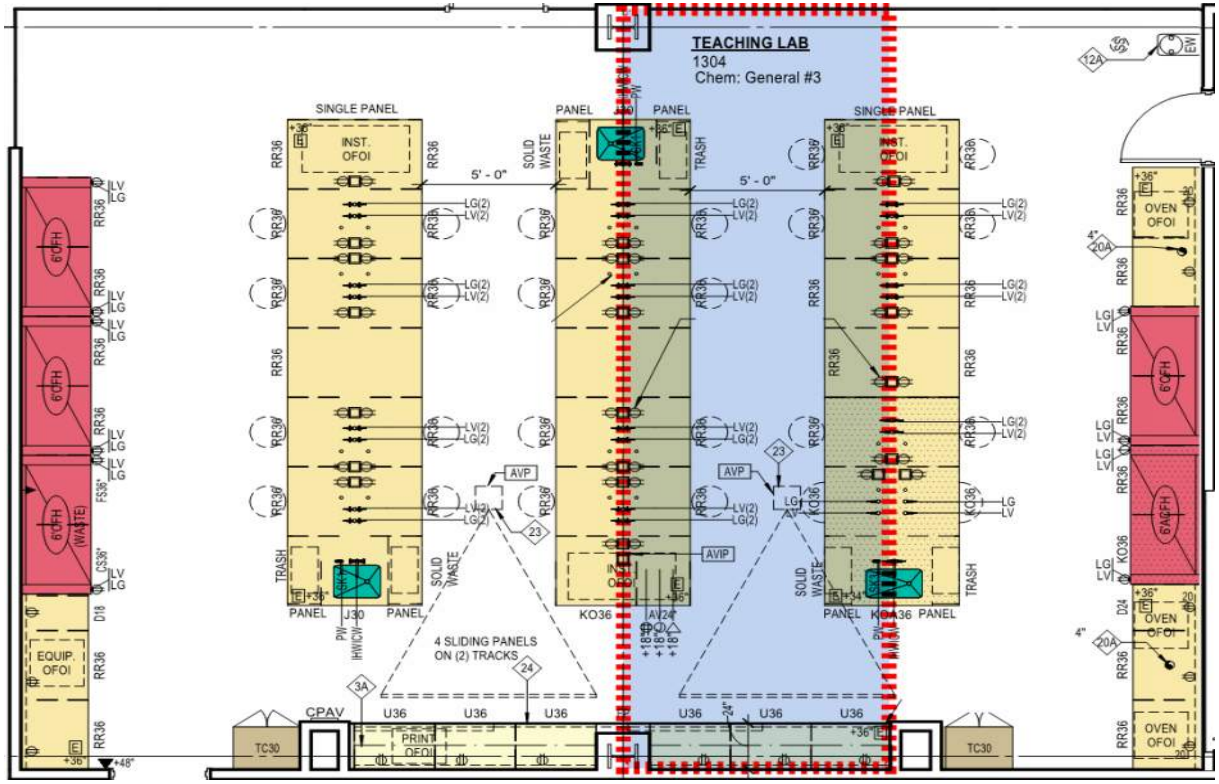
2.2 Manifolding of Fume Hood exhausts shall be allowed when a written report prepared by either an Industrial Hygienist or Chemical Engineer verifies that the hazardous materials are compatible and the exhaust concentration from both room and fume hood shall not exceed 25% of the LFL per CMC 505.

2.3 A copy of the Hazardous Materials Inventory shall be given to the local fire authority.

Building Planning Considerations

Laboratory Planning Module

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



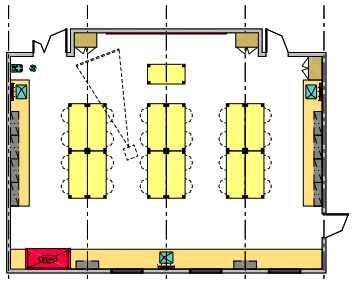
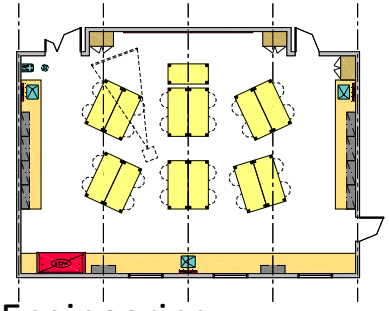
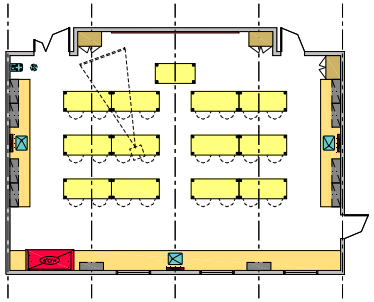
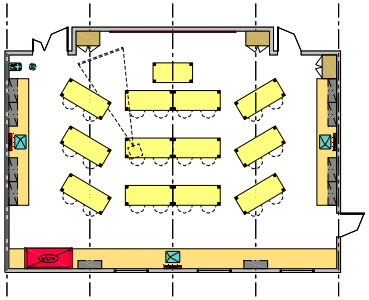
2015 – 2019	Private	2020 – Beyond
20%	10’-0”	5%
0%	10’-4”	0%
50%	10’-6”	50%
30%	10’-8”	20%
0%	11’-0”	25%

2015 – 2019	Public	2020 – Beyond
0%	10’-0”	0%
17%	10’-4”	0%
75%	10’-6”	82%
0%	10’-8”	9%
8%	11’-0”	9%

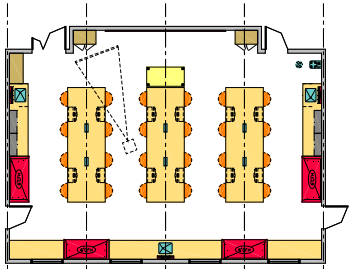
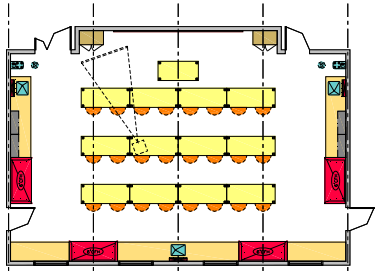
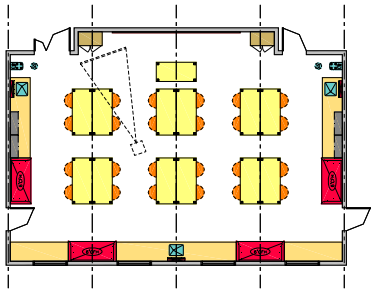
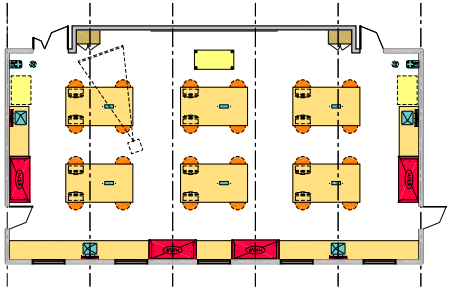
2015 – 2015	Comm. College	2020 – Beyond
30%	10’-0”	0%
0%	10’-4”	0%
60%	10’-6”	81%
0%	10’-8”	6%
10%	11’-0”	13%

Science Learning Laboratories

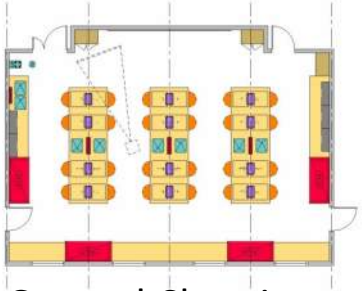
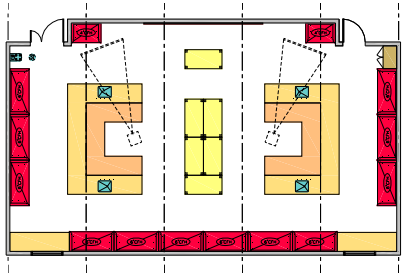
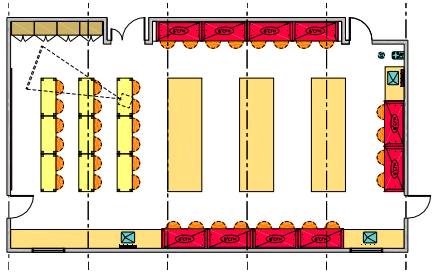
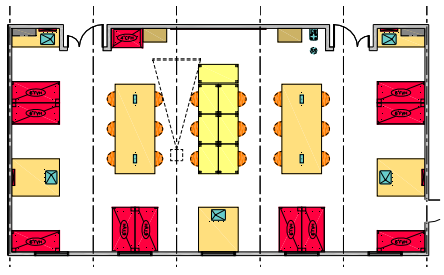
Traditional Laboratory Layouts

Earth Science - Physics - Engineering

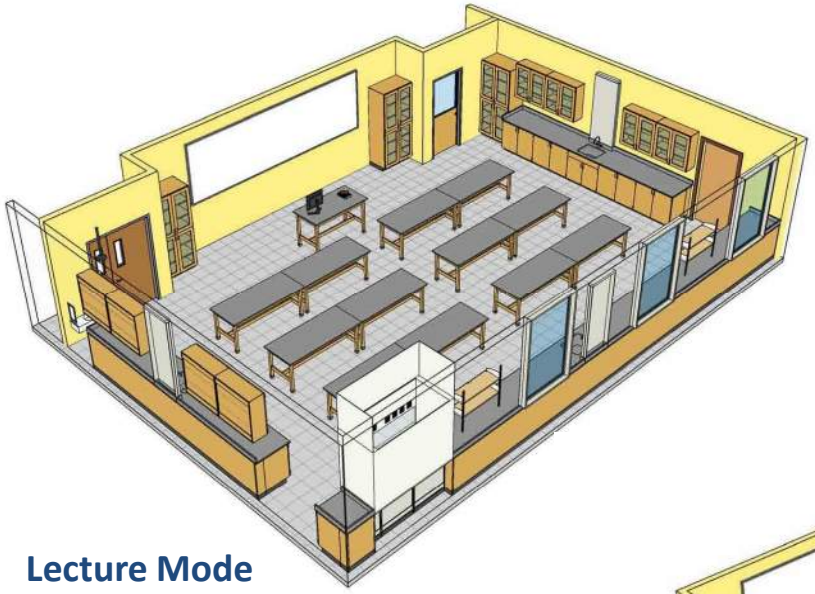





Biology - Microbiology - Plant Sciences - Zoology

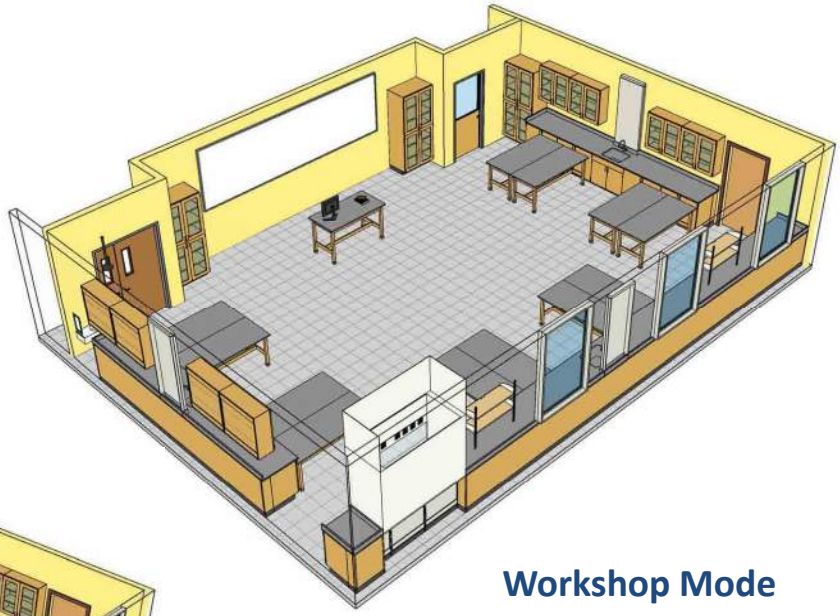





General Chemistry - Organic Chemistry

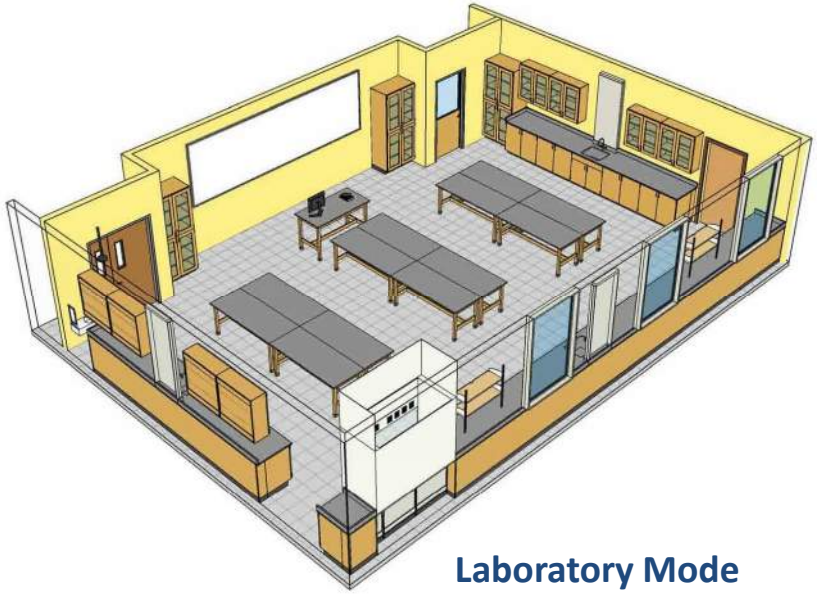
Laboratory Design Trends – Greater Flexibility



Lecture Mode



Workshop Mode



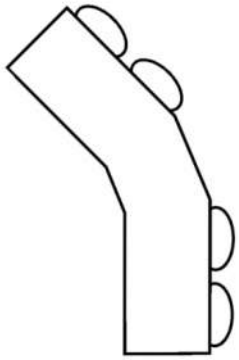
Laboratory Mode

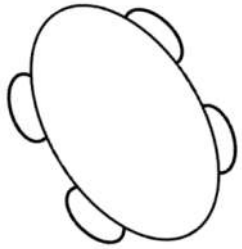
Science Learning Laboratories

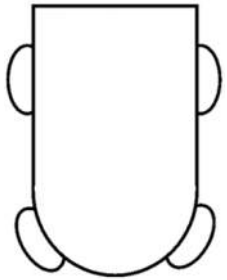
Laboratory Design Trends – Greater Flexibility

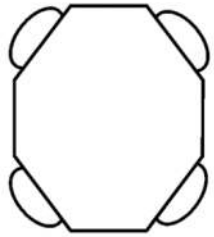
Science Learning Laboratories

Team Learning / Shaped Benches









Science Learning Laboratories

Team Learning / Shaped Benches

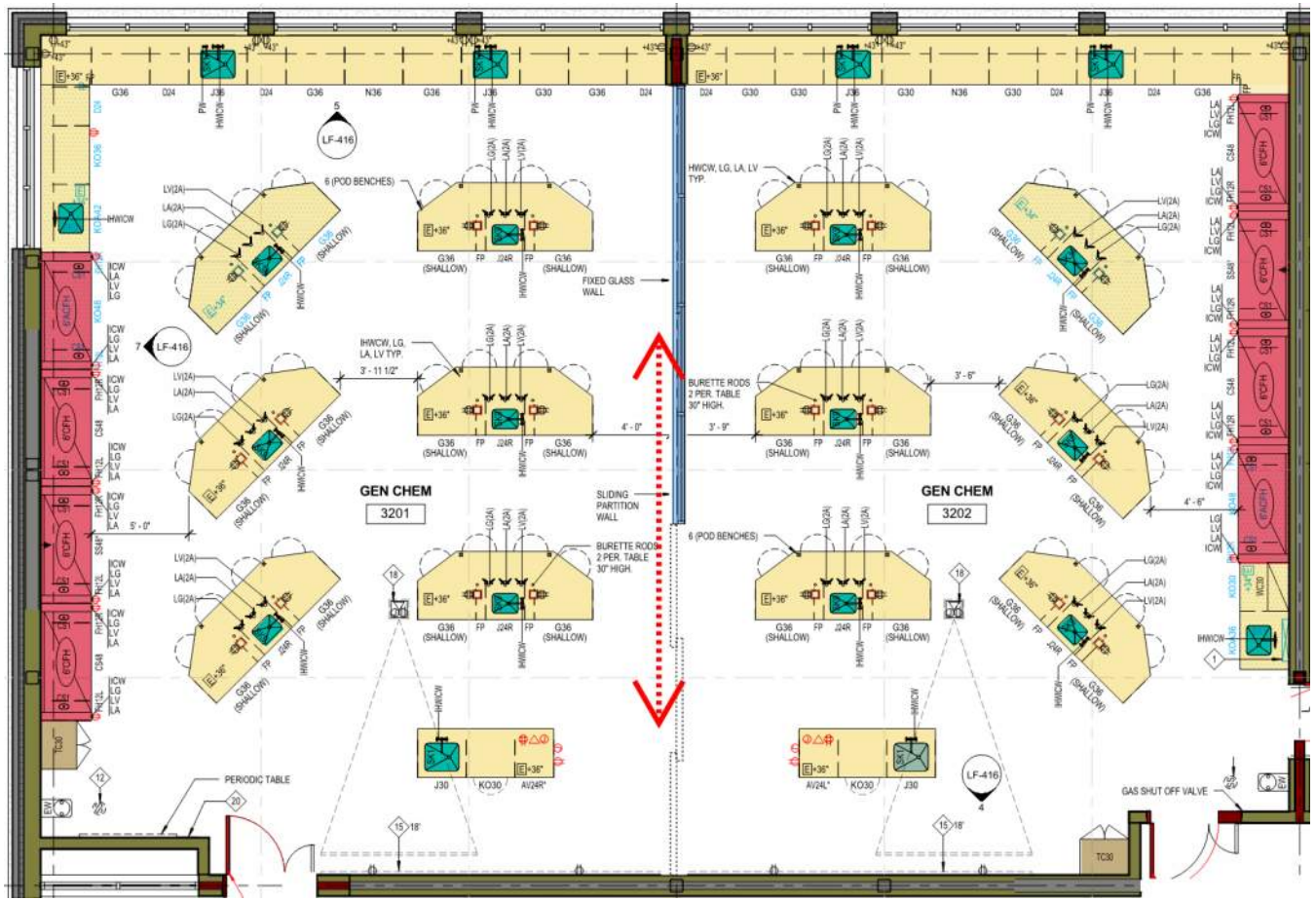
Lab Design Trends – Paired Teaching Laboratories

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



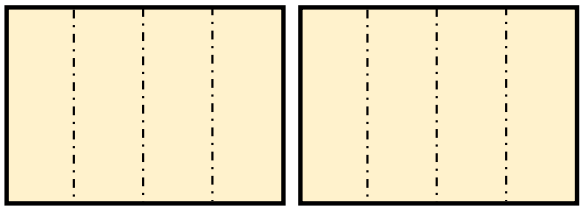
Science Learning Laboratories

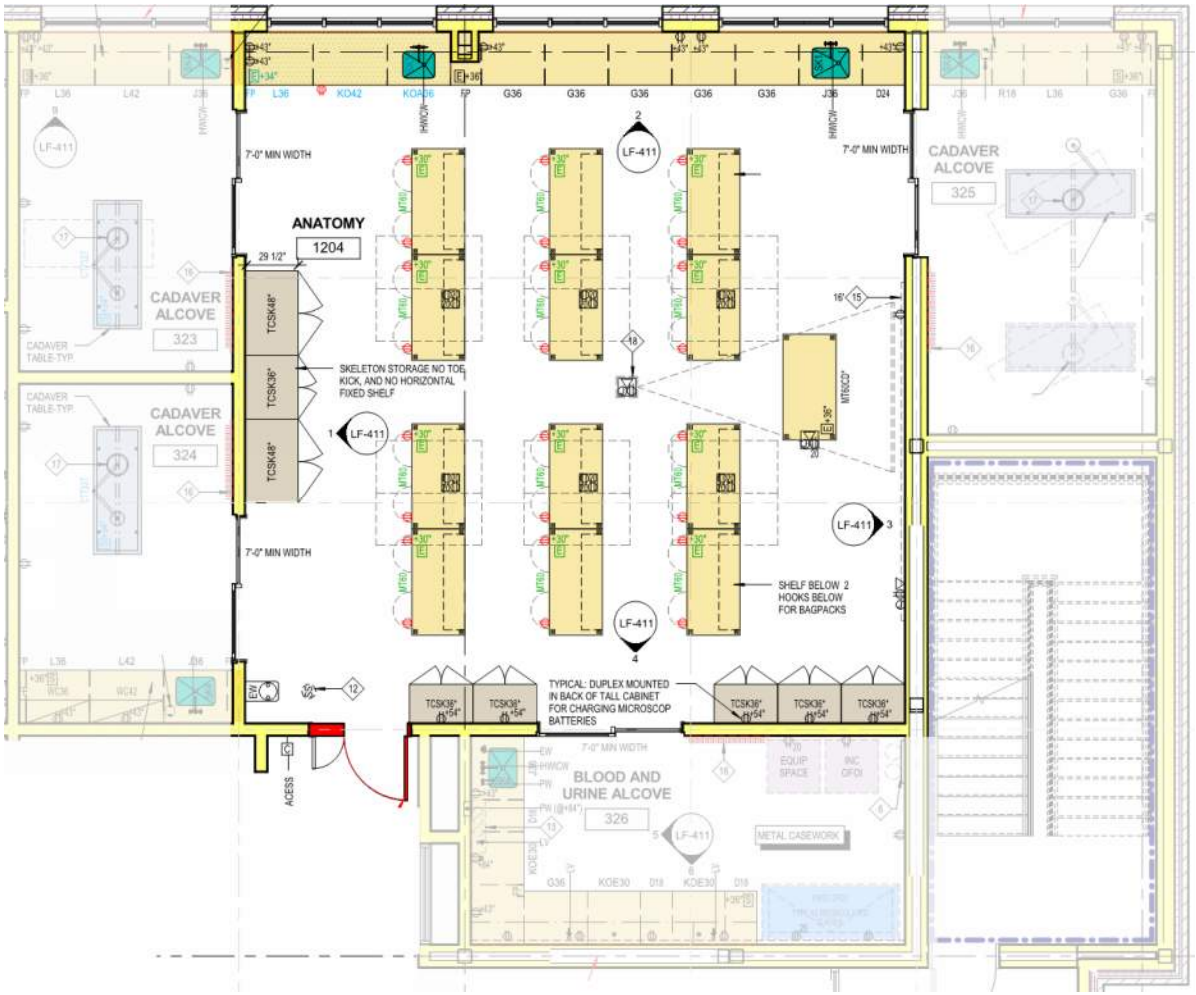
Lab Design Trends – Paired Teaching Laboratories

Science Learning Laboratories

Lab Design Trends – Multi-Use Teaching Laboratories

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

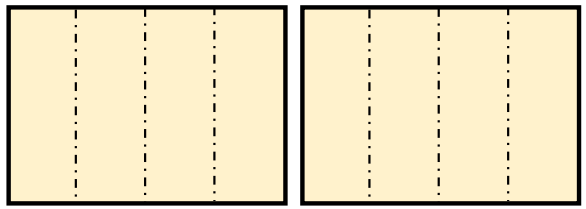




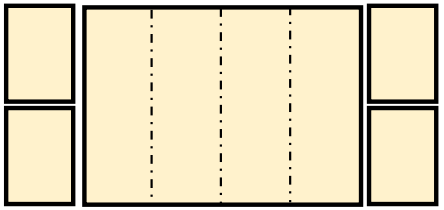
Science Learning Laboratories

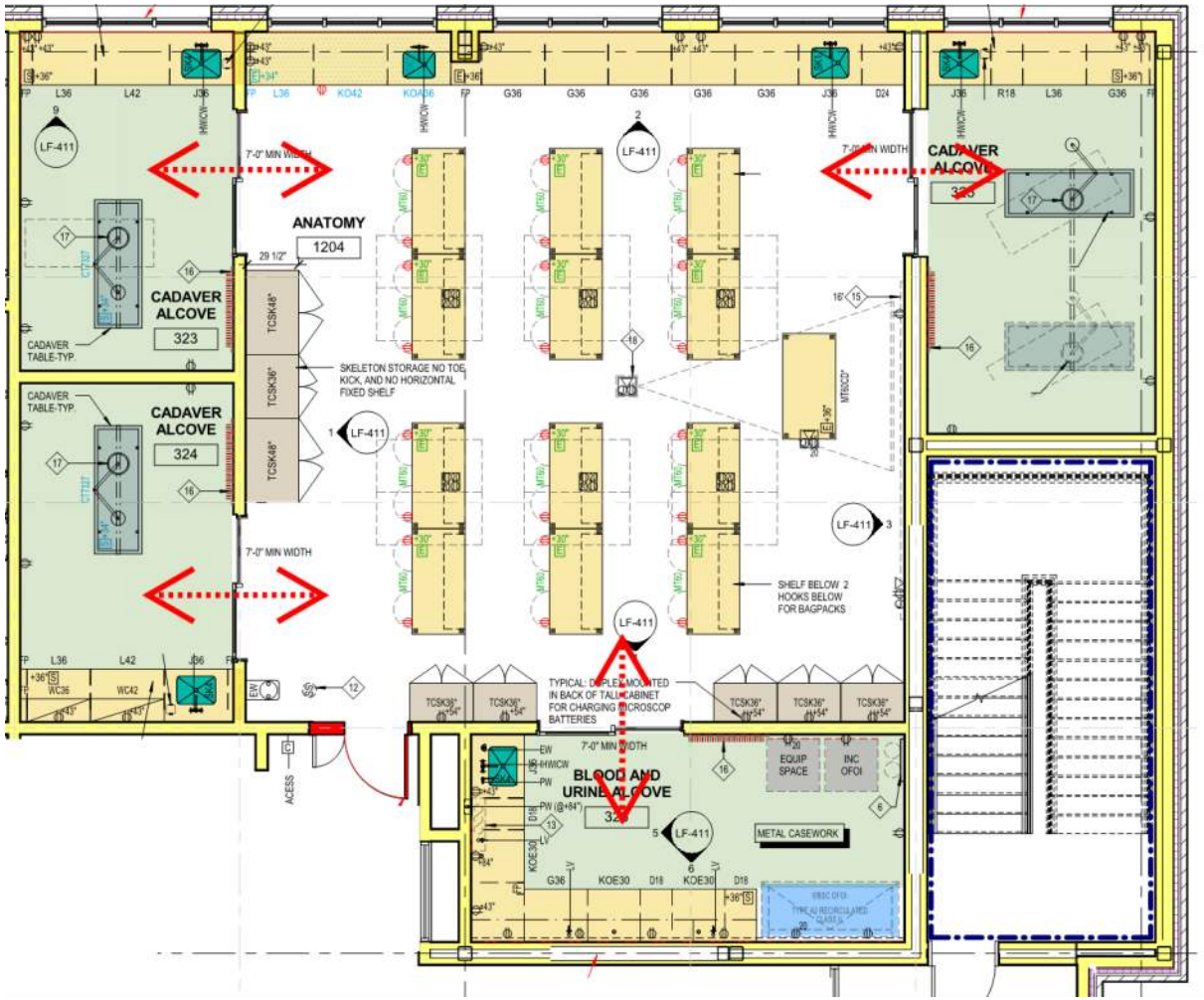
Lab Design Trends – Multi-Use Teaching Laboratories

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



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



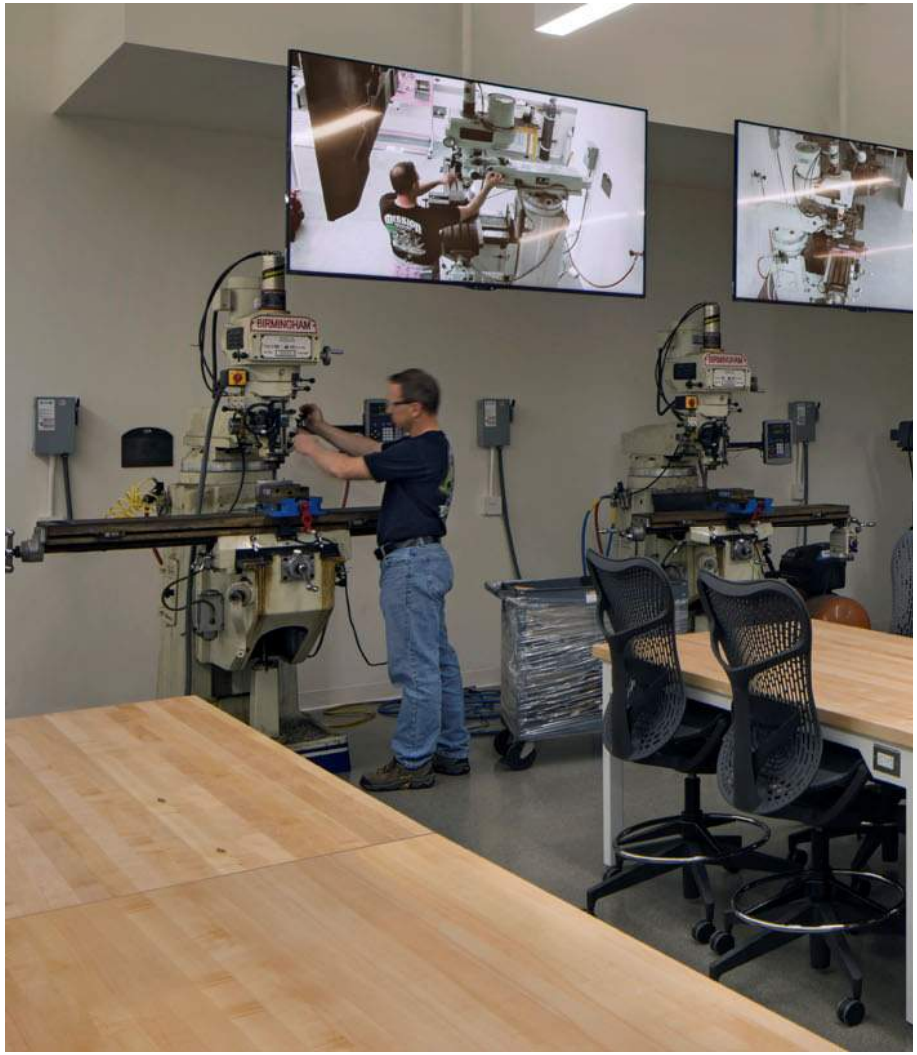


Science Learning Laboratories

Lab Design Trends – Multi-Use Teaching Laboratories

Science Learning Laboratories

Lab Design Trends – Multi-Use Teaching Laboratories



- No Space for Alcoves
- Isolate Dangerous Equipment
- Keyed Lockouts on Equipment
- Cameras & Displays for Demo

Engineering Learning Laboratories

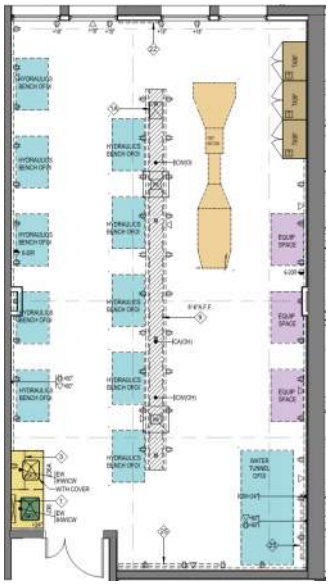
Lab Design Trends – Engineering Fluids Lab Example

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

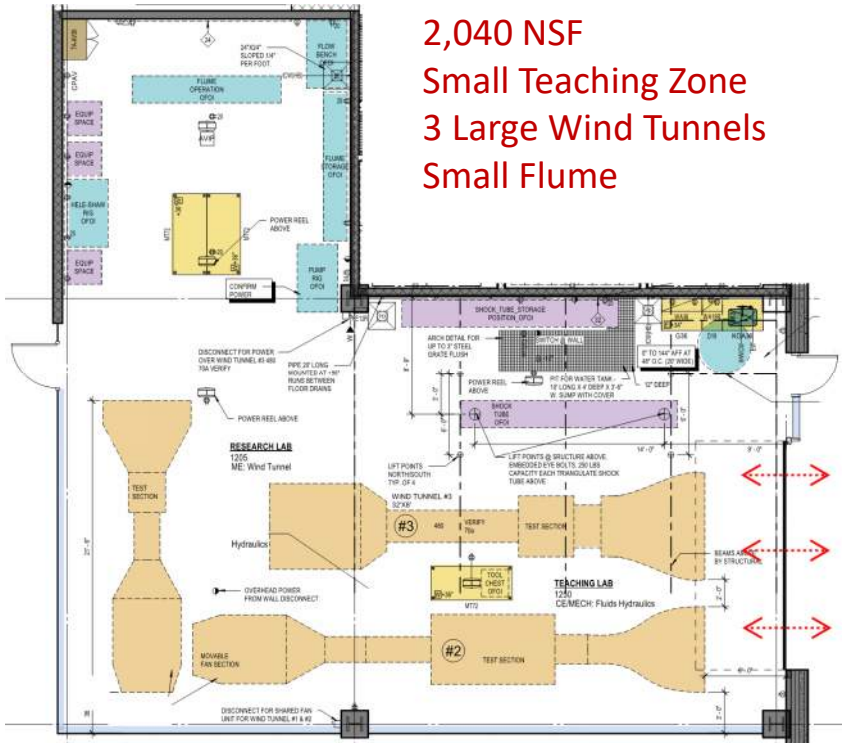
Lab Design Trends – Engineering Fluids Lab Example

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

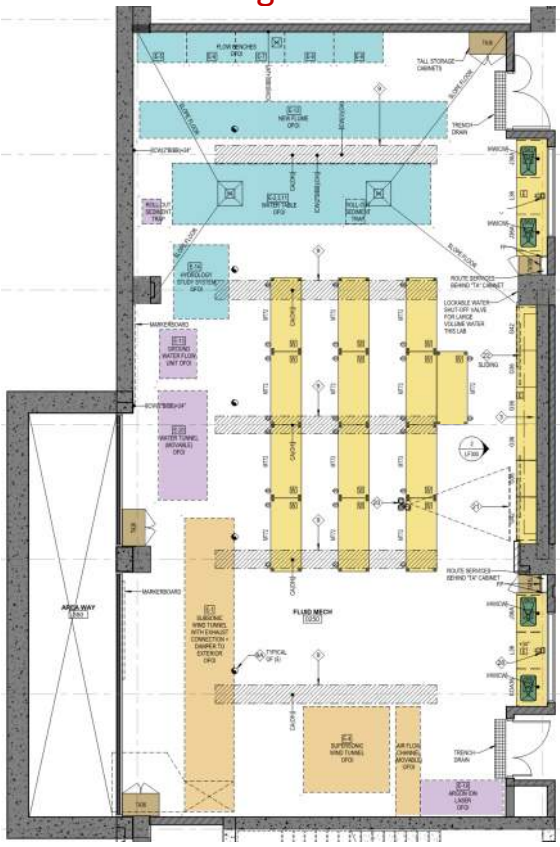
850 NSF
No Teaching Zone
No Large Wind Tunnels
No Large Flumes



2,040 NSF
Small Teaching Zone
3 Large Wind Tunnels
Small Flume



1,920 NSF
Large Teaching Zone
2 Wind Tunnels
2 Large Flumes

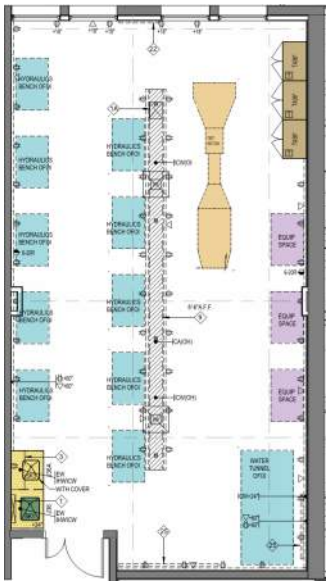


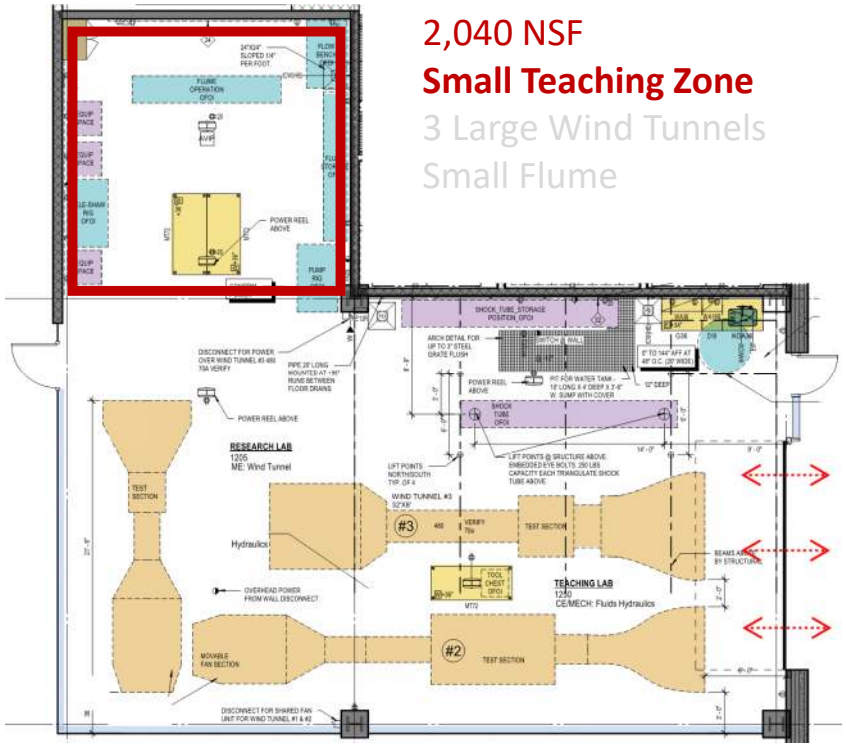
Engineering Learning Laboratories

Lab Design Trends – Engineering Fluids Lab Example

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

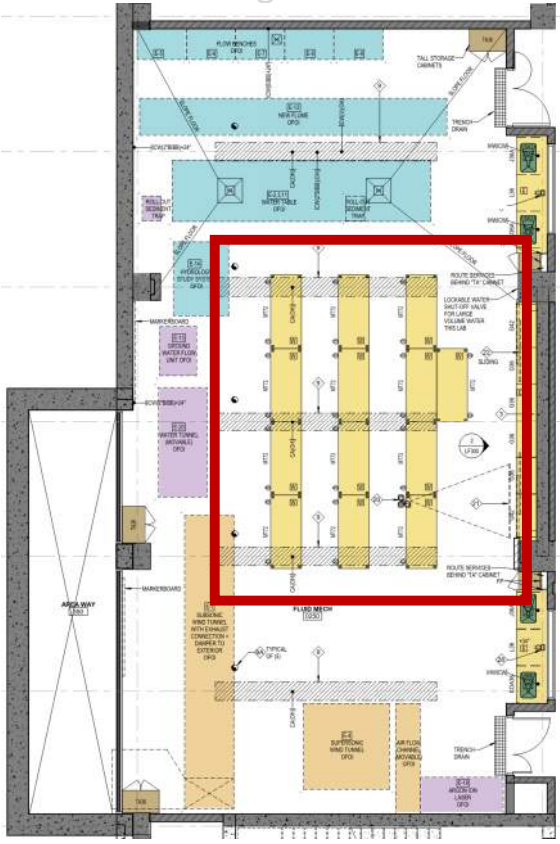
850 NSF
No Teaching Zone
No Large Wind Tunnels
No Large Flumes





2,040 NSF
Small Teaching Zone
3 Large Wind Tunnels
Small Flume

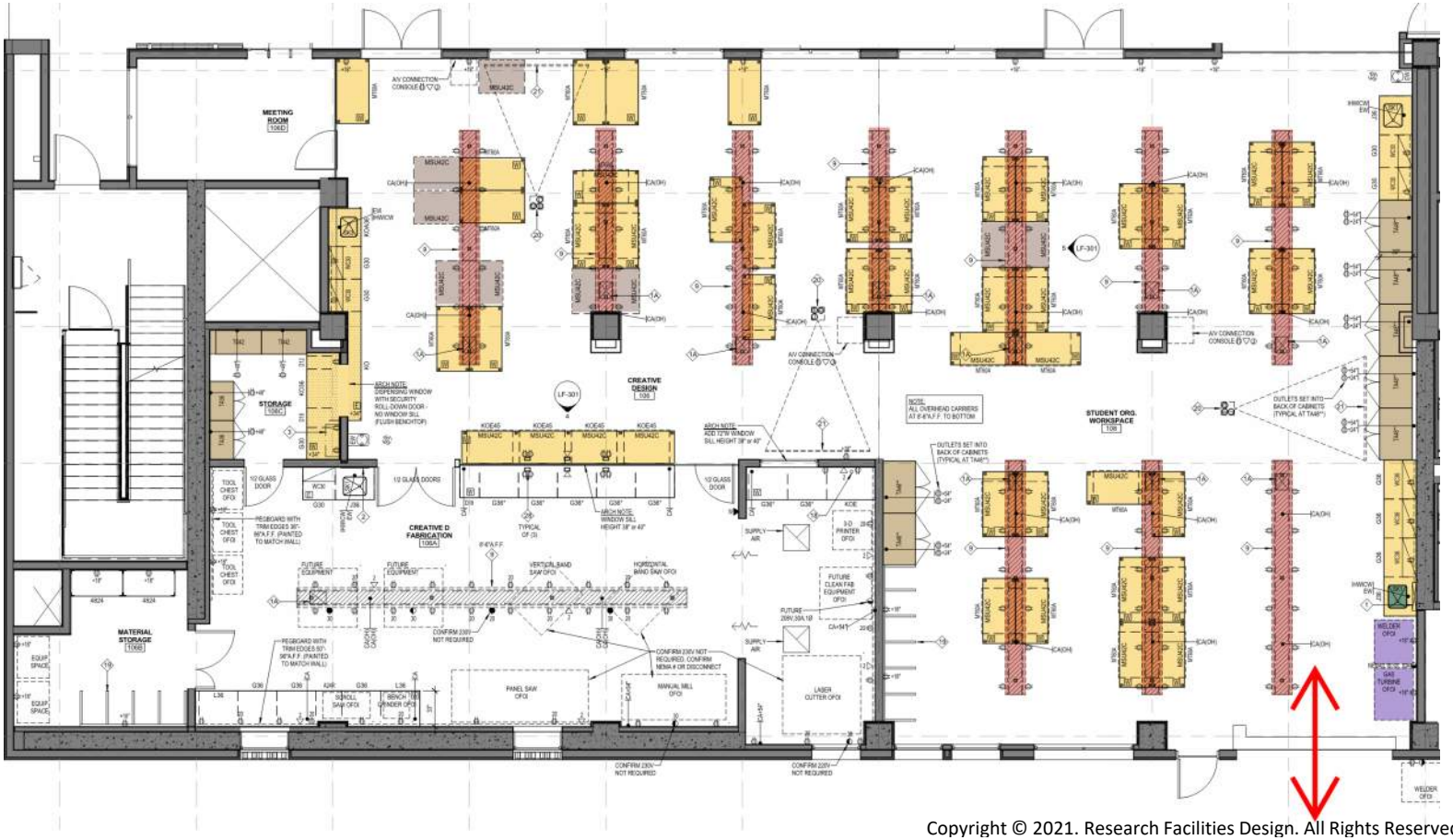
1,920 NSF
Large Teaching Zone
2 Wind Tunnels
2 Large Flumes



Engineering Learning Laboratories

Lab Design Trends – **Engineering Project Labs**

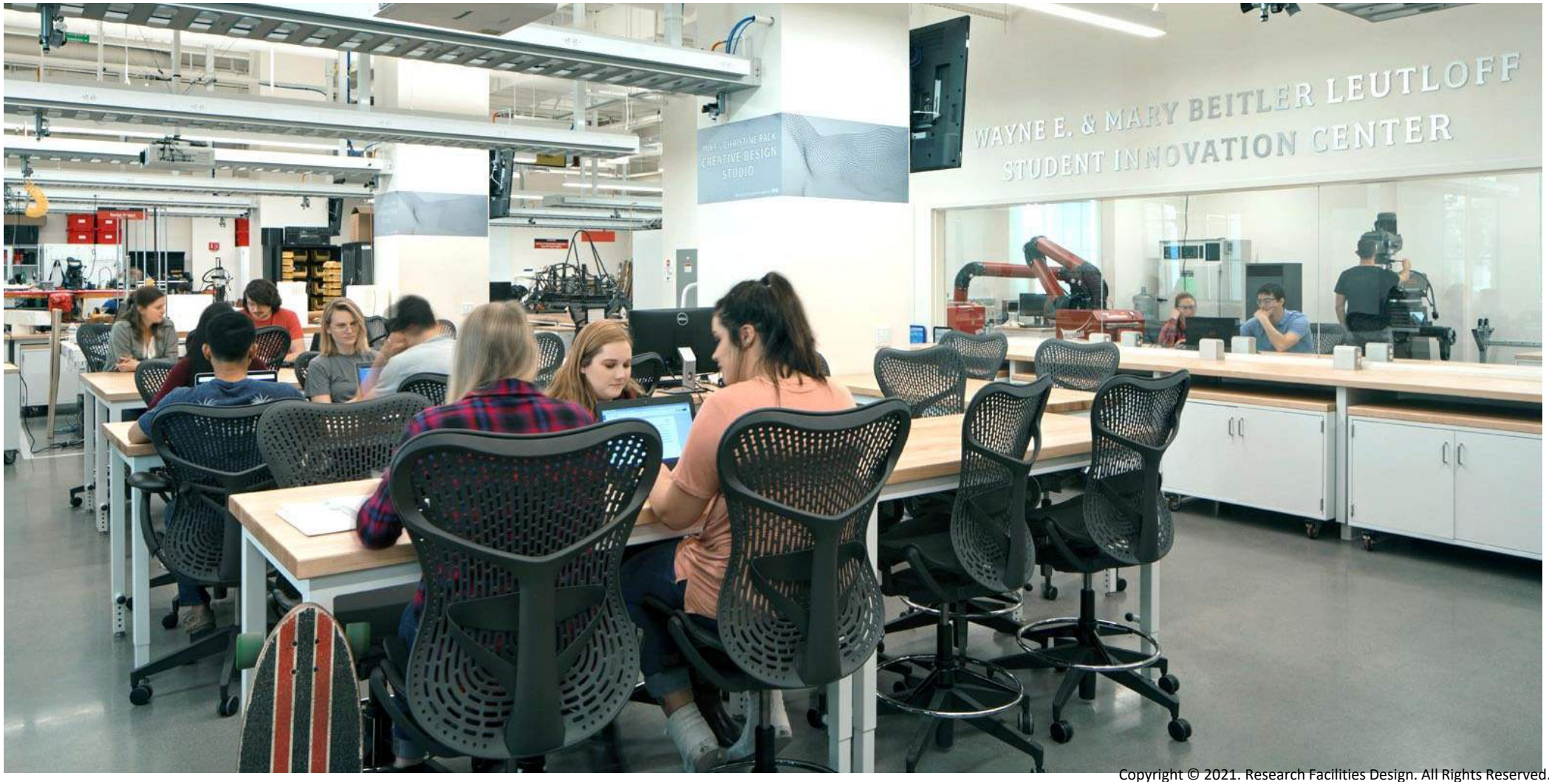
- Equipment & Assembly Type Labs
- Assigned Home for Student Teams
- Metrics Less Useful
- Strategic Adjacencies



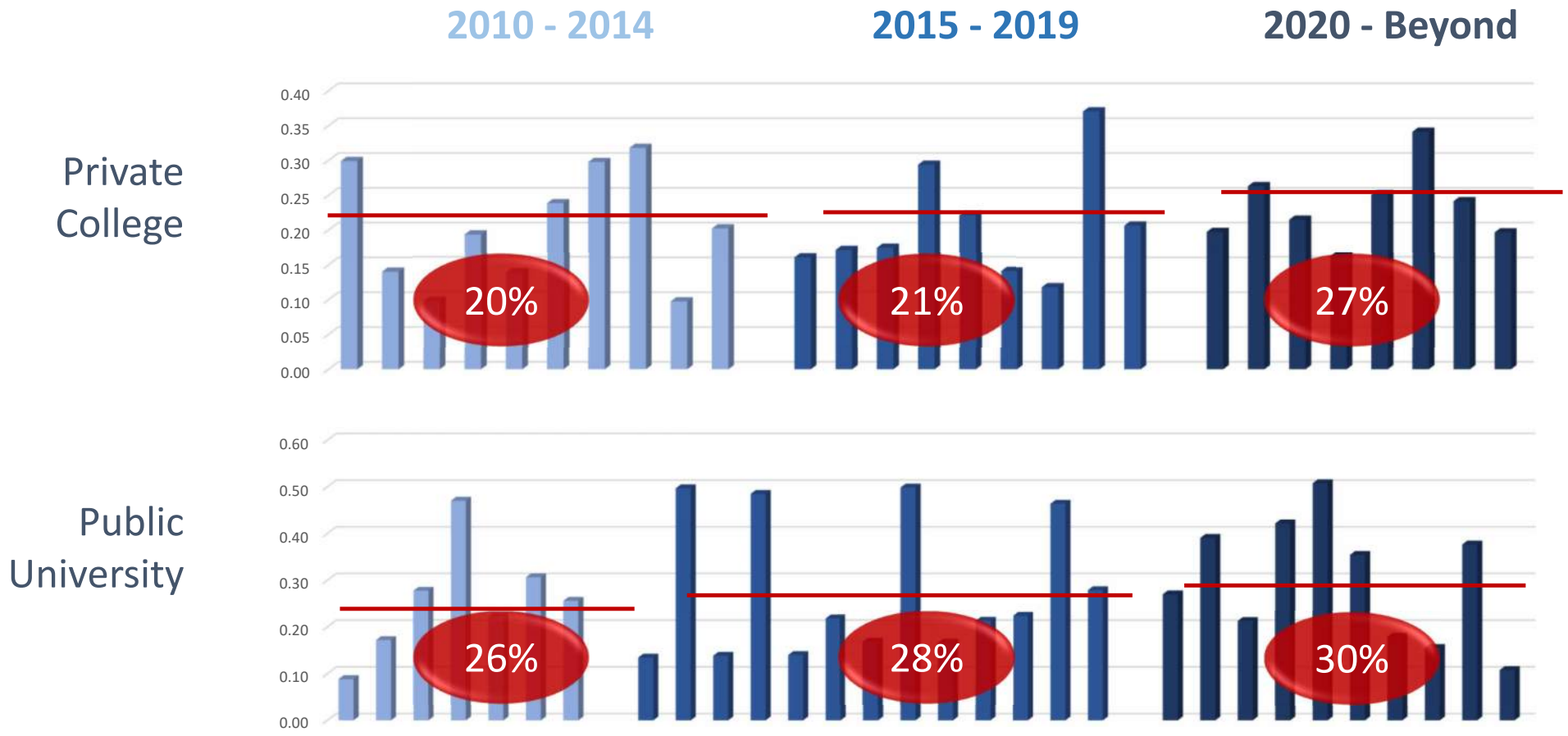
Engineering Learning Laboratories

Lab Design Trends – **Engineering Project Labs**

- Equipment & Assembly Type Labs
- Assigned Home for Student Teams
- Metrics Less Useful
- Strategic Adjacencies



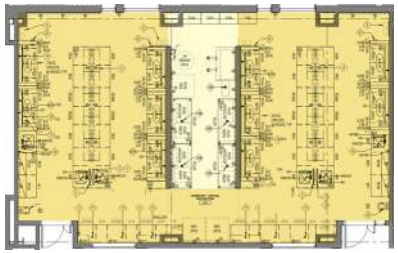
Research Area / Teaching + Research + Support



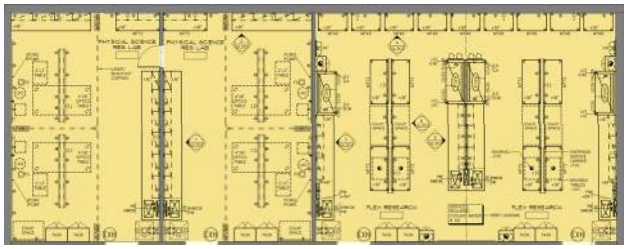
Environments for Discovery | Undergraduate Research Accommodations

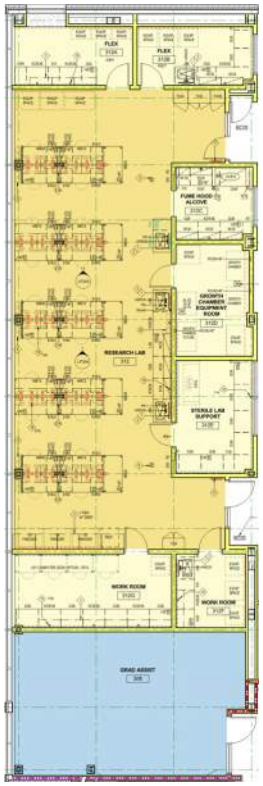
- Evolution away from Individual Faculty Labs to Shared Suites
- Small Research Labs based on Function not Ownership
- Research Themed Lab Suites

Chico State – Small Labs
3 to 4 Faculty Each
= 400 nsf Allocation



Northern Arizona U – Medium Labs
= 630 nsf Allocation

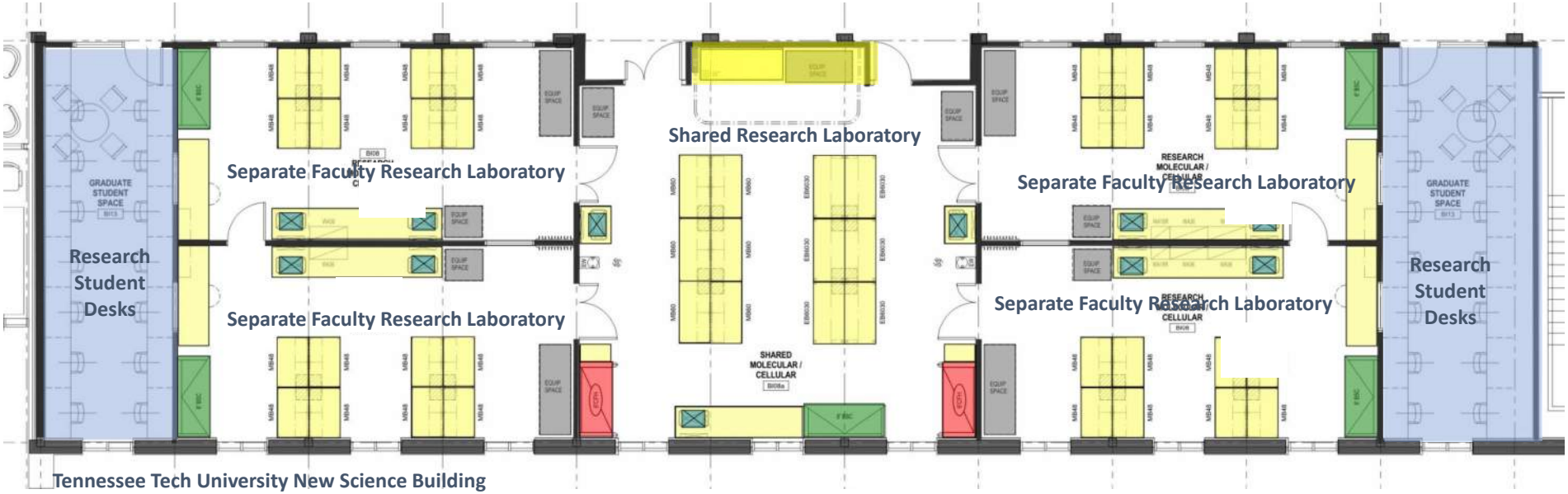




Utah State – Lab Suites for
4 Faculty Each
= 580 nsf Allocation

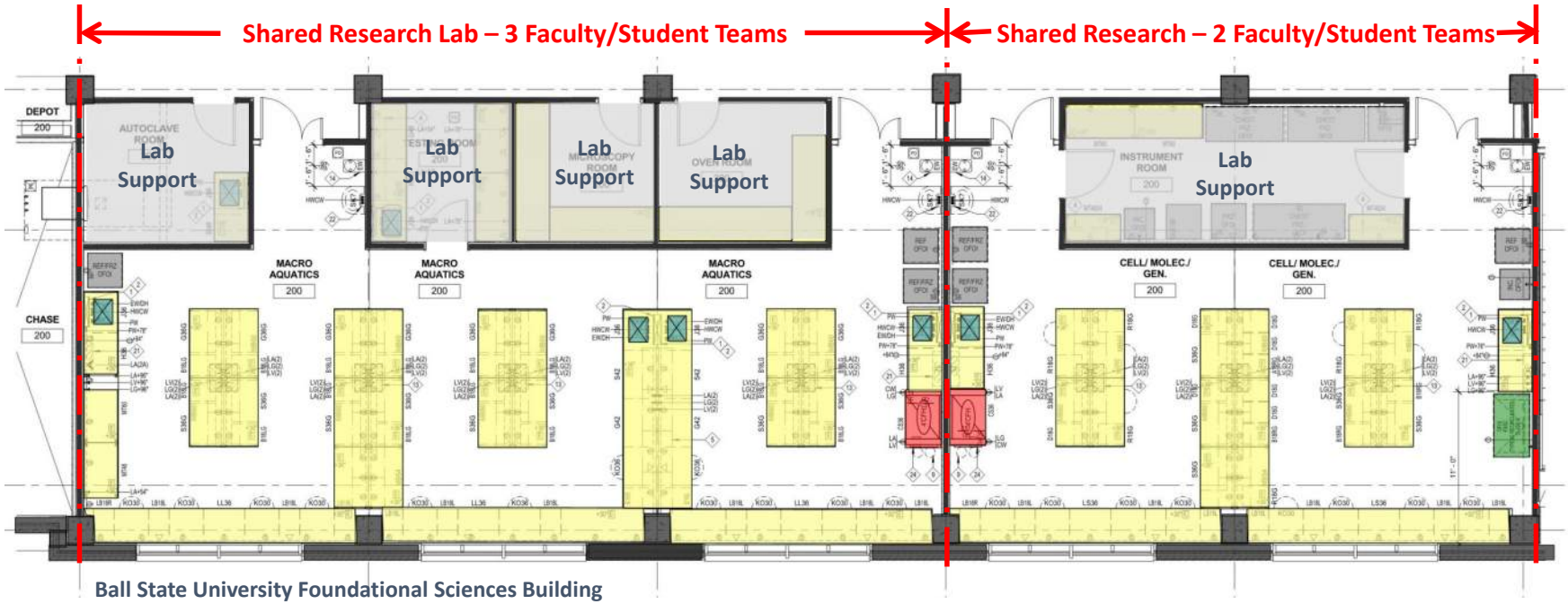
Cal Poly SATRC
Lab suites for
3 Faculty Each
= 600 nsf Allocation

- Suite of 4 Faculty Research Laboratories
- Separate Lab per Faculty @ 480 nsf each
- Shared Laboratory @ 960 nsf for Overflow and Shared Equipment / Instrumentation
- Shared Student Desk Spaces per Pair of Faculty Research Laboratories



Environments for Discovery | Undergraduate Research Accommodations – Shared Labs

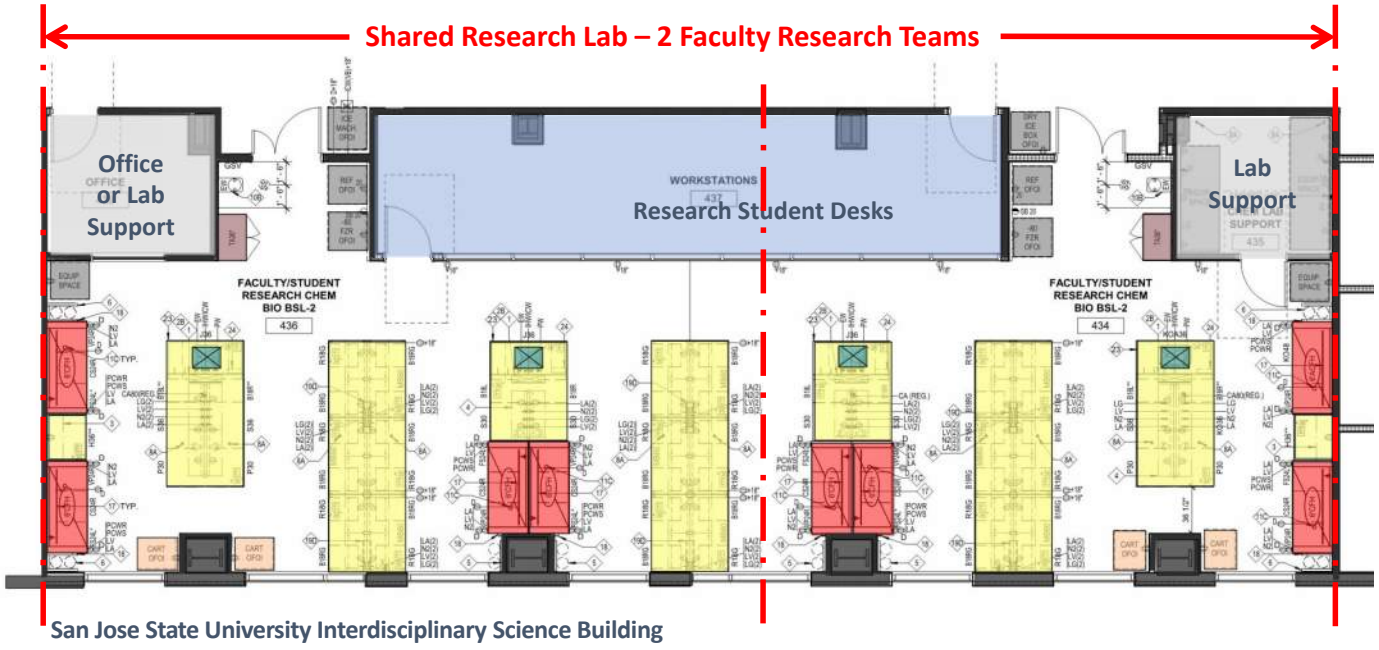
- Faculty Research Labs for 2 to 4 Faculty teams
- Shared Lab for 2 Faculty Teams = 1,050 NSF
- Shared Lab for 3 Faculty Teams = 1,530 NSF
- Shared Lab for 4 Faculty Teams = 2,060 NSF
- Lab Support Zone along Corridor



Ball State University Foundational Sciences Building

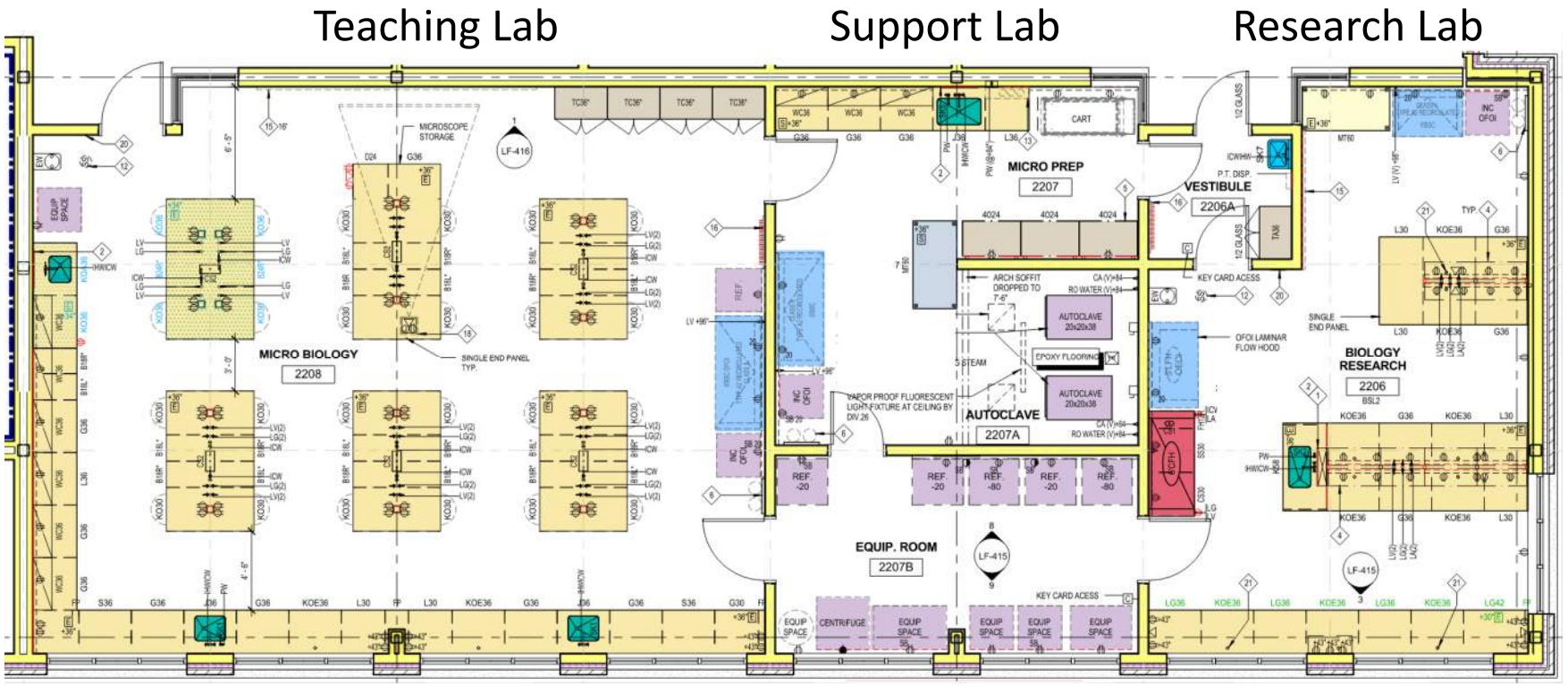
Environments for Discovery | Undergraduate Research Accommodations – Shared Labs

- Faculty/Student Research Labs - 2 to 4 teams
- Shared Lab for 2 Research Teams = 1,890 NSF
- Shared Lab for 4 Research Teams = 3,780 NSF
- Lab Support Rooms along Corridor
- **Research Student Desk space adjacent to Labs for ease of monitoring**



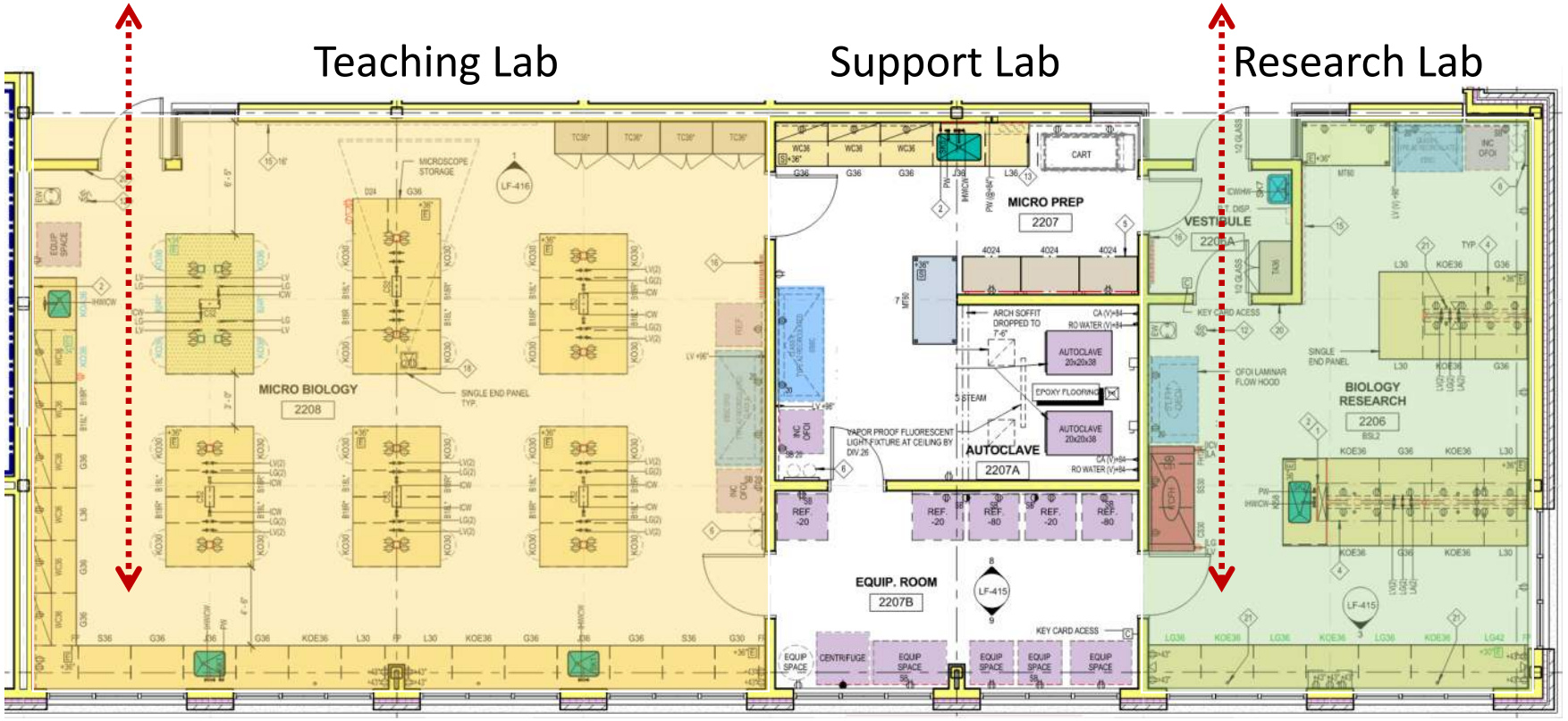
San Jose State University Interdisciplinary Science Building

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



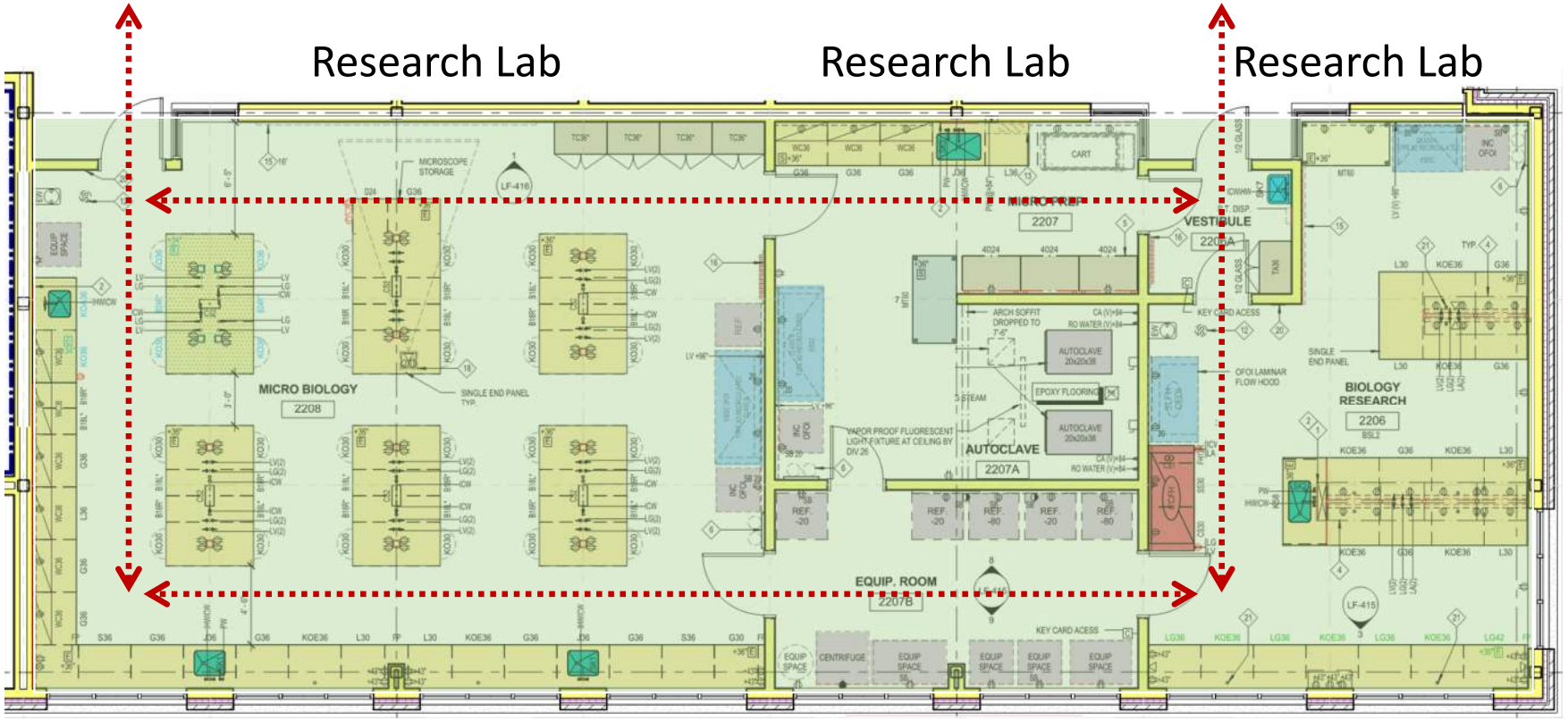
Environments for Discovery | Undergrad Research Accommodations – Leveraged Research

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



Environments for Discovery | Undergrad Research Accommodations – Leveraged Research

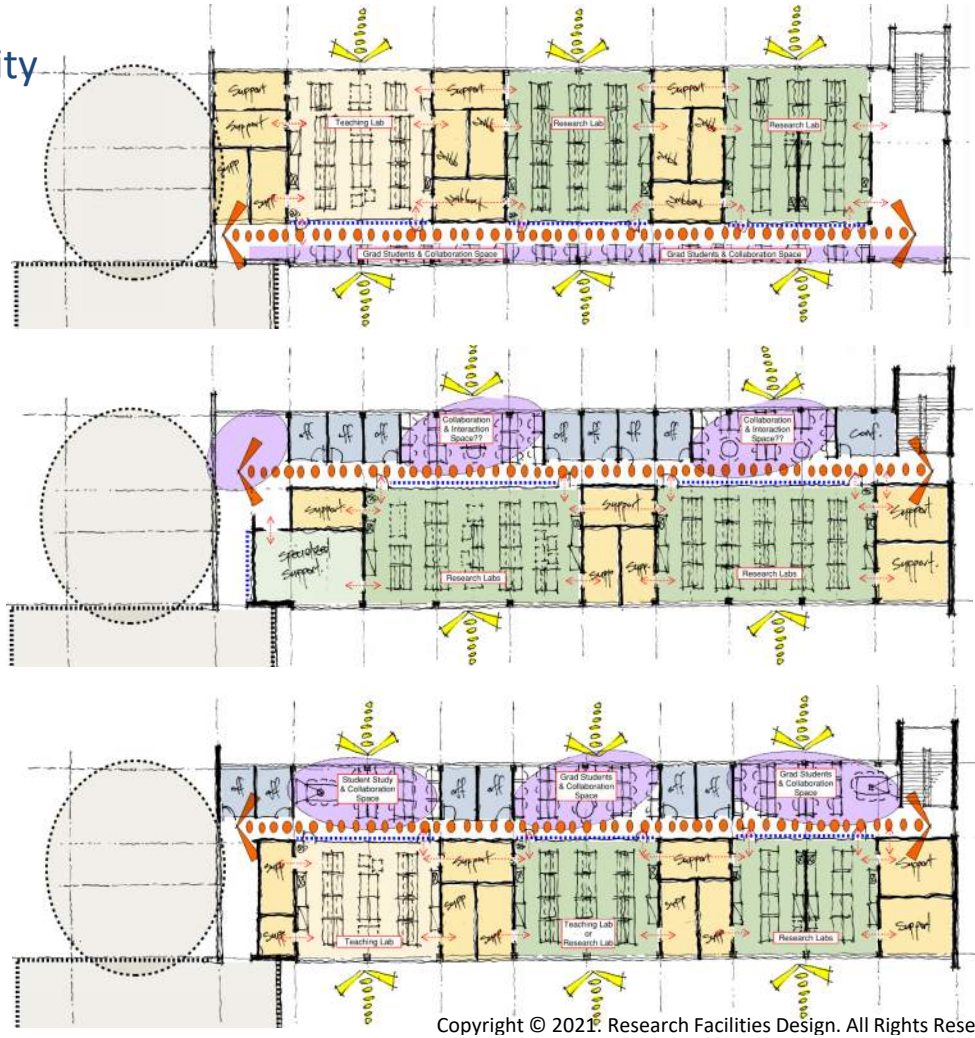
- Modest dedicated Research allocation during the academic year
- Coupled with Teaching Laboratory for extended use during the summer
- Shared Laboratory Support Space in between



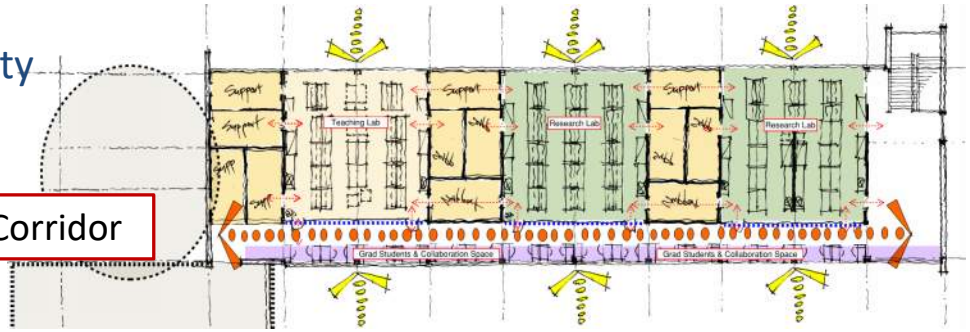
Undergraduate Research Accommodations

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

- Transform Spaces for Modern Research Labs
- Consider Shifting Circulation Patterns to Achieve Flexibility
- Activate and Daylight Corridors



- Transform Spaces for Modern Research Labs
- Consider Shifting Circulation Patterns to Achieve Flexibility
- Activate and Daylight Corridors



Environments for Discovery

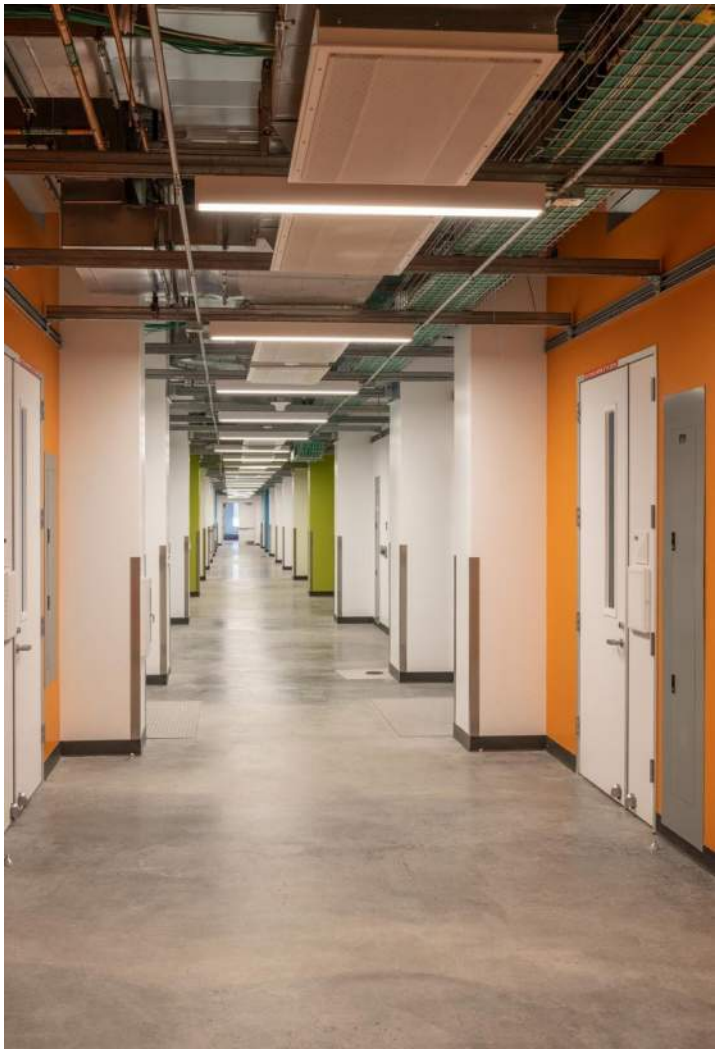
Flexibility in Research Laboratories - Flexible Benching

Environments for Discovery

Flexibility in Research Laboratories – Separated Write-up

Environments for Discovery

Flexibility in Research Laboratories – Service Corridor



Presentation Outline

1) **Considerations for Science & Technology Facilities**
   - » Learning & Research Communities
   - » Recruitment & Retention
   - » Engaged, Active & Applied Learning
   - » Transparency, Connections & Extended Learning
2) **Planning Trends for Science & Technology**
   - » Building Planning Considerations
   - » Active Learning Laboratories
   - » Undergraduate Research & Project Laboratories
3) **Innovation, Maker & Advanced Manufacturing Spaces**
4) **Benchmarking & Metrics**
5) **The 'Tradeline Three'**

Hands-On Learning

Maker Space Types & Users

Maker Spaces Variations:

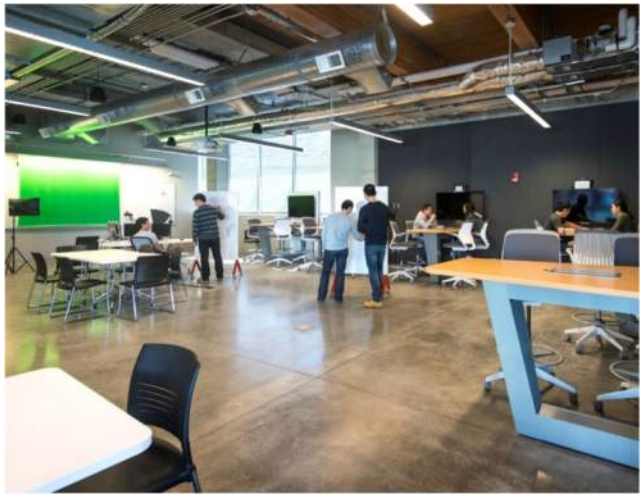
- Ideation & Visualization Labs
- Lightweight Tools & Materials Spaces
- Prototyping & Industrial Mfg Labs
- Large Scale Shops
- Project Assembly Labs

Maker Spaces Users:

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

Hands-On Learning

Design & Ideation Spaces



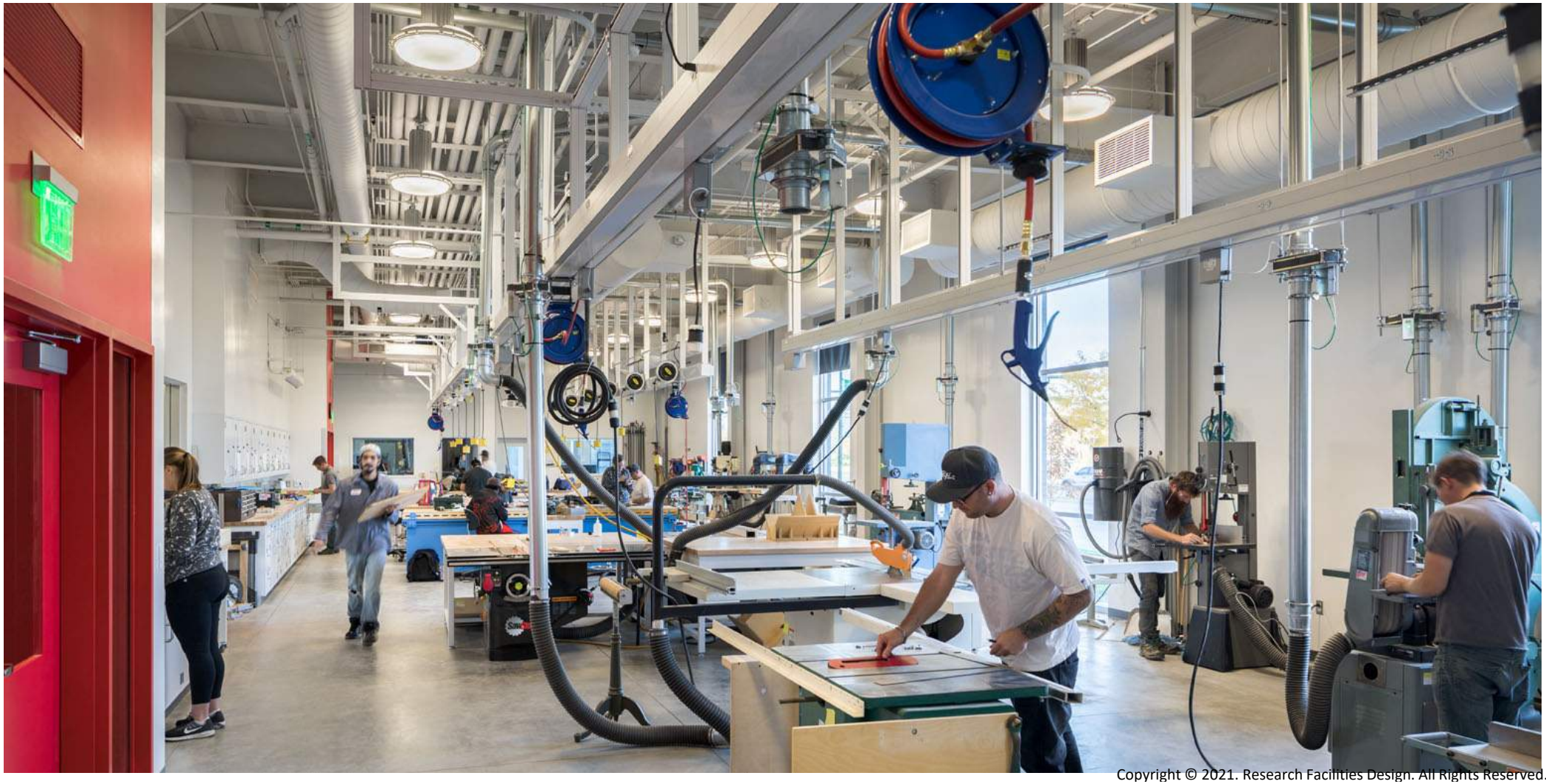
Hands-On Learning > Maker ‘Light’

Hands-On Learning

Additive Prototyping 3-D Printers

Hands-On Learning > Prototyping

Hands-On Learning > Subtractive Prototyping & Shops



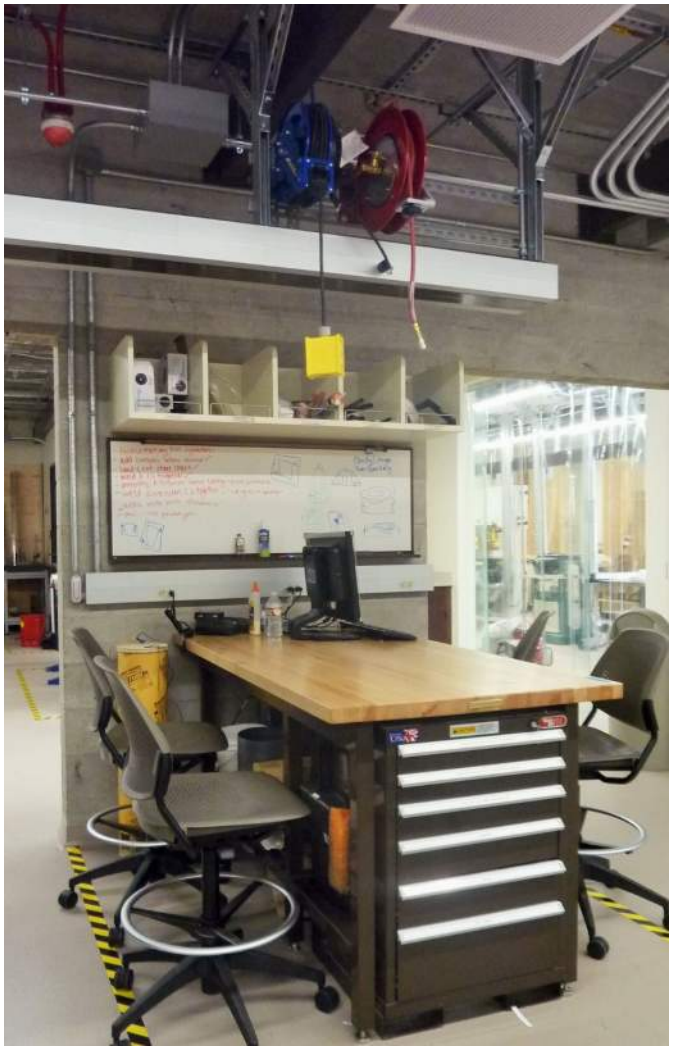
Hands-On Learning

Subtractive Prototyping & Shops

Hands-On Learning

Subtractive Prototyping & Industrial Manufacturing

Hands-On Learning > Project & Assembly

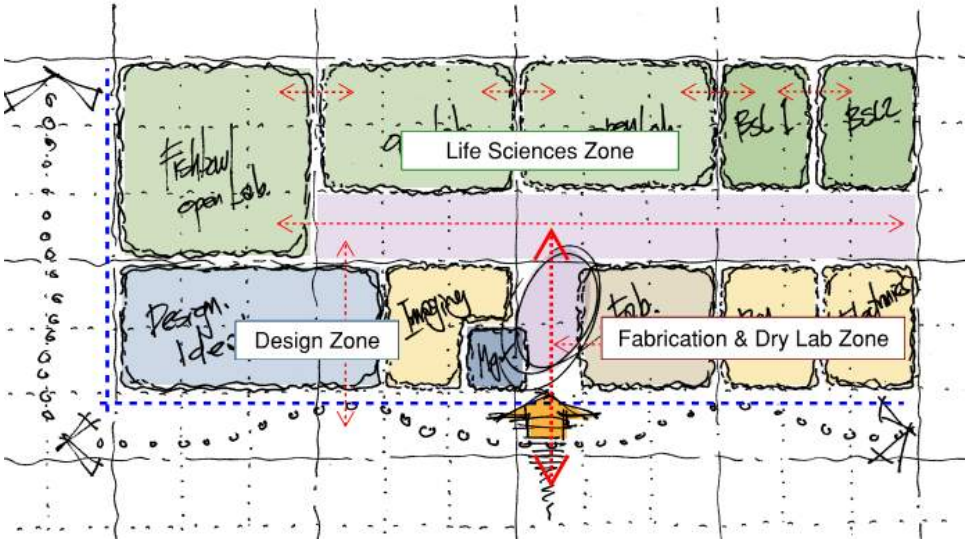


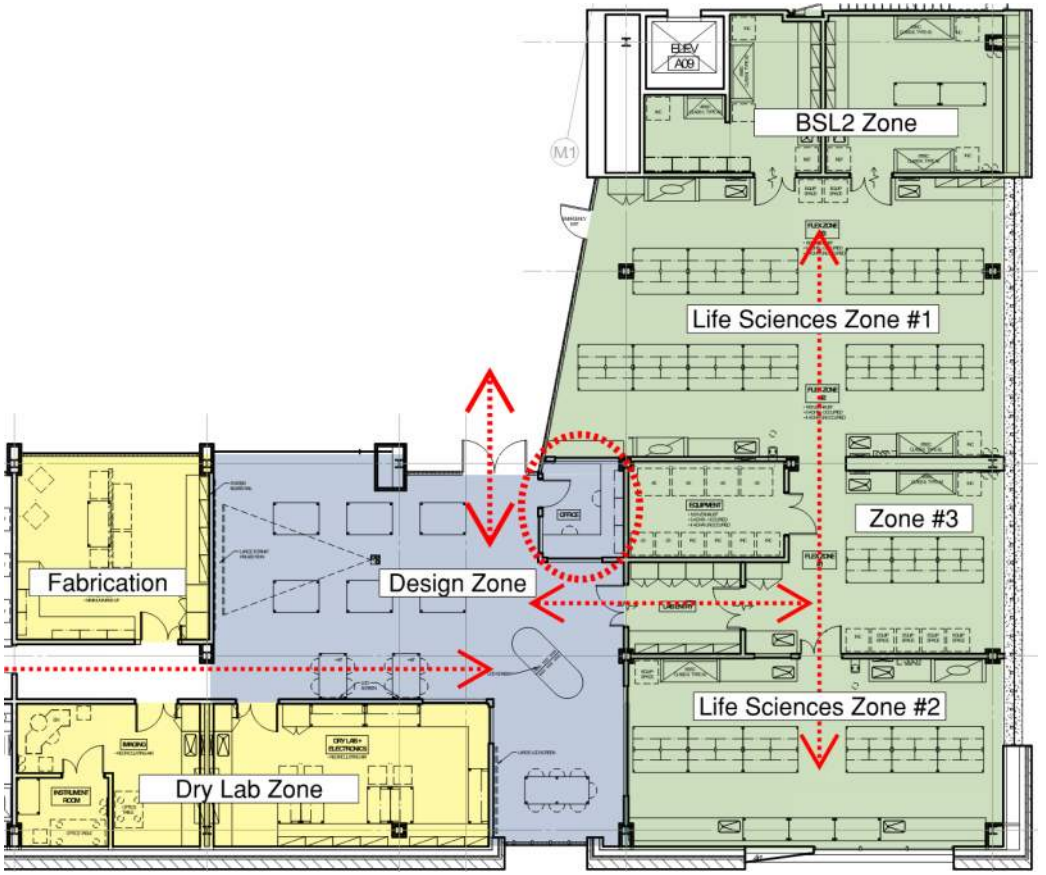
Hands-On Learning > Project & Assembly

Hands-On Learning > Bio-Maker Spaces

Bio-Maker - Emerging Concepts

- Design / Ideation / Visualization
- Life Science / Wet Lab Zone / Instruments
- Dry Lab Zone / Fabrication
- Independent Undergraduate Projects
- Citizen Scientist





Hands-On Learning > Bio-Maker Spaces

Bio-Maker - Emerging Concepts

- Design / Ideation / Visualization
- Life Science / Wet Lab Zone / Instruments
- Dry Lab Zone / Fabrication
- Independent Undergraduate Projects
- Citizen Scientist

Presentation Outline

1) **Considerations for Science & Technology Facilities**
   - » Learning & Research Communities
   - » Recruitment & Retention
   - » Engaged, Active & Applied Learning
   - » Transparency, Connections & Extended Learning
2) **Planning Trends for Science & Technology**
   - » Building Planning Considerations
   - » Active Learning Laboratories
   - » Undergraduate Research & Project Laboratories
3) **Innovation, Maker & Advanced Manufacturing Spaces**
4) **Benchmarking & Metrics**
5) **The 'Tradeline Three'**

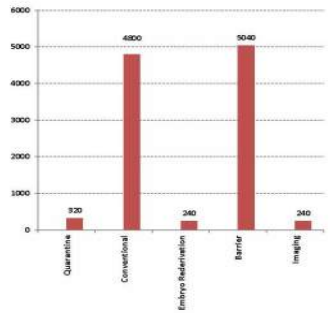
Programming Tools > Benchmarking Database

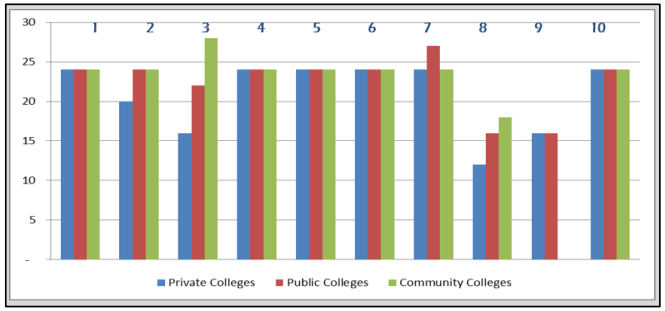
Benchmarking Application to Your Project

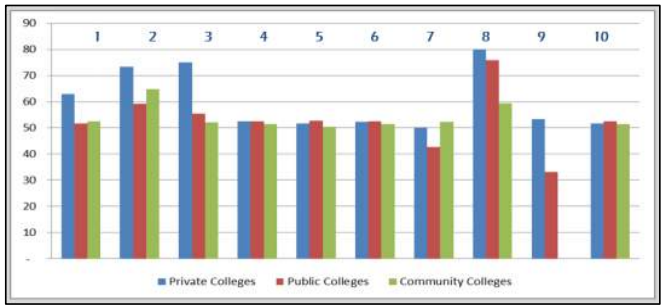
- Use as a ‘Guide’ not a ‘Predictor’
- Align with Similar Projects
- Checks and Balances





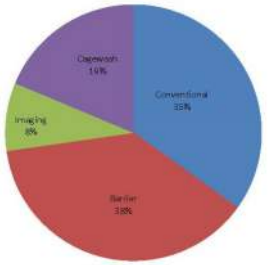


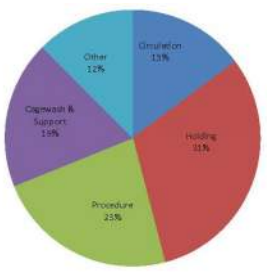


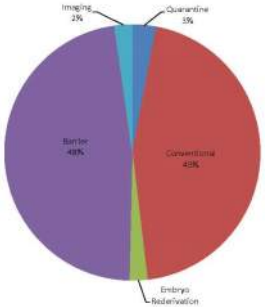
ROOM LIST / SPACE TABULATION

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						Construction Cost/GSF by Type of Space					
		Laboratory + Support	Core Functions	Vivarium		Office/Admin + Conference		Laboratory + Support	Core Functions	Vivarium		Office/Admin + Conference	
	Estimated Construction Cost	$400	$400	$500		$225		$400	$400	$500		$225	
	Estimated Construction Cost		$366			$73,496,053			$366			$89,843,421	





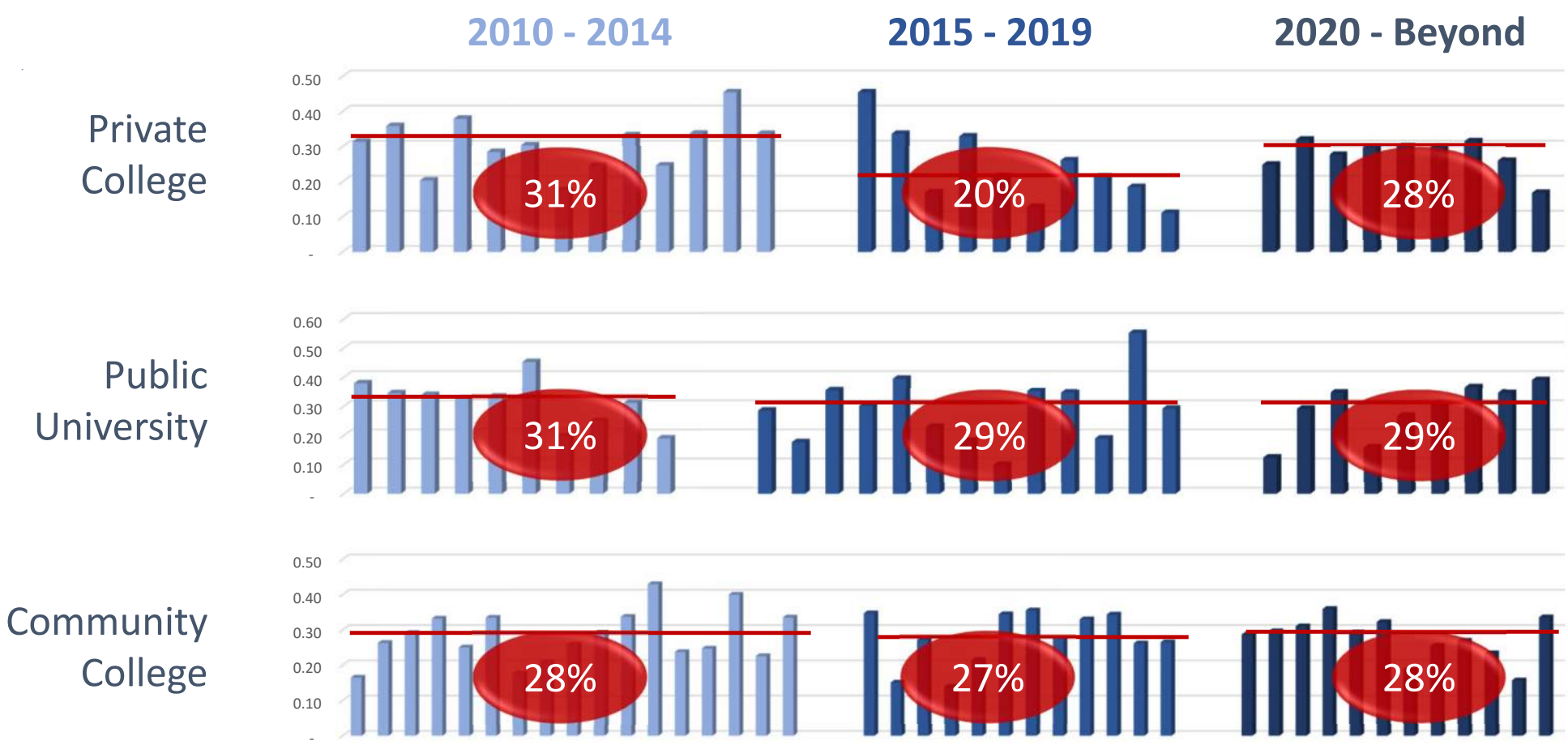


Programming Tools

Net / Gross Building Efficiency Ratio

Programming Tools

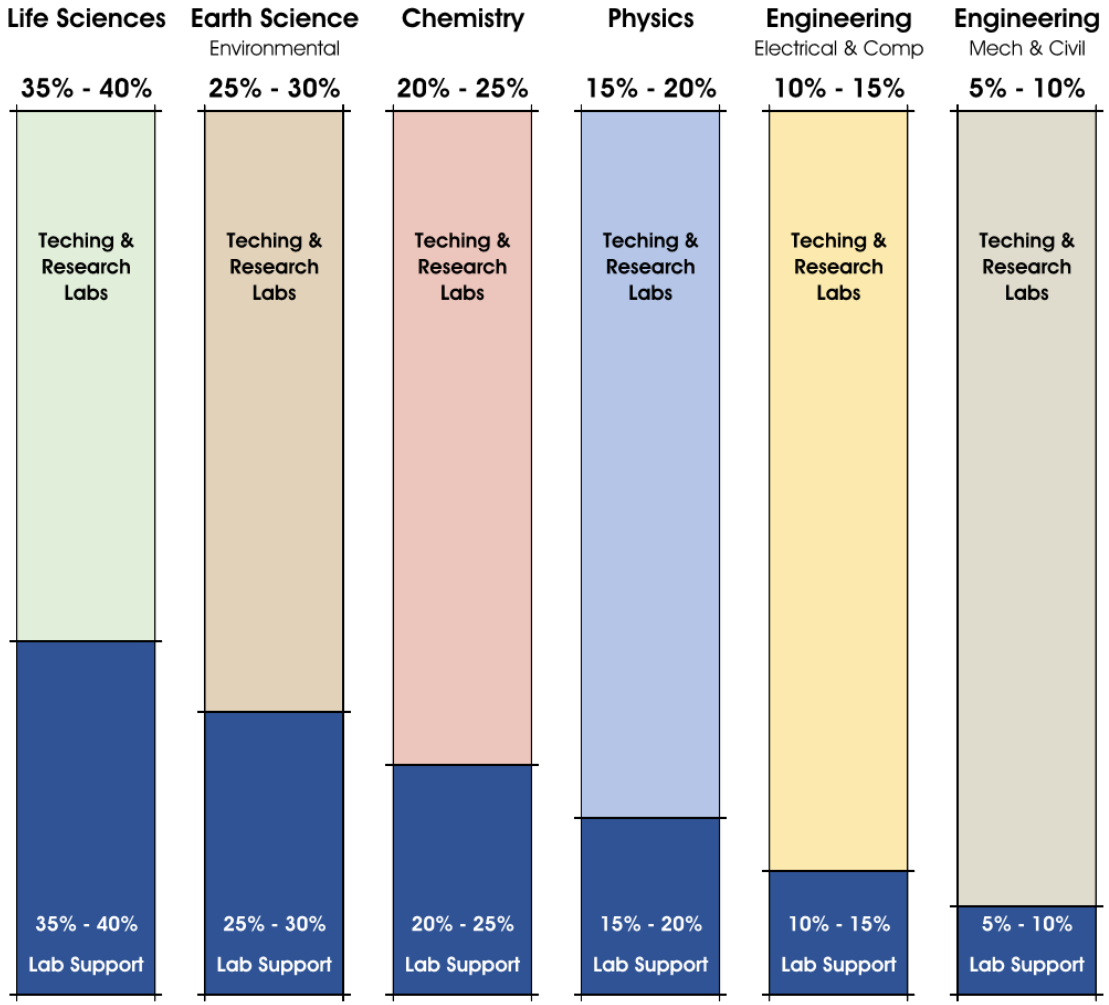
Laboratory Support Area Ratio



Programming Tools | Laboratory Support Area Ratio

Lab Support / Lab + Lab Support

- Lab Support Ratios vary significantly by Discipline
- Life Sciences have much higher Lab Support Ratios with spaces such as:
  - Animal Facilities
  - Greenhouse / Headhouse
  - Glasswash / Autoclave
  - Media Prep
  - Controlled Environment Rooms
  - Tissue Culture
  - Equipment Rooms, etc.
- Engineering facilities have much lower Lab Support Ratios – large shared equipment tends to be located within the Teaching and/or Research Laboratories



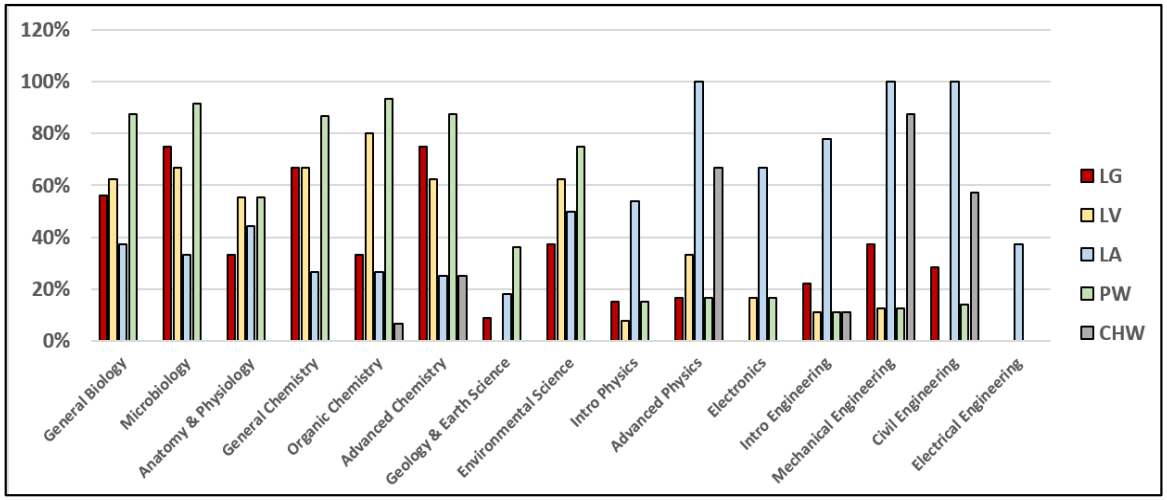
Programming Tools

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

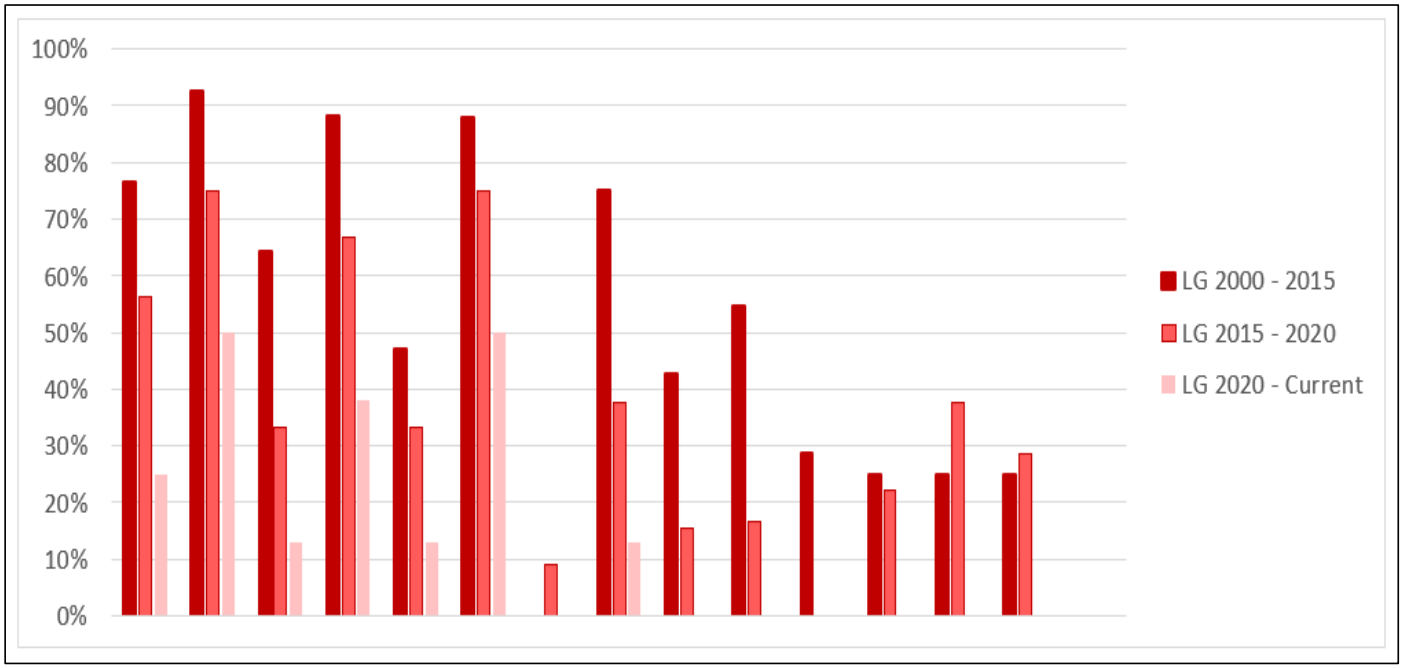
2015 - Current	LG	LV	LA	PW	CHW
General Biology	56%	63%	38%	88%	0%
Microbiology	75%	67%	33%	92%	0%
Anatomy & Physiology	33%	56%	44%	56%	0%
General Chemistry	67%	67%	27%	87%	0%
Organic Chemistry	33%	80%	27%	93%	7%
Advanced Chemistry	75%	63%	25%	88%	25%
Geology & Earth Science	9%	0%	18%	36%	0%
Environmental 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%



Programming Tools | 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**

Comparison - Natural Gas Reductions in Teaching Labs



Programming Tools > Laboratory Ventilation Air

Almost Always Recirculating Air

Sometimes Recirculating Air

Almost Always Once - Through Air

Always Once - Through Air

Programming Tools > Laboratory Ventilation Air

Recirculating Air:
- Computer Sciences
- GIS
- Astronomy

Sometimes Recirculating Air:
- Physics
- Engineering
- Geology
- Earth Science

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

Programming Tools > Laboratory Ventilation Air

Recirculating Air:

- Computer Sciences
- GIS
- Astronomy

Sometimes Recirculating Air:

- Physics
- Engineering
- Geology
- Earth Science

Always Once - Through Air
(Minimum Make-up Air)

- Maker Spaces
- Shops
- Mechanical & Civil Engineering

Programming Tools > Laboratory Ventilation Air

Always Once - Through Air

(Required Elevated Air Change Rates)

- Chemistry
- Organic Chemistry
- Anatomy & Physiology
- Biology

Presentation Outline

1) **Considerations for Science & Technology Facilities**
   - » Learning & Research Communities
   - » Recruitment & Retention
   - » Engaged, Active & Applied Learning
   - » Transparency, Connections & Extended Learning
2) **Planning Trends for Science & Technology**
   - » Building Planning Considerations
   - » Active Learning Laboratories
   - » Undergraduate Research & Project Laboratories
3) **Innovation, Maker & Advanced Manufacturing Spaces**
4) **Benchmarking & Metrics**
5) **The 'Tradeline Three'**

The ‘Tradeline Three’ Take-Aways

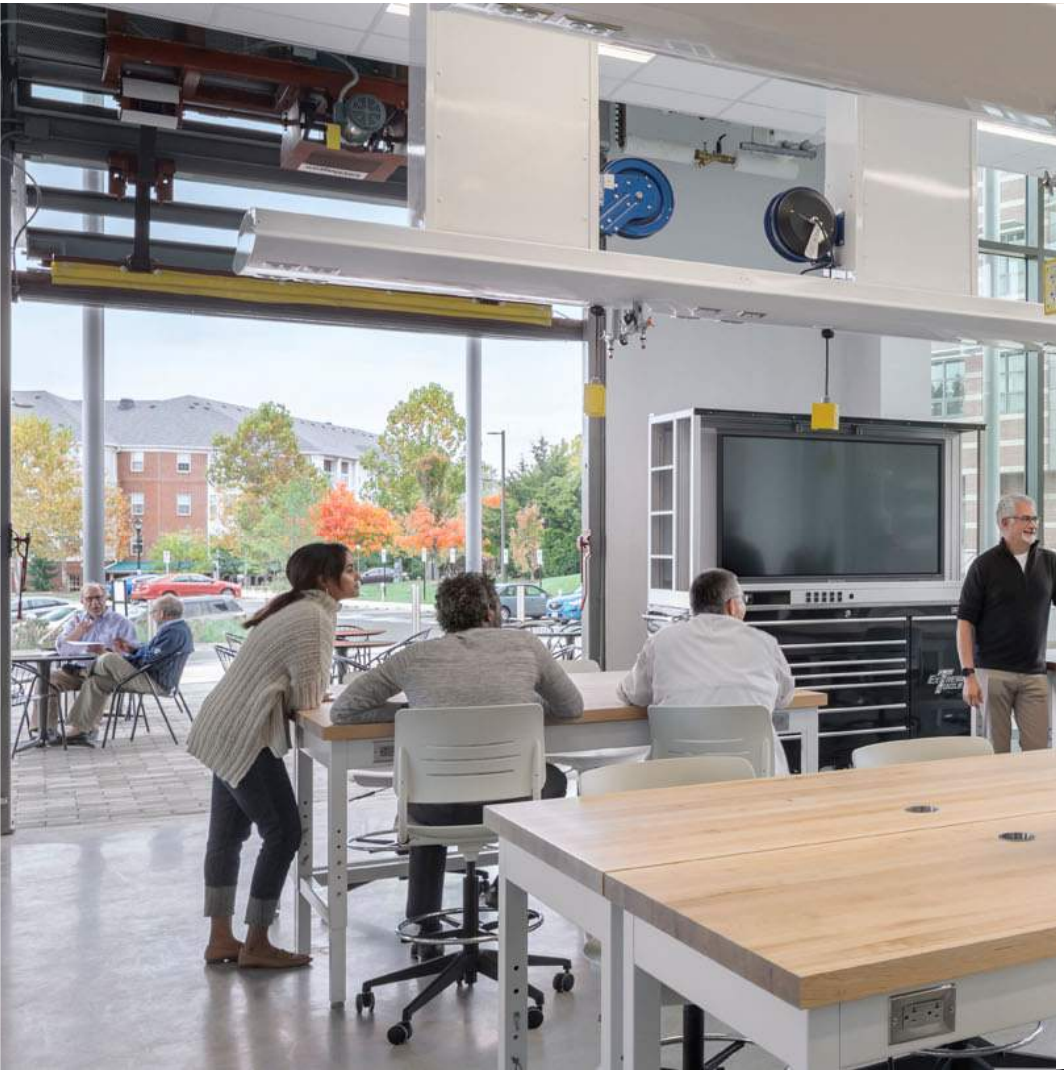
1. ***Get More out of your Science Facility: Students, Partnerships, Outreach***

2. ***Extend your Learning Environments: Clusters & Multi-use Neighborhoods, Efficiency & Evolving Curriculum***

3. ***Focus on the Details… but Don’t Miss the Big Picture***

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

Questions / Discussion



RESEARCH FACILITIES DESIGN

San Diego Office
3965 Fifth Avenue, Suite 400
San Diego, California 92103
(619) 297-0159

Raleigh Office
555 Fayetteville Street, Suite 300
Raleigh, North Carolina 27601
(919) 213-7007

www.rfd.com
rfd@rfd.com