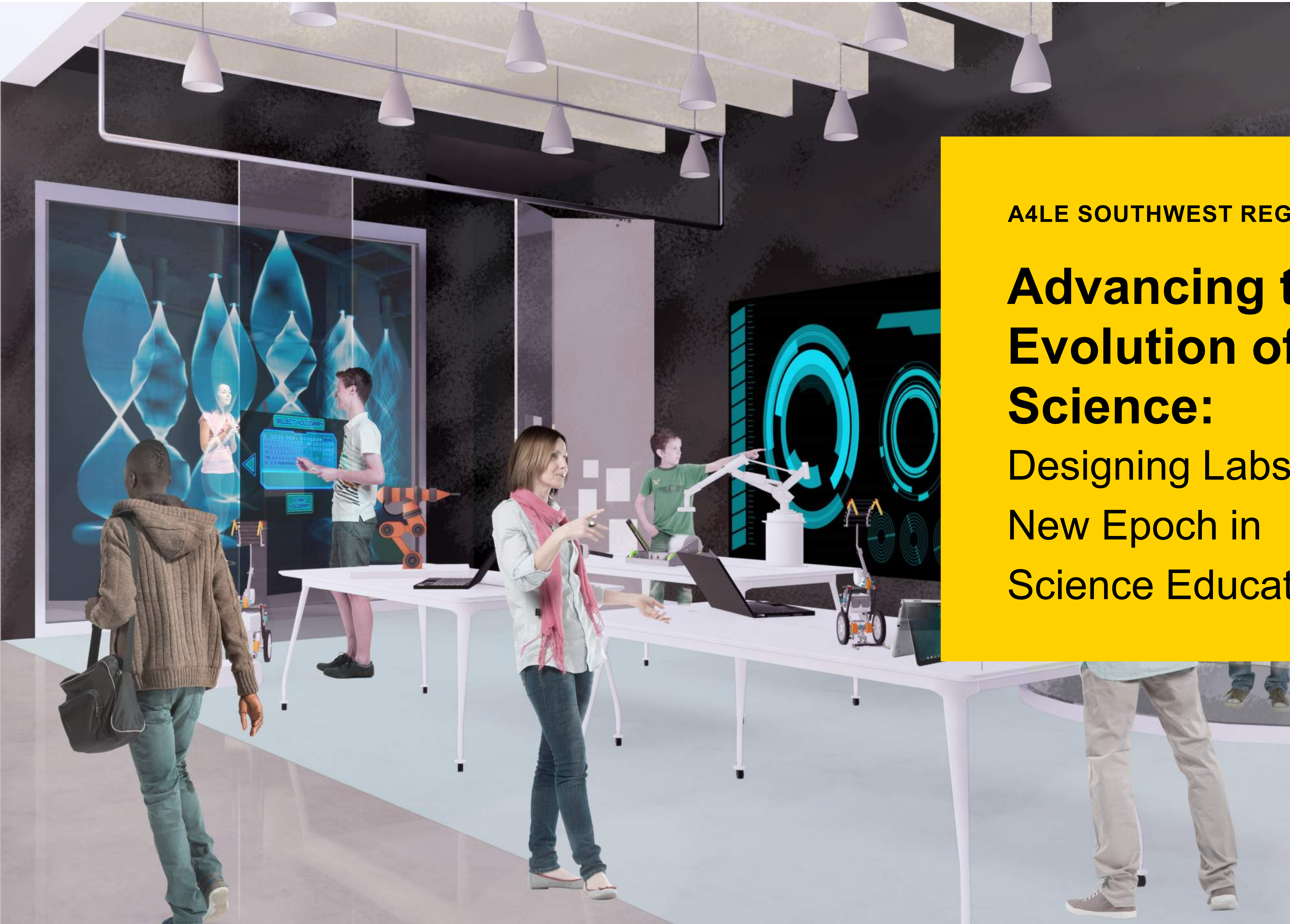


CORGAN

A4LE SOUTHWEST REGION

Advancing the Evolution of Science:

Designing Labs for a New Epoch in Science Education

evolution of education

Introductions

Anthony Wang

Vice President

Jason Mellard

Senior Associate

Learning Objectives

1

Participants will receive the tools required to reimagine the student experience in the laboratory settings on their campus

2

Attendees will gain insights from research-based advances and case studies to provide greater flexibility and functionality for science labs

3

Attendees will make connections between university, community college and K-12 environment to improve each

4

Participants will be able to best align the design of their campus’s science education spaces with curriculum and generational learning styles

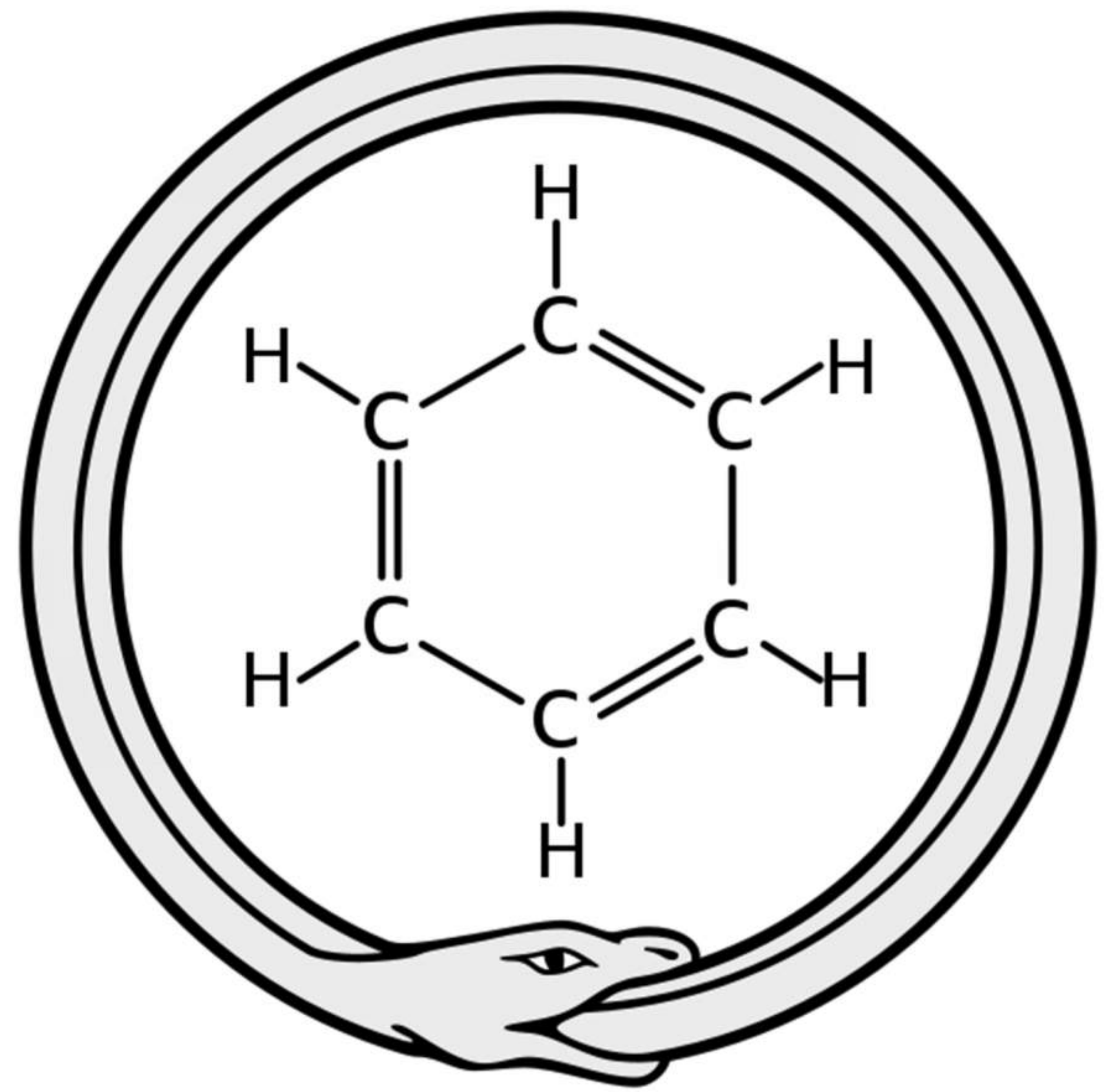
CORGAN

Discovery Through Divergent Thinking

Chemist August Kekulé visualized the circular structure of benzene when he saw a snake made of atoms take its tail into its mouth, forming a closed ring in a dream.

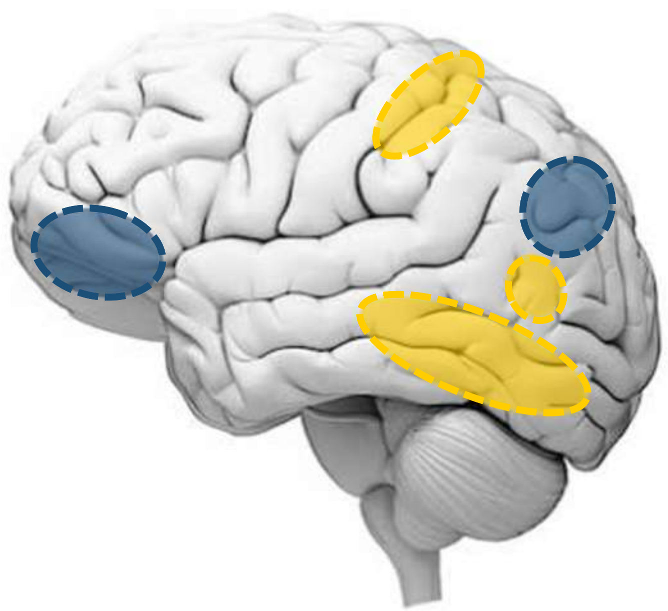
The dream prompted a breakthrough in his understanding of benzene as a closed ring molecule during a time when all known molecules were straight lines.

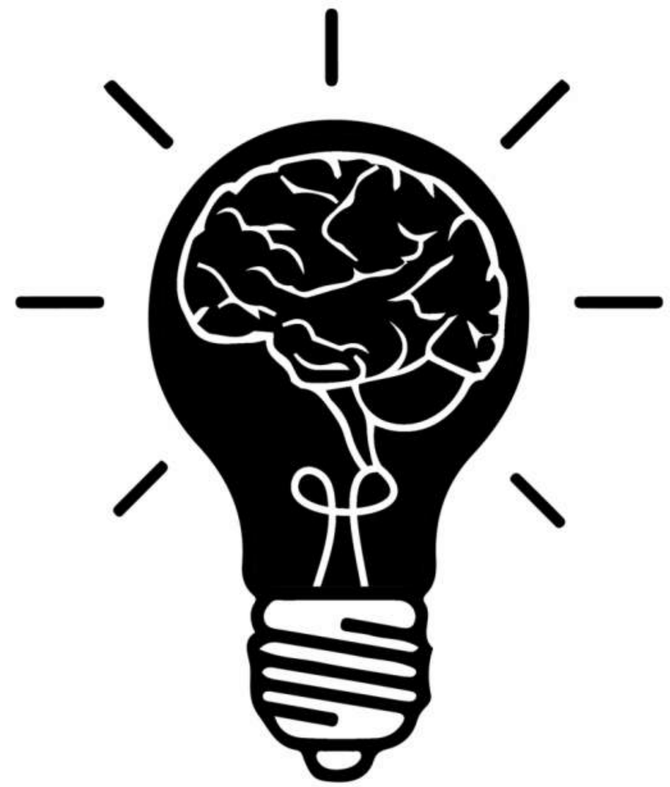
Kekulé's theory resulted in a clear understanding of aromatic compounds and thus had a major impact on the development of chemical science and industry.

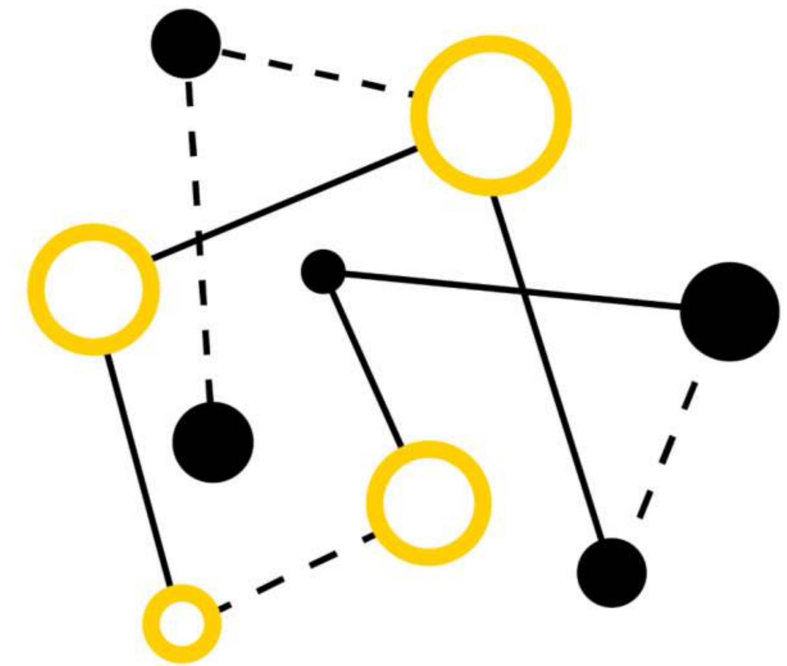


Visual processing and emotion

Logic and cognitive control







Dreams

Highly sensory, disinhibited thought

Insight, creativity, thinking outside the box

Creativity

Producing novel and useful solutions

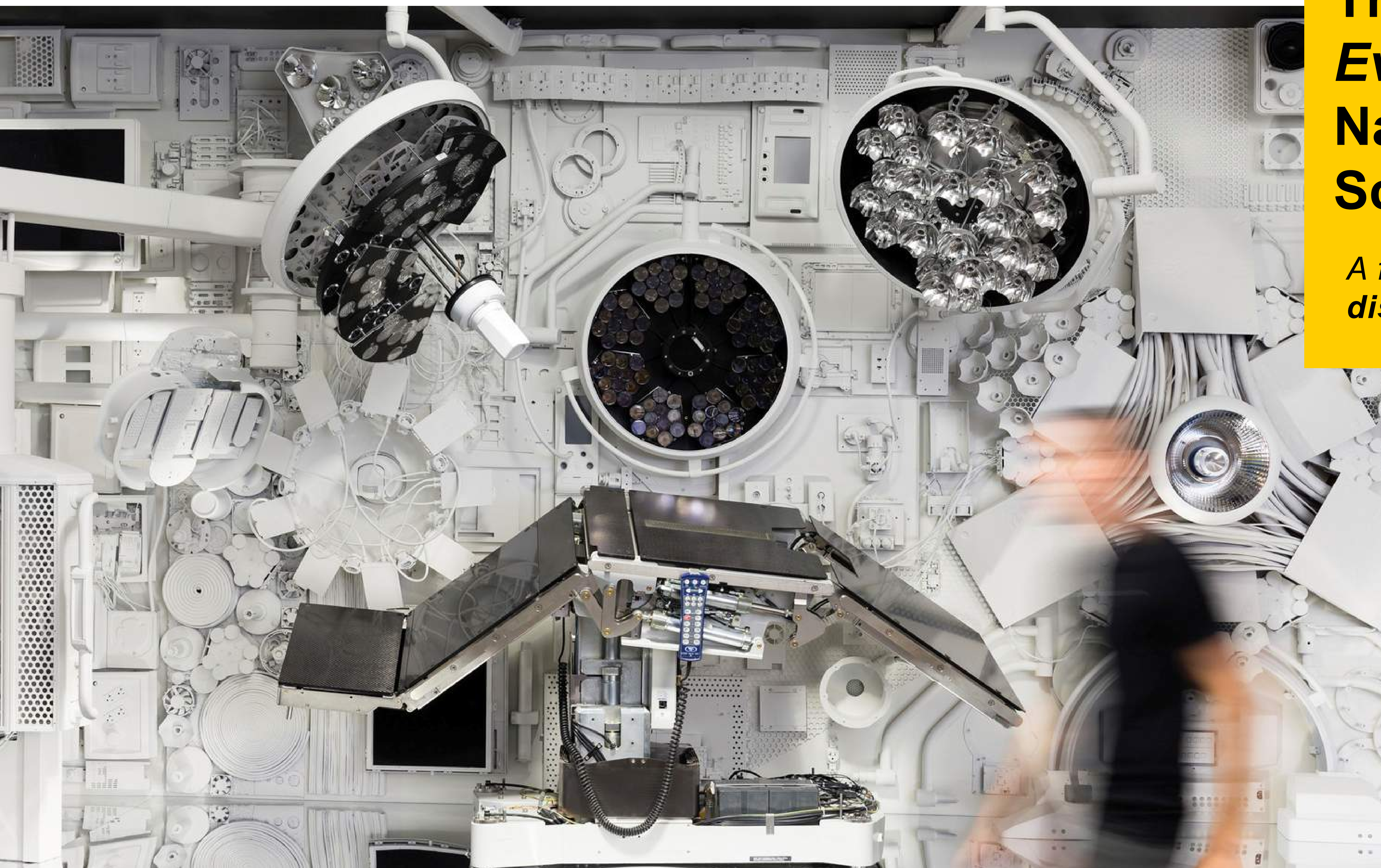
Related to openness to experience, self-efficacy, and intrinsic motivation

Discovery

Connecting and problem-solving

Overcoming obstacles and a natural resistance to change

(Barrett, 2014; Barrett, 2020; Purves et al, 2018; Farmer & Matlin, 2019; Prabhu, 2008; Hwang, 2013; Bonifacio et al, 2018)



The *Evolutionary* Nature of Science

*A field driven by **discovery***

- Pursuit and application of **knowledge**
- Systematic study of the world through **observation, experimentation, and analysis**
- The study and practice of science **drives change** in the world

Science Education

- Didactic and laboratory-based
- Build understanding of complex and abstract theories on a **foundation of experiential understanding**
- Science education is the **original project-based learning**

Defining a New “Epoch” in Science Education

Overlay of Technology

Evolving Pedagogies

Research Focus

Interdisciplinary Connections

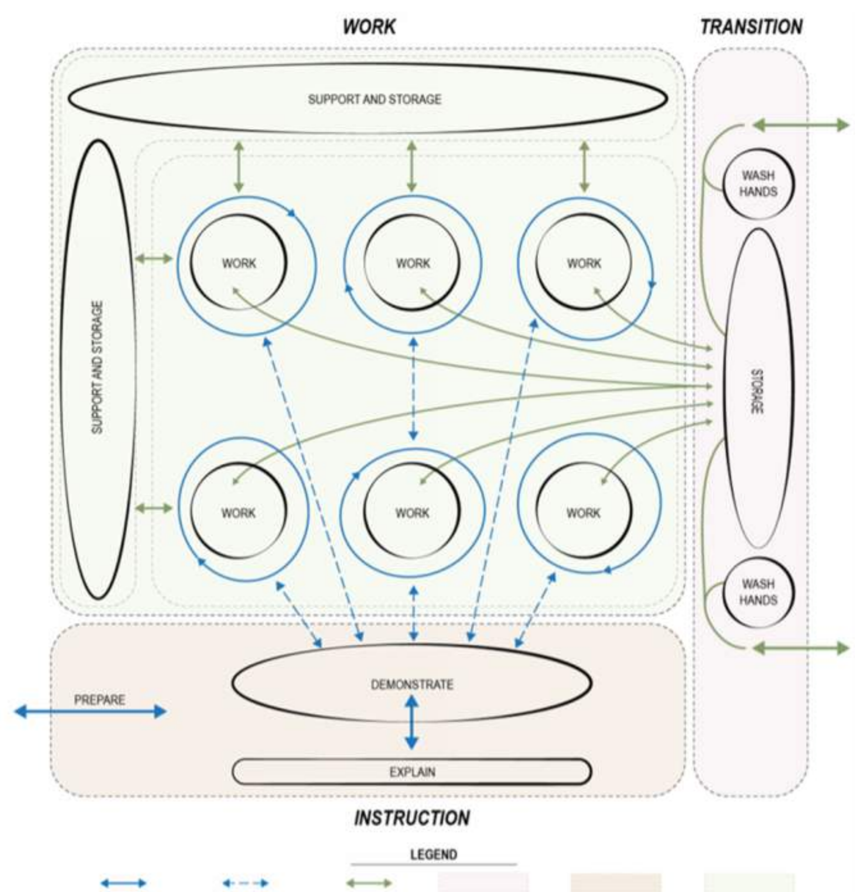
Designing spaces for safe, effective, and inspiring science learning is a **technical challenge**, but in reality, ***what's happening in students' minds*** as they learn science **is much more complex**

Advancing Science Learning in K-12 and Higher Education

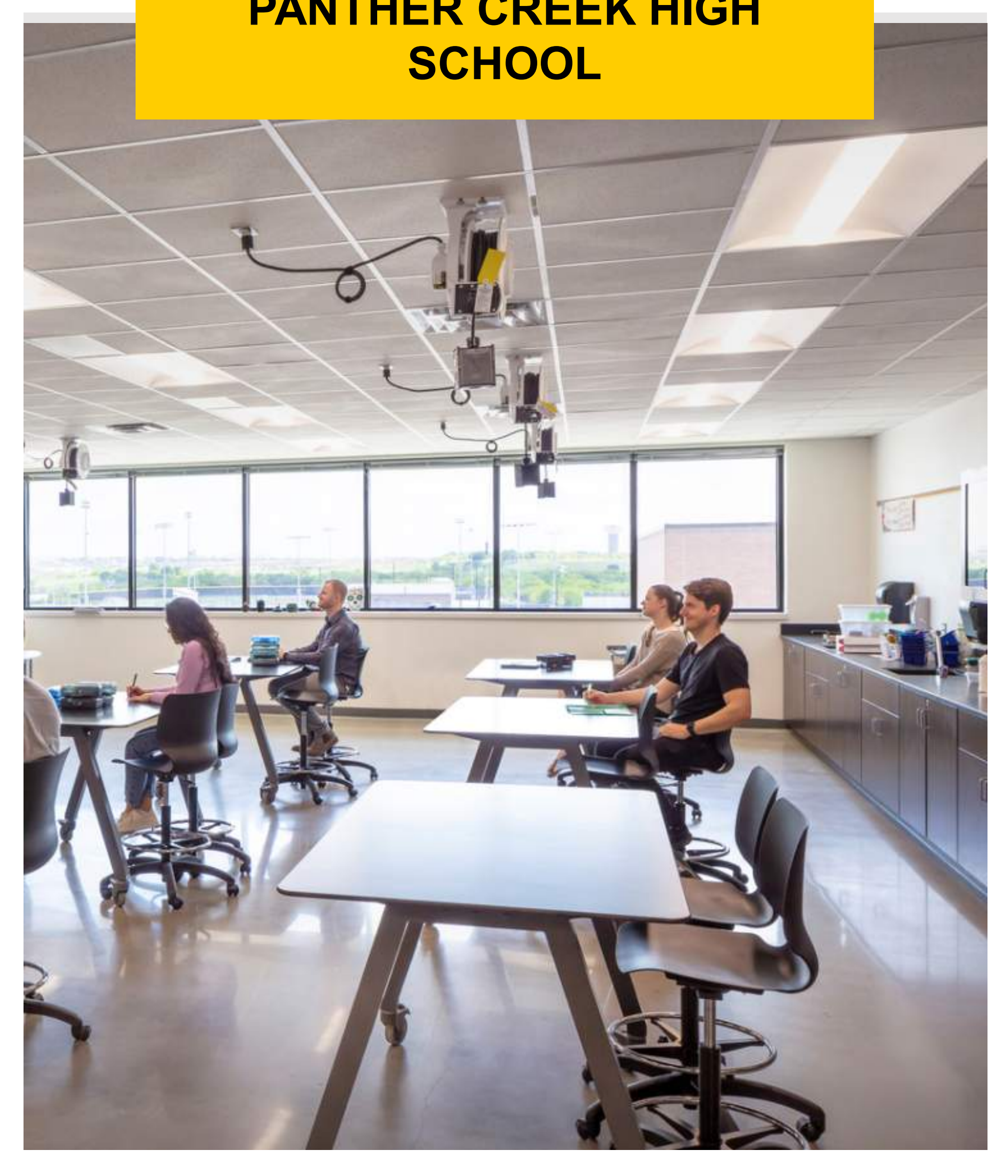
Project Case Studies

PANOLA COLLEGE

TARRANT COUNTY COLLEGE SYNERGY LABS



PANTHER CREEK HIGH SCHOOL



The Science of Learning

Advancing the Evolution of Science

Passive Learning

Focuses on the cognitive experience of internalizing new information presented by a teacher or expert.

Students listen, but are not physically engaged, experimenting, or exploring as they learn.

Passive Learning creates **weaker, more limited neural connections.**

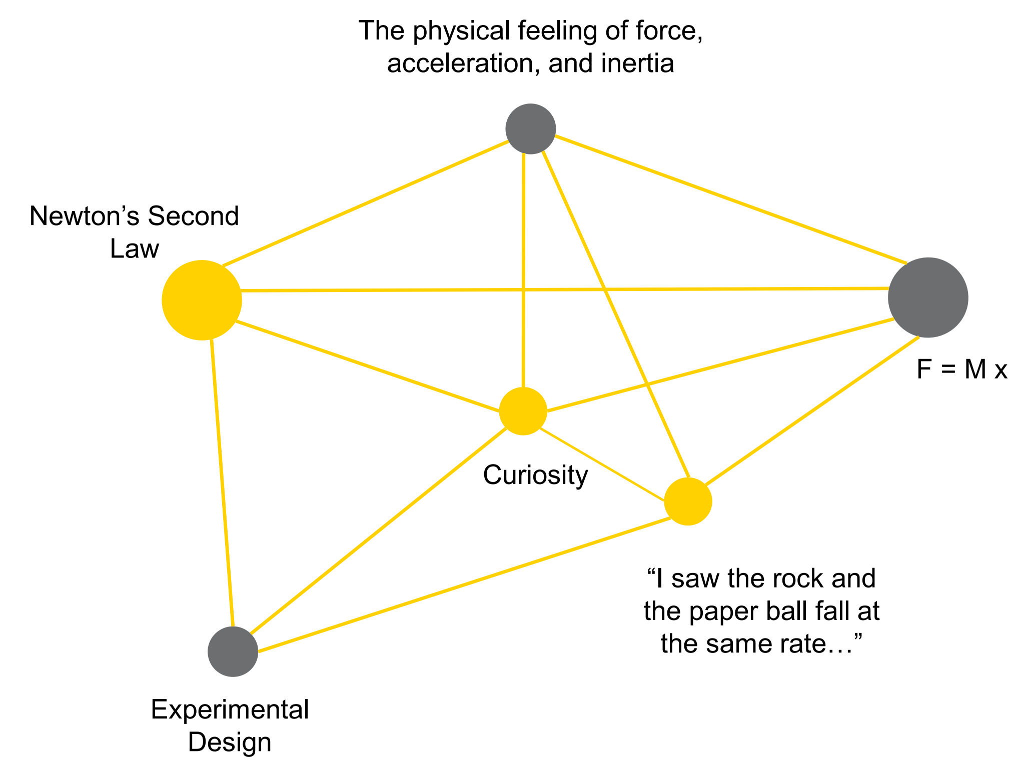
(Hoogendoorn, 2015; Herold, 2019)

Active Learning

Encourages students to engage their mind, their body, and their environment as they learn.

Student-led, hands-on, inquiry-based experiences.

Active learning forms more deeply embedded and more easily retrievable memories and **more effective learning outcomes.**



MIND

- Learning is student-led and inquiry-based
- Creativity and problem-solving are encouraged through divergent and critical thinking
- The formation of generalized knowledge is the goal

BODY

- Movement is encouraged through hands-on activities
- Increased sensory engagement takes advantage of the body's natural perceptual capabilities

ENVIRONMENT

- Engage the social, cultural, technological, natural, and material environment
- Holistic learning environments connect students to the real world
- Integrate real-life experiences into the classroom

What is Active Learning?

Treats learning as a process based in experience — Integrates a student's mind, body, and environment

(Hoogendoorn, 2015; Allal, 2001)

Why are laboratories important for science learning?

Pedagogical Considerations

1

CONCEPTUAL UNDERSTANDING

Enhance comprehension of science concepts through experimentation

2

CRITICAL THINKING

Observe phenomena, apply reasoning, and solve problems to connect learned concepts with new situations

3

REAL-WORLD EXPERIENCE

Participate in a community of practice and utilize the scientific method as a lens for solving problems in the lab and beyond

4

CURIOSITY

Nurture students' natural desire to explore and experiment through inquiry-based learning experiences

The Importance of "Doing"

- **Experiential Learning**
- **Observation alone** can contribute to an **inflated perception of learning and ability**
  - Merely watching does not provide the ***feeling of doing*** (kinesthetic, sensory, emotional states)
- **Physical experience aids in understanding complex, abstract concepts**
  - **Sensorimotor brain areas** are activated during hands-on experiences, *and* later when reasoning about the experienced phenomena
  - Sensorimotor activation was found to explain **improved learning outcomes**

> No matter how many times people watch a performance, they never gain one critical piece: **the feeling of doing**. Subtleties of performing are difficult to detect by sight alone, and the **kinesthetic, sensory, and emotional states evoked within the moment of performing are difficult to mentally simulate"**
>
> *Kardas and O'Brien, 2018*

[Kardas & O'Brien, 2018; Kontra et al, 2015]

Hebb's Law

Learning and Neuroplasticity

"Neurons that ***fire*** together ***wire*** together"

Navigating Evolutions in Education

EVOLVING PEDAGOGIES

Understanding Generation Alpha

Born 2010 to 2025

- First generation born entirely in the **21st century** and first to live decidedly into the **22nd century**
- Technologically literate
- Skilled creators of **products and services of value**
- Meaningful and relevant **skills-based experiences**

[Zmuda et al, 2017; Hughes, 2020; McCrindle, 2020]

Teaching Generation Alpha

- Shift from content mastery to **meaningful and relevant skill-building experiences**
- Align with Alpha's natural drive for **innovation, entrepreneurship, and knowledge-sharing**
  - High-Fidelity Learning Environments and Industry Partnerships
- **Personalized learning**
- **Technology**
  - Active Use of **Extended Reality (XR) Technologies**
  - The Future of EdTech: Anticipating the **Metaverse**
  - **A Balanced Approach**

> They will be lifelong learners, holding multiple jobs across multiple careers. They will also need to be adaptive, constantly upskilling and retraining to remain relevant to the changes anticipated as they move through their working life
>
> ***McCrindle***

[McCrindle, 2020; Hughes, 2020]

In-Demand Skills

America Succeeds
Durable Skills

- Character
- Collaboration
- Communication
- Creativity
- Critical Thinking
- Fortitude
- Growth Mindset
- Leadership
- Metacognition
- Mindfulness

World Economic Forum
Education 4.0 Framework

- Global citizenship skills
- Innovation and creativity skills
- Technology skills
- Interpersonal skills
- Personalized and self-paced learning
- Accessible and inclusive learning
- Problem-based and collaborative learning
- Lifelong and student-driven learning

Brookings Institute
Skills for a Changing World

- Collaboration
- Communication
- Content
- Critical Thinking
- Creative Innovation
- Confidence

McKinsey Global
Workforce Skills Model

- Higher Cognitive Skills
- Social and Emotional Skills
- Technological Skills

[Hirsh-Pasek et al, 2022; Roth et al, 2017; Golinkoff et al, 2016; Jezard, 2018; McKinsey Global Institute; Cole et al; 2021; Silva et al, 2022]

Extended Reality (XR)

XR encompasses a ***spectrum of technologies*** ranging from real-world to fully immersive

The active use of immersive technology shifts learning from passive consumption of digital media to ***active creation, interaction, and problem-solving.***

[Pomerantz, 2018; Pomerantz, 2019; Herold, 2019; Hoogendoorn, 2015; Lindgren et al, 2016]

XR: Pedagogical Applications

SKILL DEVELOPMENT

Supports competency-based teaching and learning. ***Shifts abstract concepts into skills-based practice***

HANDS-ON EXPERIENCE

Facilitates immersive, tactile, and intuitive learning experiences with ***active technologies***.

EXPANDED LEARNING

Provide access to ***situations*** and ***resources*** that may not be accessible in the real world

[Pomerantz, 2018; Pomerantz, 2019; Herold, 2019; Hoogendoorn, 2015; Lindgren et al, 2016]

XR Technologies for Learning

GigXR - HoloPatient

Anatomage Table

3D Immersion CAVE

Designing for Science Education

CORGAN

What's New in Science Labs?

- **Flexibility** and Multifunctionality
- Lab **Digitization:**
  Automation, Artificial Intelligence, Bioinformatics and Machine Learning, Computer Modeling, Data Analysis
- **Virtualization:**
  Digital Collaborations and Virtual Labs
- **Applied** Science Learning
- **Collaborative** Science Hubs
- **Outdoor Connections**

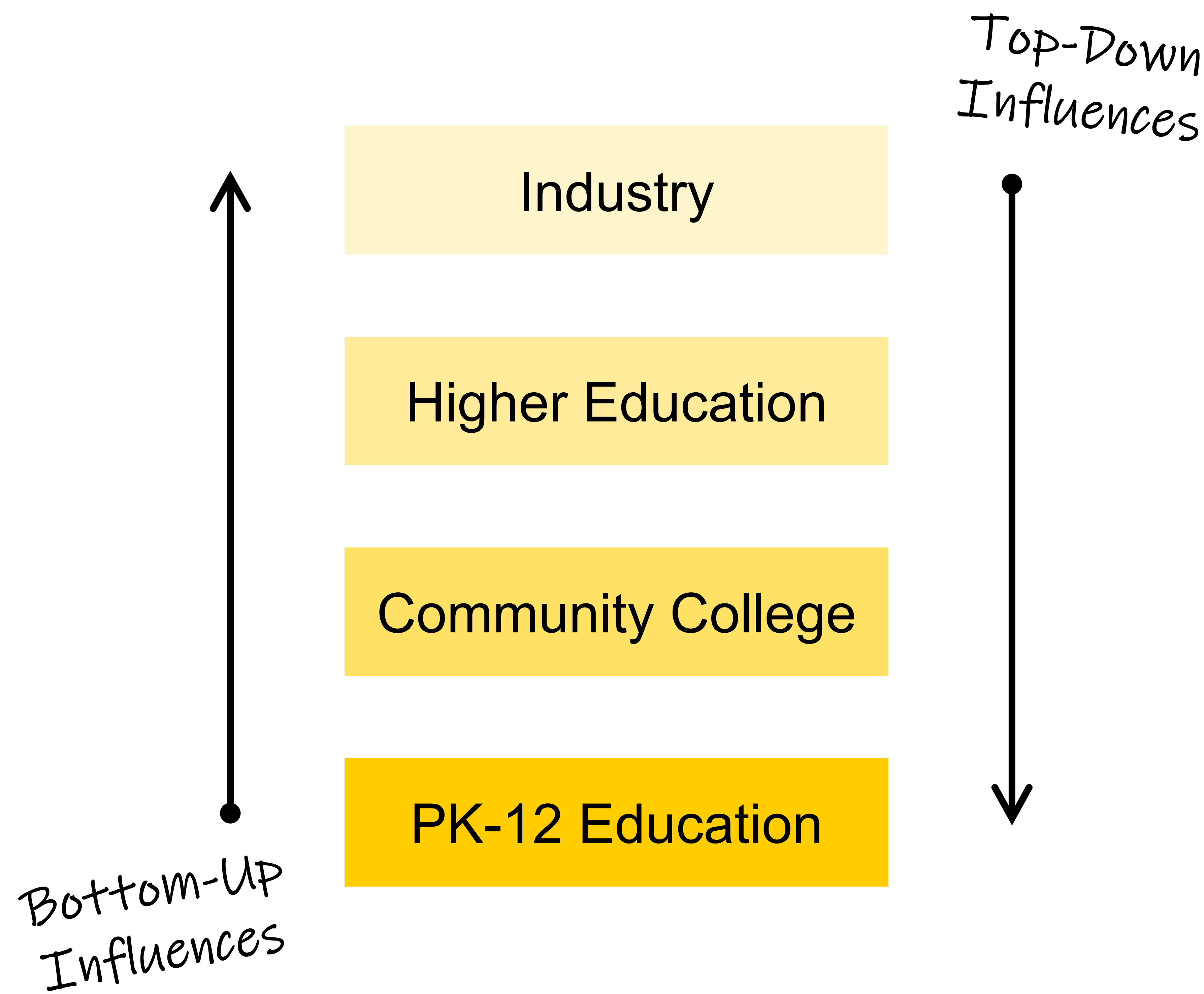
Examining Bidirectional Influences on Science Lab Design

Top-Down Influences

- Professional laboratories in industry settings inspire **forward-thinking methodologies and environments** in higher ed and PK-12

Bottom-Up Influences

- Improved PK-12 facilities **elevate expectations** for higher ed and industry laboratories
- Educational **experiences shape students' thinking, skills, and approach to learning and how they engage with their space**



Panola College Science Labs

Project Case Study

DRIVEN BY EFFICIENCY AND DEEP FLEXIBILITY

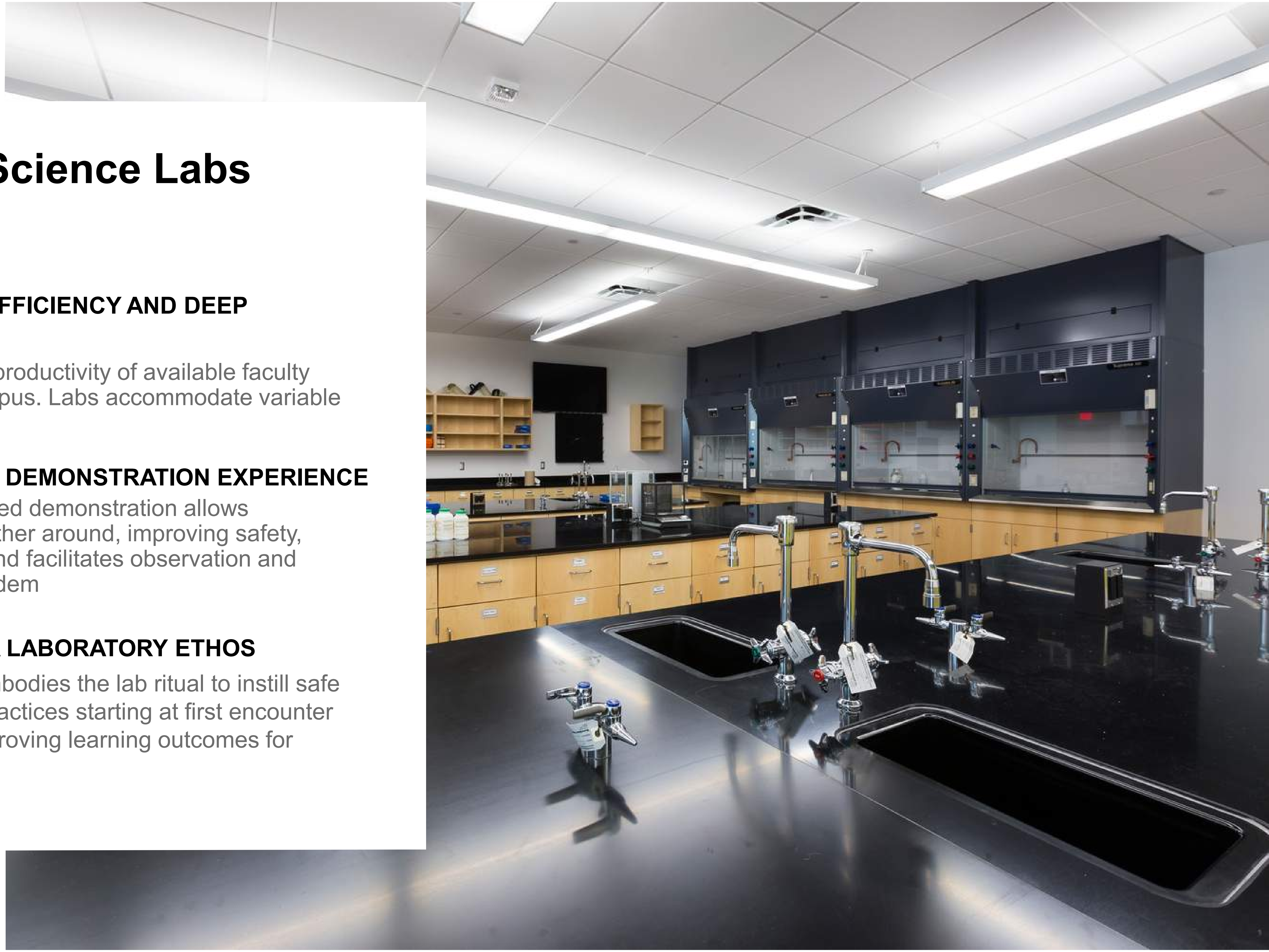
Maximize the productivity of available faculty on a rural campus. Labs accommodate variable class sizes

INTEGRATED DEMONSTRATION EXPERIENCE

Centrally located demonstration allows students to gather around, improving safety, eye contact, and facilitates observation and practice in tandem

INSTILLING A LABORATORY ETHOS

Lab design embodies the lab ritual to instill safe and healthy practices starting at first encounter with a lab, improving learning outcomes for students



Learning in Context

…learning is a process of ***enculturation*** in which the opportunity to observe and to practice ***in situ*** allows the development of **contextualized competencies**...

(Allal, 2001)

CORGAN

Cognitive Apprenticeship

Participation in a ***community of practice*** *is both the* ***process and the goal for learning***

Situated Perspective:

- Knowledge and the acquisition of skill is ***bound by context***
- ***How*** and ***where*** something is learned is a part of ***what*** is learned
- Learning within a ***culture of authentic practices*** mirrors the professional context, allowing learned concepts to translate to ***real-world knowledge***

(Allal, 2001)

FLEXIBILE DESIGN WITH DEMONSTRATION AT THE CENTER

Tarrant County College Synergy Labs

Project Case Study

A SEAMLESS LECTURE-TO-LAB EXPERIENCE

- Developed prototypical lab layouts that provide an **integrated lecture and lab experience**
- Range of options that can be applied in response to a variety of campus conditions
- Traditional divides between lab and lecture creates opportunity for discontinuity in learning
- **Outcome Goal:** better science education outcomes through **tighter integration of lecture and lab experienced by smaller cohorts of students**

…**blur the distinctions between lab and lecture** to provide…**immersive experiences** in science that **promote discovery and understanding.**

— *Round & Lom, 2015*

Supporting Positive Student Attitudes

Student attitudes toward lab experiences are dependent on:

- Perceived excitement
- Difficulty
- Time efficiency
- **Association between lab and lecture material**

[Basey & Francis, 2011; Round & Lom, 2015]

SYNERGY CONCEPT

DIVERSITY

The students who benefit most from an integrated lab/lecture approach are those at the bottom end of the performance curve. Improving success rates for underperformers means more students will be encouraged to enroll.

RELEVANCE

By providing a highly interactive technology rich environment similar to the work environment, students will be better prepared for making connections between content in the class and industrial application.

ENGAGEMENT

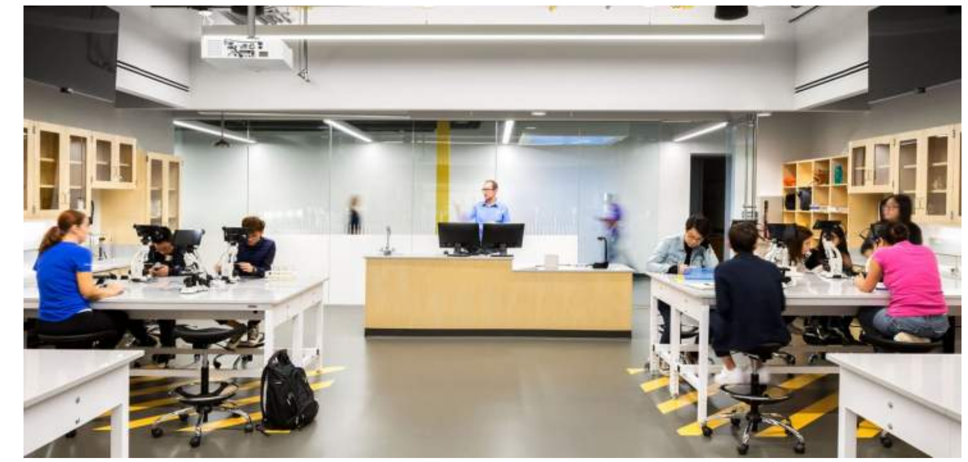
The organization of students into small working groups allows for greater interaction between peers and faculty. Allowing the group to integrate lecture and lab content in an active, research-based, technology rich, teaching environment.

ACCESS

Integrated lab/lecture spaces increase student success, resulting in successful degree completion and transfer to 4-year universities. State-of-the-art technology in the studio spaces will contribute to preparing students for a technologically-advanced workforce.

METRICS

Research shows that students in an integrated environment achieved a greater percentage of A's and B's, and fewer failures than in those traditional lecture with a separated lab. However, by providing a highly interactive technology rich environment similar to the work environment, students will be better prepared for making connections between content in the class and industry application.



APPROACH

MAKING THE CONNECTIONS

EXISTING | **ASPIRATIONS** | **SYNERGY**

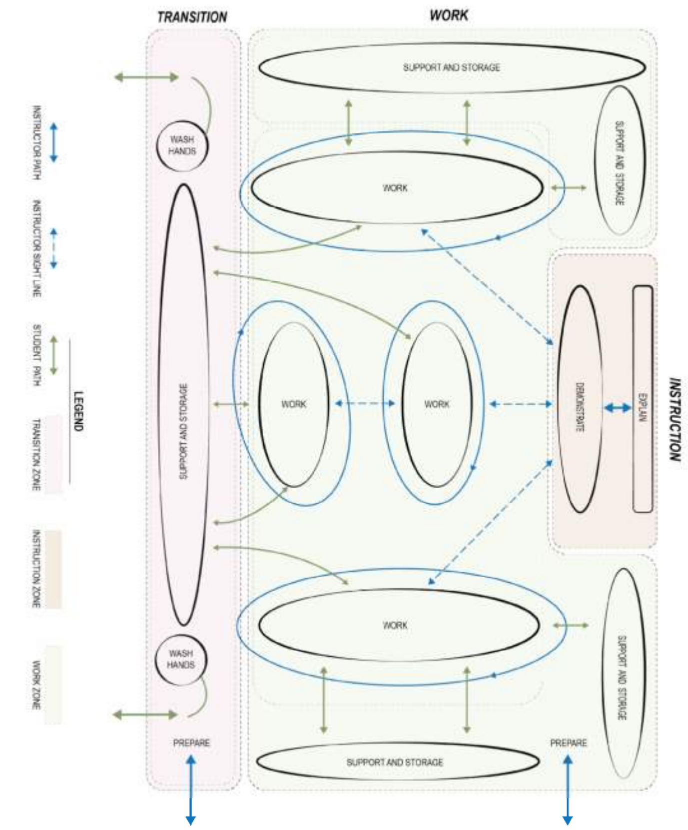
PROBLEM | APPROACH | PROCESS

05
IDEAL FLOOR PLAN

TYPOLOGY OVERVIEW
GENERAL CHEMISTRY

TYPE A	TYPE B-1	TYPE B-2	TYPE C-1	TYPE C-2	TYPE D	TYPE E
3	1	2	2	2	1	2

IDEAL LAB RITUAL
GENERAL CHEMISTRY



PEDAGOGICAL REQUIREMENTS

VERSATILITY OF RECONFIGURATION	■□□□□
USAGE OF HAZARDOUS MATERIAL	■■■■■
SHARE-ABILITY WITH OTHER DISCIPLINES	■■□□□
SUITABILITY FOR LECTURE	■□□□□

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TYPOLOGY OVERVIEW
BIOLOGY

TYPE A	TYPE B	TYPE C	TYPE D-1	TYPE D-2	TYPE E	TYPE F-1	TYPE F-2
1	2	2	1	2	2	1	1

ROOM AREA

AREA > 1300 SF — 41.67% | AREA < 1300 SF — 58.33%

ROOM OCCUPANCY

OCCUPANCY > 24 — 16.67% | OCCUPANCY = 24 — 83.33%

WORKSTATION HEIGHT

COUNTER HEIGHT — 75% | SITTING HEIGHT — 25%

ROOM PROPORTION

PROPORTION > 3/4 (MORE SQUARE) — 33.33% | PROPORTION < 3/4 (MORE ELONGATED) — 67.77%

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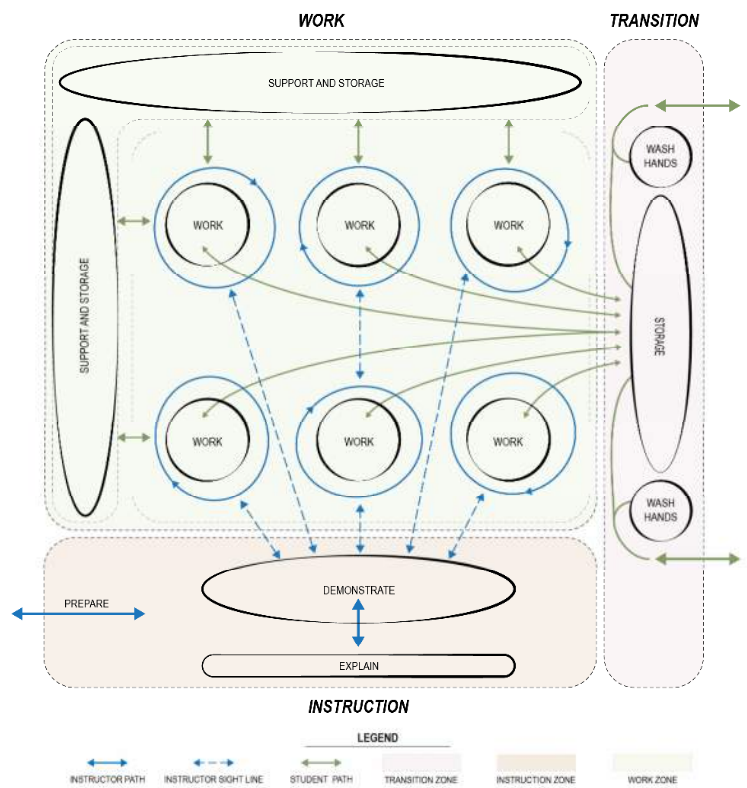
IDEAL LAB RITUAL
BIOLOGY



PEDAGOGICAL REQUIREMENTS

VERSATILITY OF RECONFIGURATION	■□□□□
USAGE OF HAZARDOUS MATERIAL	■■□□□
SHARE-ABILITY WITH OTHER DISCIPLINES	■■■□□
SUITABILITY FOR LECTURE	■■■■□

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This page shows variations within the same department

We studied the ideal lab ritual, which serves as a guideline for ideal lab layout

The pedagogical requirements explore the possibility and feasibility for synergy overlay

06
SYNERGY OVERLAY

TCC LABS ASPIRATIONAL IMAGES REVIEW - OVERALL SCORE MATRIX

IMAGE	CHEMISTRY	BIOLOGY	DEANS	GEOLOGY	PHYSICAL SCIENCES	FACILITIES
	DEPARTMENT SCORE					
1	0.65	0.48	0	0.2	0.5	0.4
2	0	0.12	0	0.2	0	0.375
3	0.8	0.24	0.3	0.5	0.65	0.9
4	0.65	0.48	0.6	0.4	0.6	0.77
5	0.5	0.78	0.8	0.6	0.3	0.33
6	0.8	0.62	0.65	0.1	0	0.38
7	0.65	0.36	0.15	0.3	0.65	0.38
8	0.3	0.24	0.45	0.6	0.6	0.63
9	0	0.3	0.15	0	0	0.08
10	1	0.36	0.3	0.87	1	0.65

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SYNERGY LAB FEASIBILITY MATRIX

VERSATILITY FOR RECONFIGURATION | USAGE OF HAZARDOUS MATERIAL | SHARE-ABILITY WITH OTHER DISCIPLINES | SUITABILITY FOR LECTURE | FEASIBILITY FOR SYNERGY

161

We studied the feasibility of the synergy concept per department to determine if it could be applied to that lab type effectively

DEPARTMENT VISIONING

MAJORS BIOLOGY VISION OF SYNERGY LAB

05 LANGARA COLLEGE

THE FACULTY LIKES:

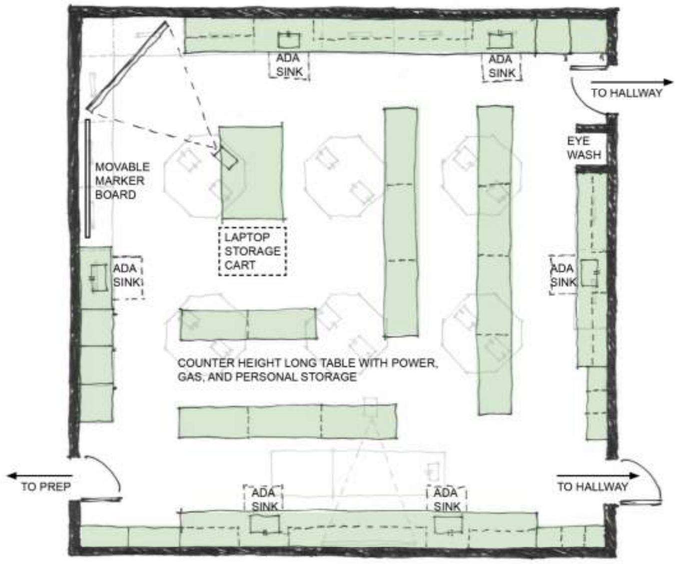
- Wide Tables for Equipments
- Powers on the Tables
- Perpendicular Teaching Spaces
- Storage Under the Tables for Microscope
- Natural Light and Visibility
- Fume Hoods
- Room Finishes

THE FACULTY DOESN'T LIKE:

- Open Slots under the Station for Student Storage
- Linear Table Setup
- No Refrigerator or Incubator
- Not Enough Storage Space for Models
- No Sinks on the Table

OVERLAY OF SYNERGY LAB CONCEPT

MAJORS BIOLOGY



SYNERGY OVERLAY

MAJORS BIOLOGY
SO CAMPUS
SSCI 1113

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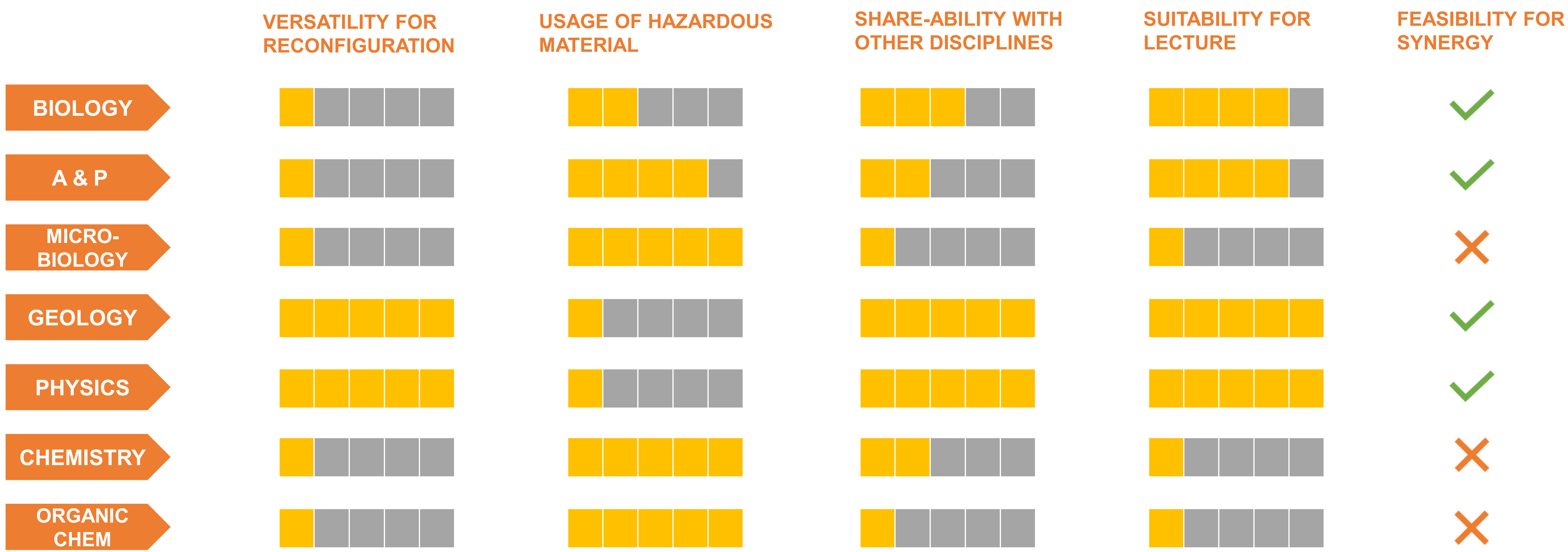
Faculty feedback was collected from the aspirational images exercise, workshops and meetings, and implemented in the synergy concept overlay

06 FEASIBILITY STUDY

SYNERGY OVERLAY



CORGAN

06 BIOLOGY

SYNERGY OVERLAY

❑ **PRECEDENT**

PRO

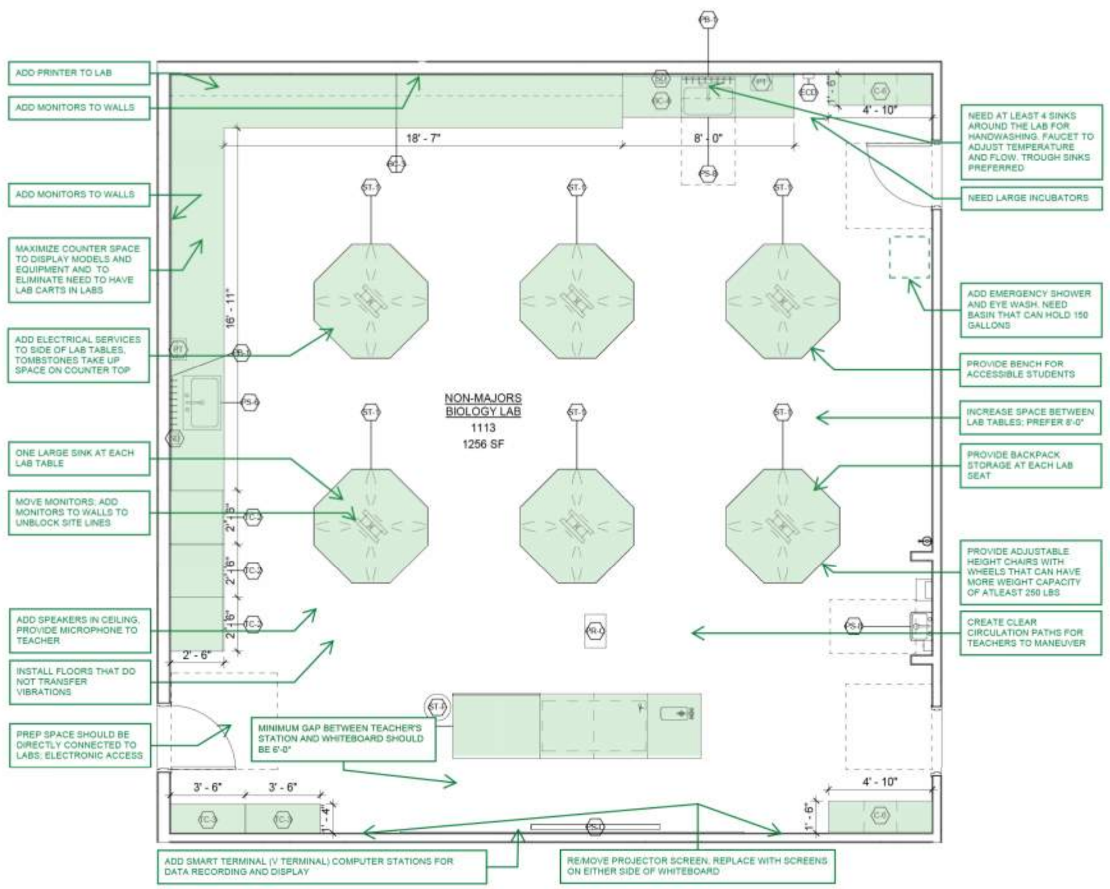
- Wide Tables for Equipment
- Power in the Tables
- Perpendicular Teaching Spaces
- Storage Under the Tables for Microscope
- Natural Light and Visibility
- Fume Hoods
- Room Finishes

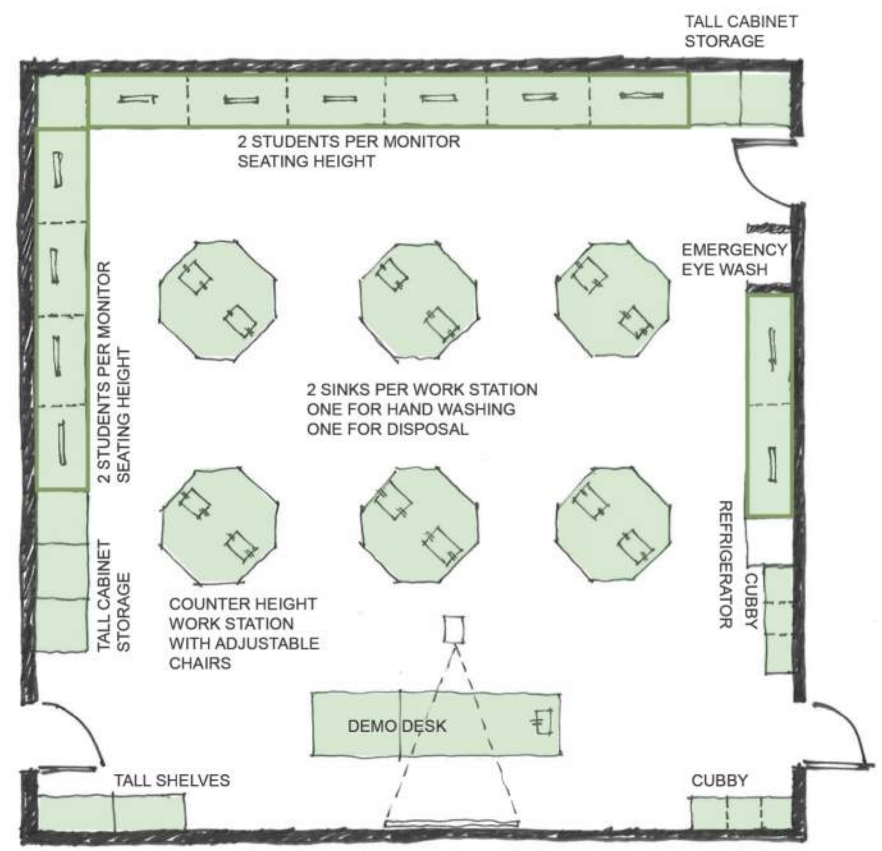
CON

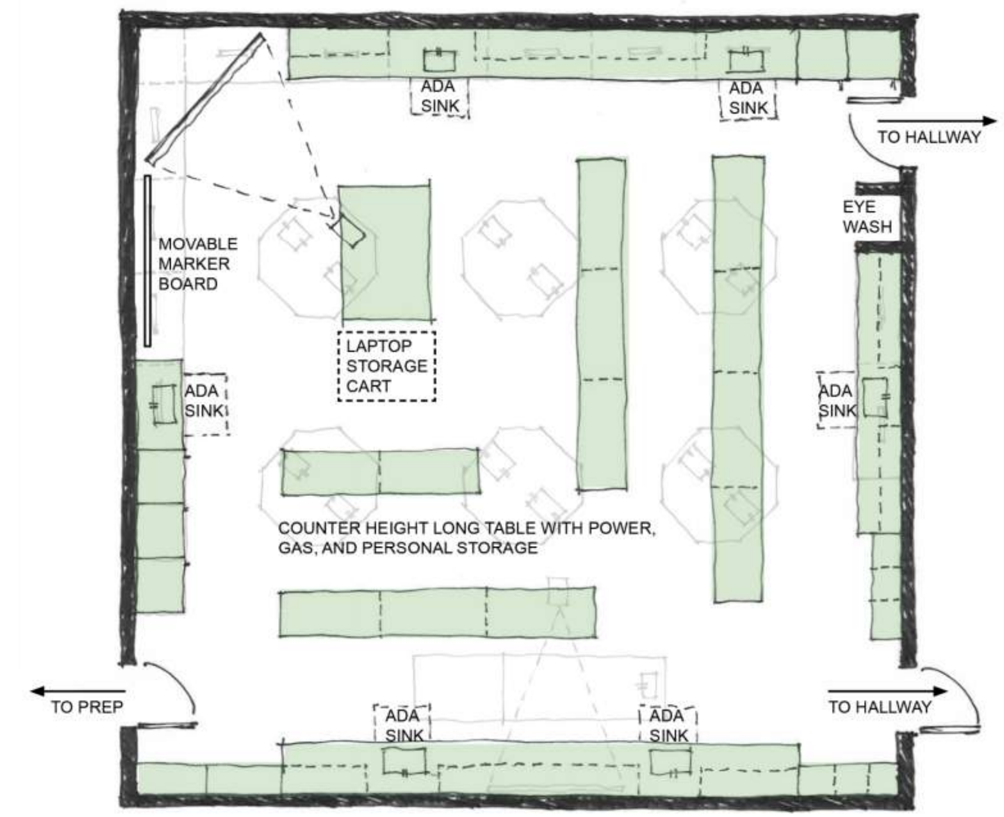
- Open Slots under the Station for Student Storage
- Linear Table Setup
- No Refrigerator or Incubator
- Not Enough Storage Space for Models
- No Sinks on the Table

06 BIOLOGY

SYNERGY OVERLAY



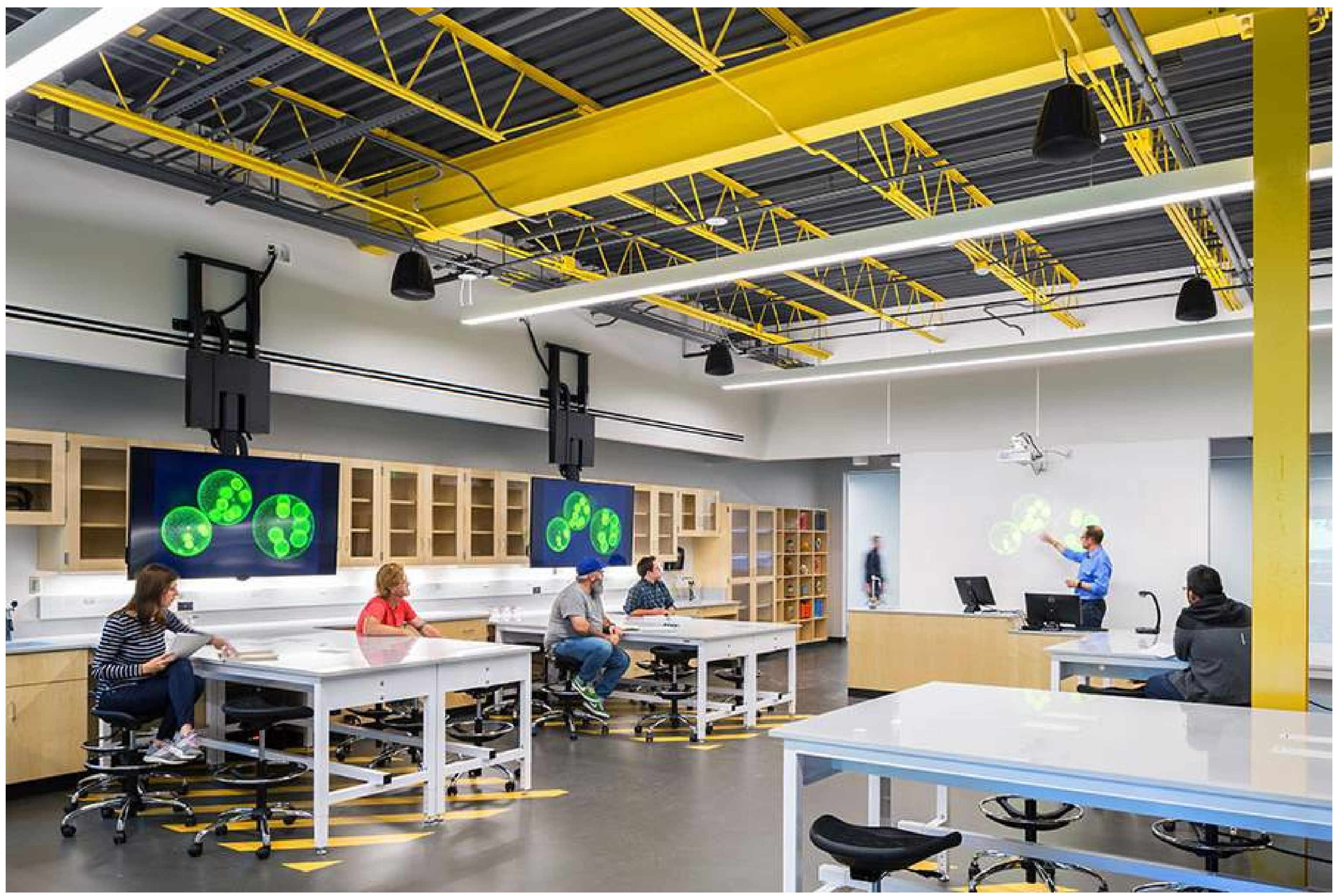




❑ EXISTING ❑ IDEAL ❑ SYNERGY

06 ANATOMY & PHYSIOLOGY

SYNERGY OVERLAY



❑ **PRECEDENT**

PRO

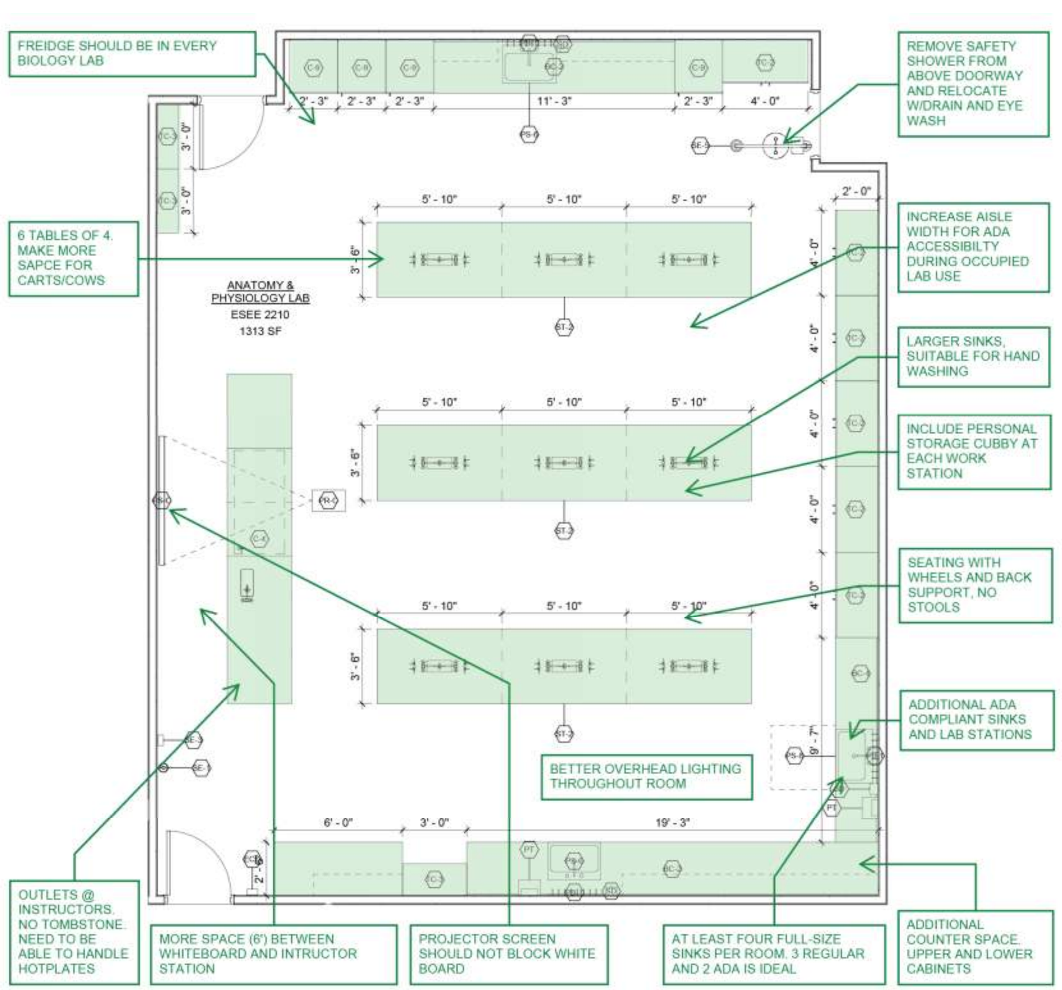
- Easy for Instructor to Supervise Student Activity
- Display Monitor for every Group of Students
- Ample Space to Walk Around
- Adequate Casework for Storage

CON

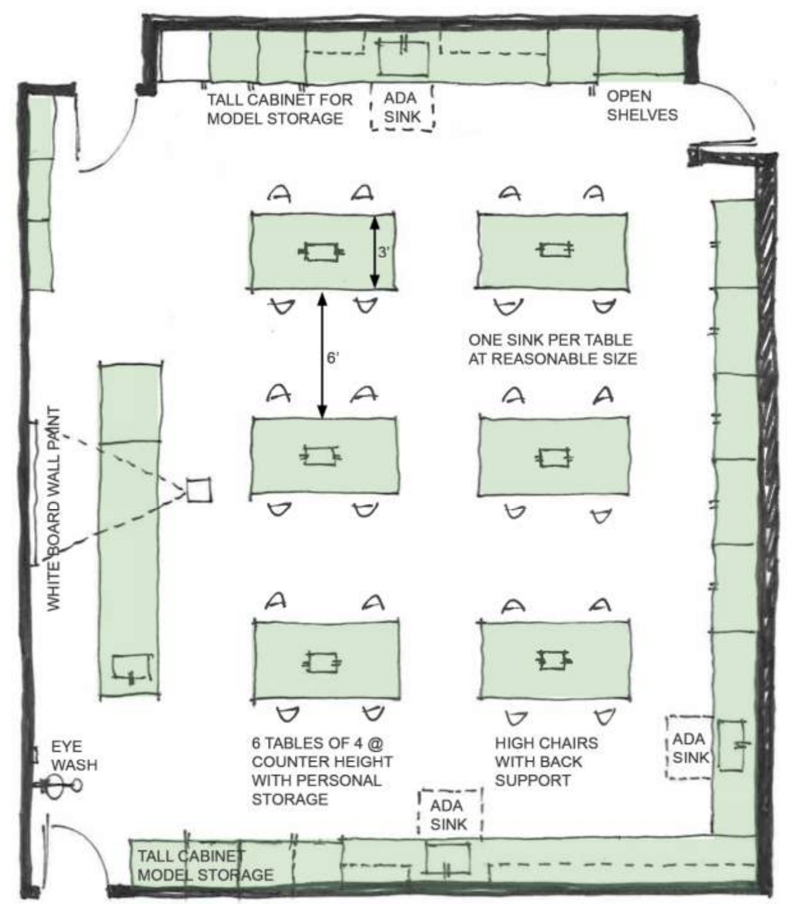
- No Space for Student Personal Storage
- Movable Tables
- No Refrigerator
- No Sinks on the Table

06 ANATOMY & PHYSIOLOGY

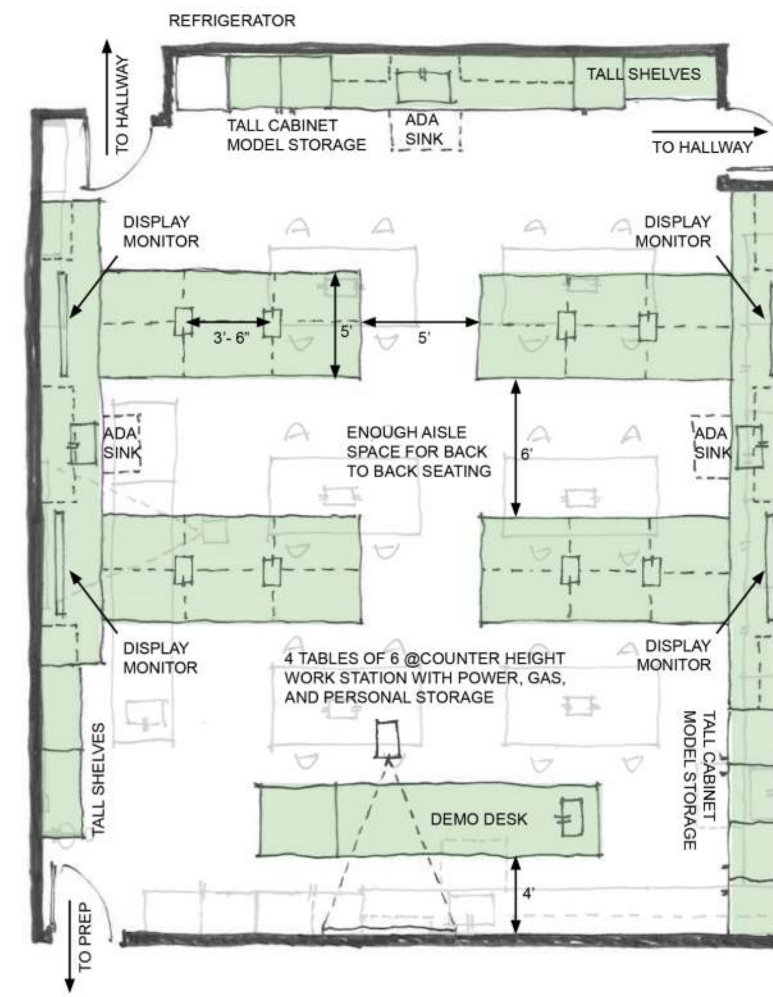
SYNERGY OVERLAY



❑ **EXISTING**



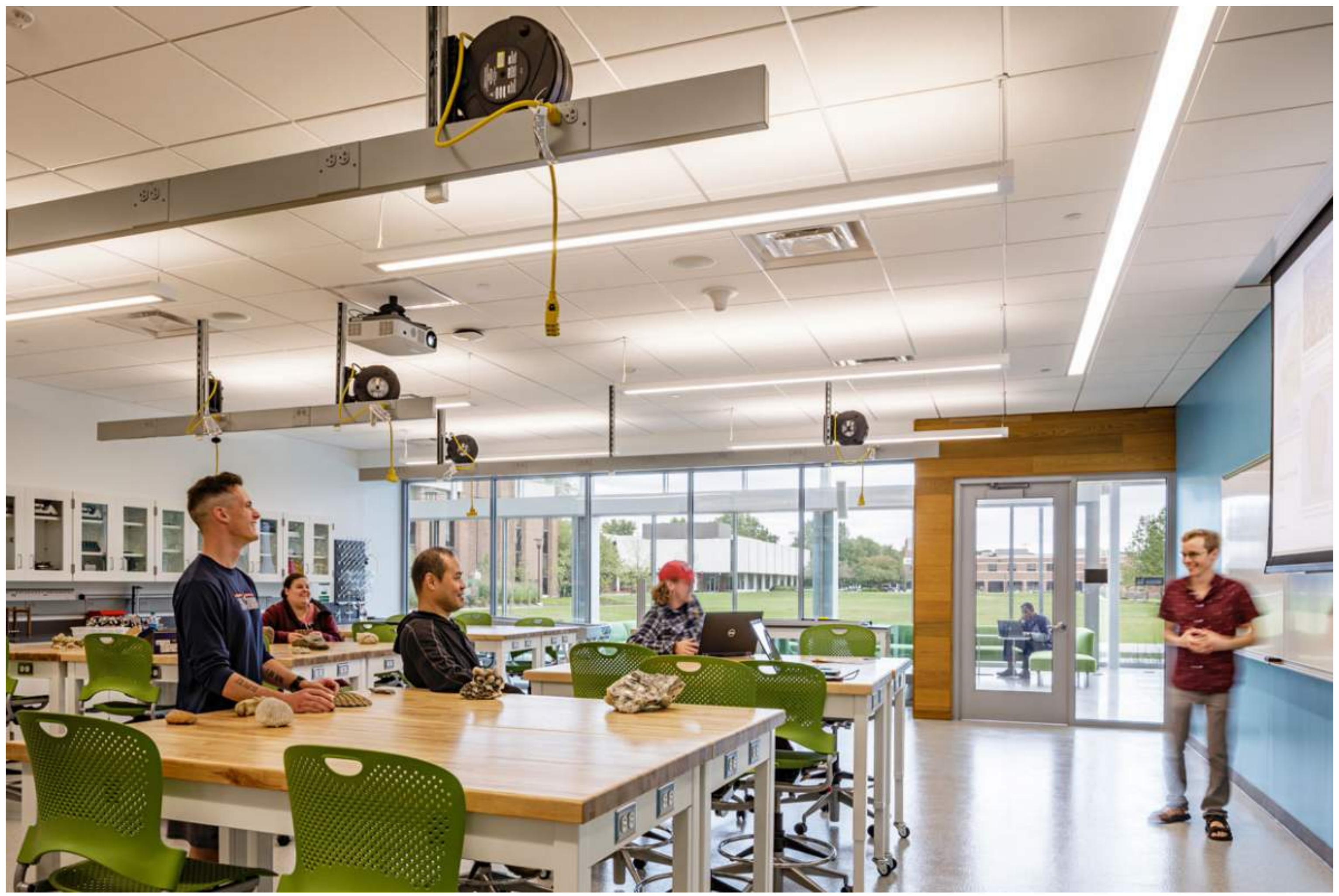
❑ **IDEAL**



❑ **SYNERGY**

06 GEOLOGY PHYSICS

SYNERGY OVERLAY



❑ **PRECEDENT**

PRO

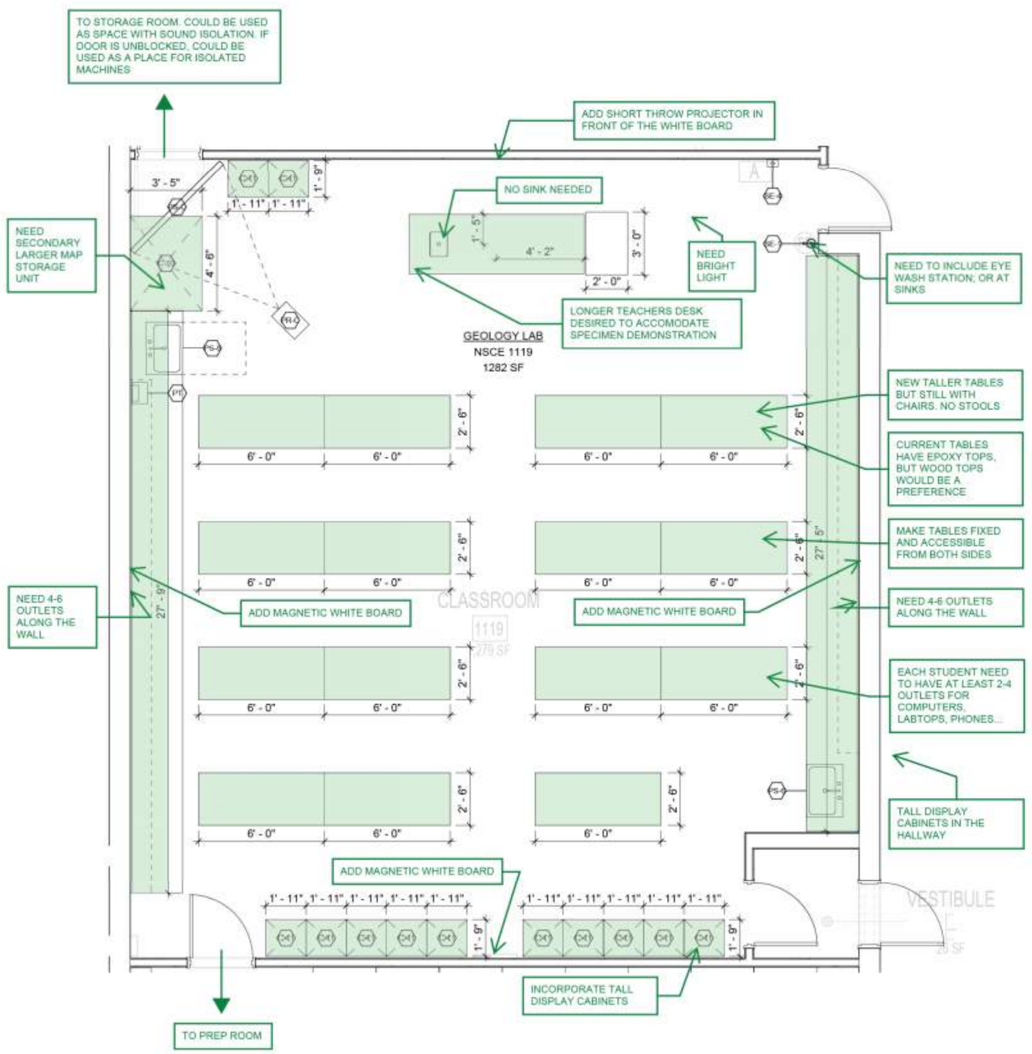
- Movable Tables
- Wood Finish for the Tables
- Powers on the Tables
- Perpendicular Teaching Spaces
- Adequate Storage Cabinets
- Natural Light and Visibility
- Overhead Power
- Modular Configuration
- Shallow and Wide Proportion

CON

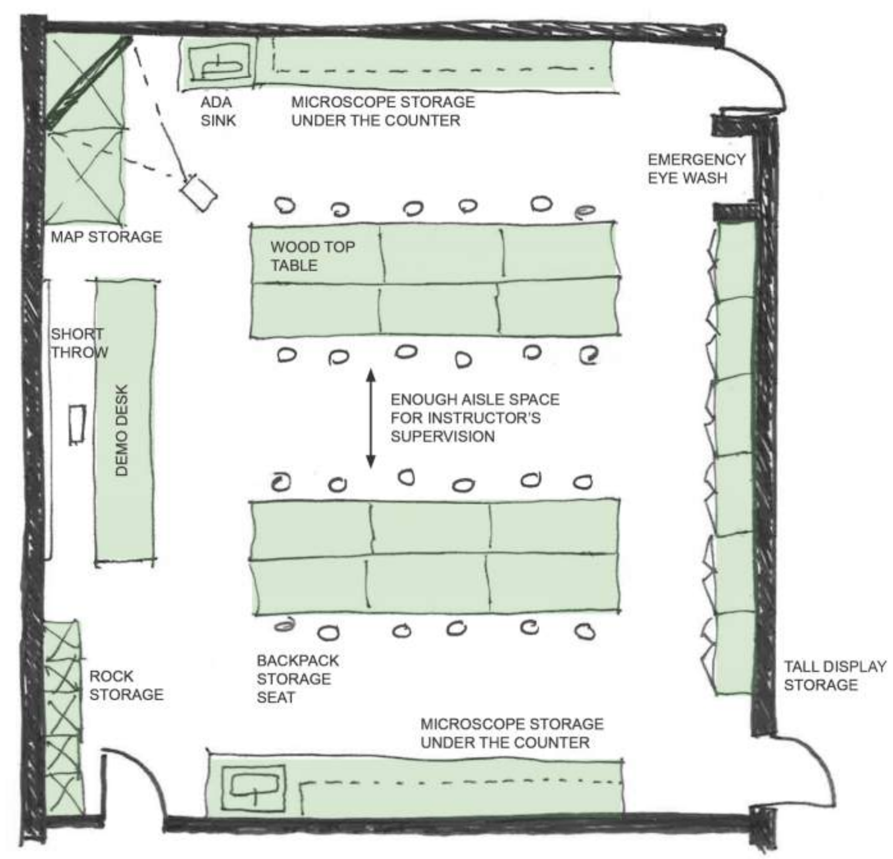
- Light is not controlled
- Need to have Display Area
- Students Entering from Side
- No Floor Plug
- No Sinks on the Table
- No Demonstration Desk
- White Board not Big Enough

06 GEOLOGY PHYSICS

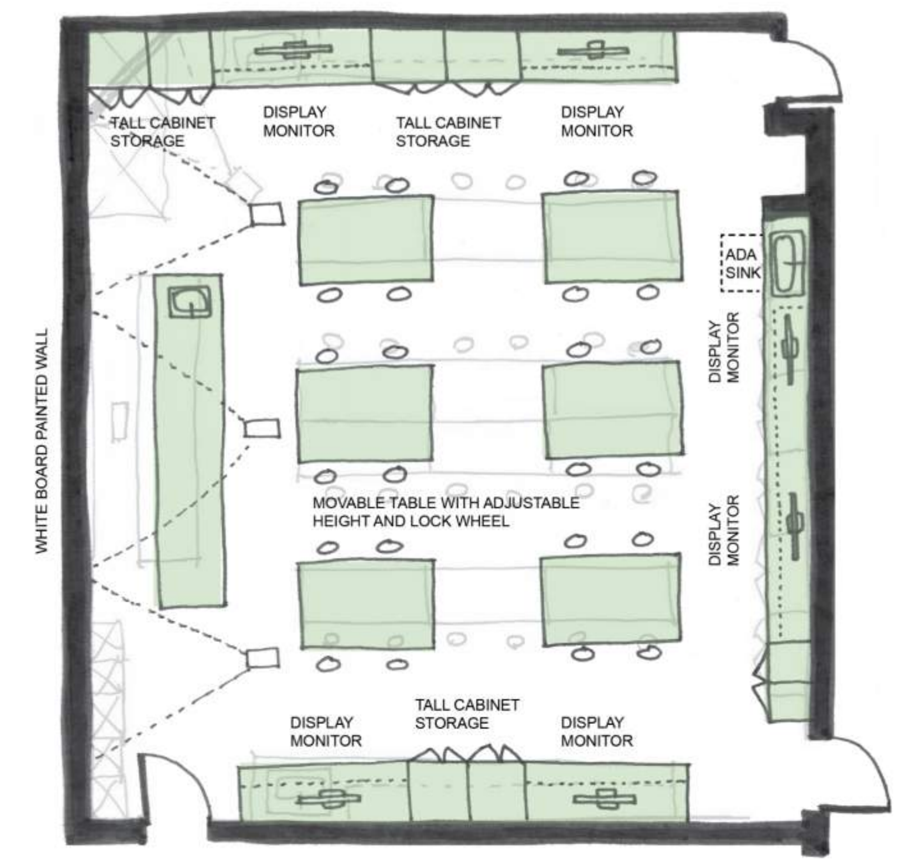
SYNERGY OVERLAY



❑ EXISTING



❑ IDEAL

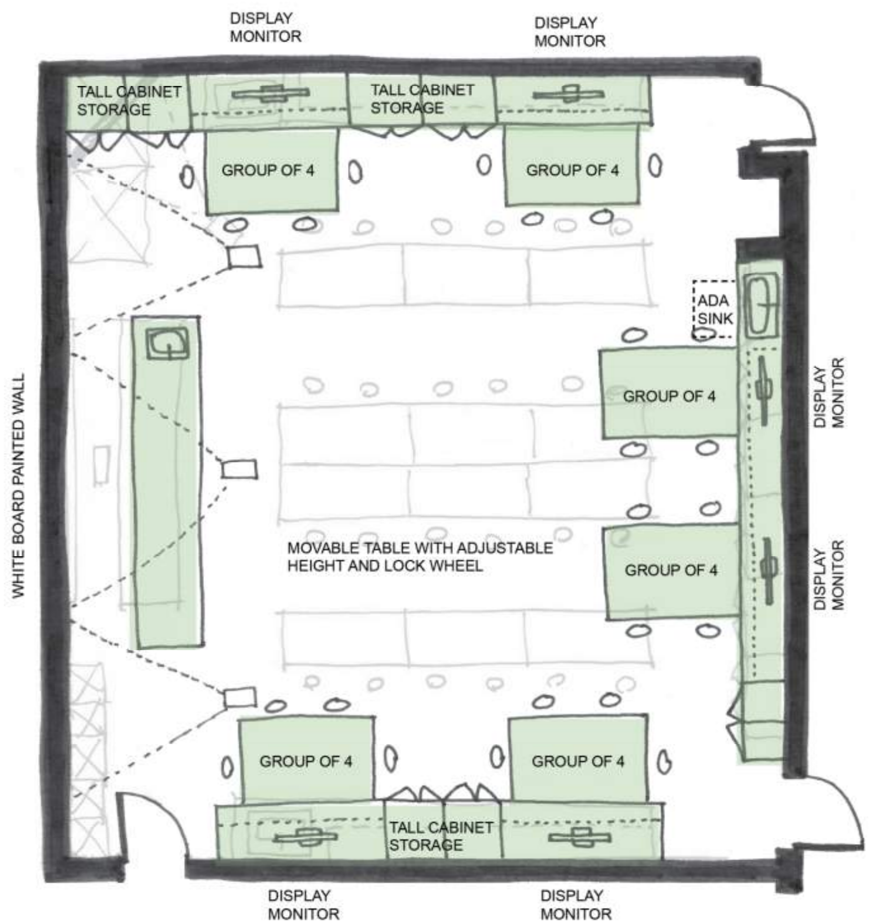


❑ SYNERGY
CONFIGURATION 1

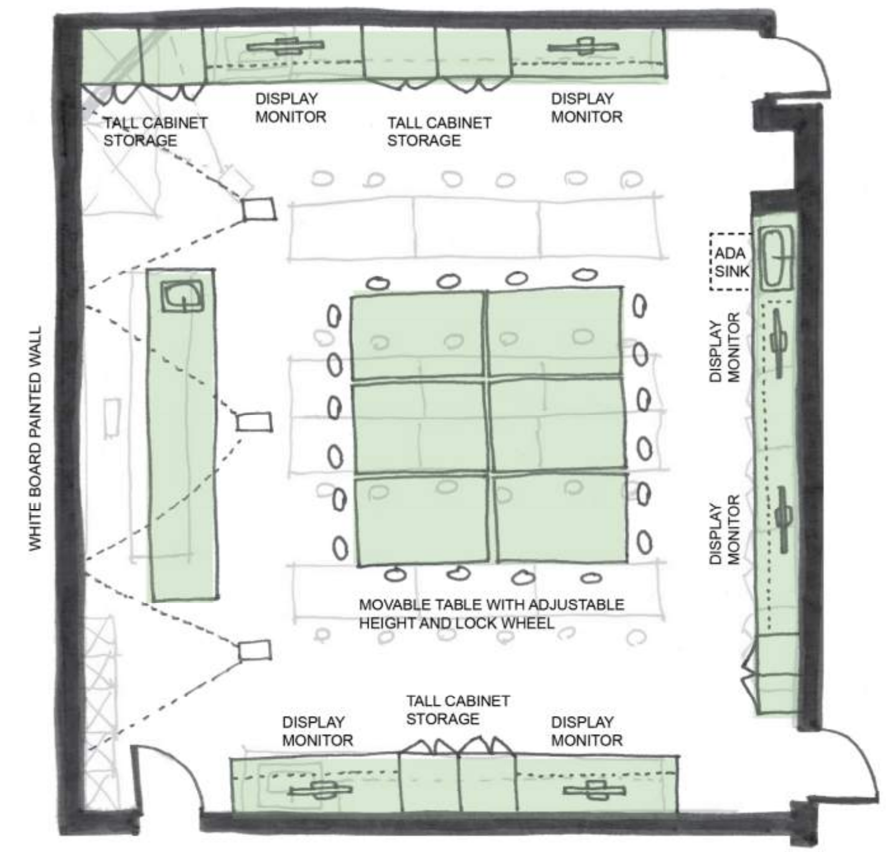
06 GEOLOGY PHYSICS

SYNERGY OVERLAY

CORGAN



❑ **SYNERGY**
CONFIGURATION 2

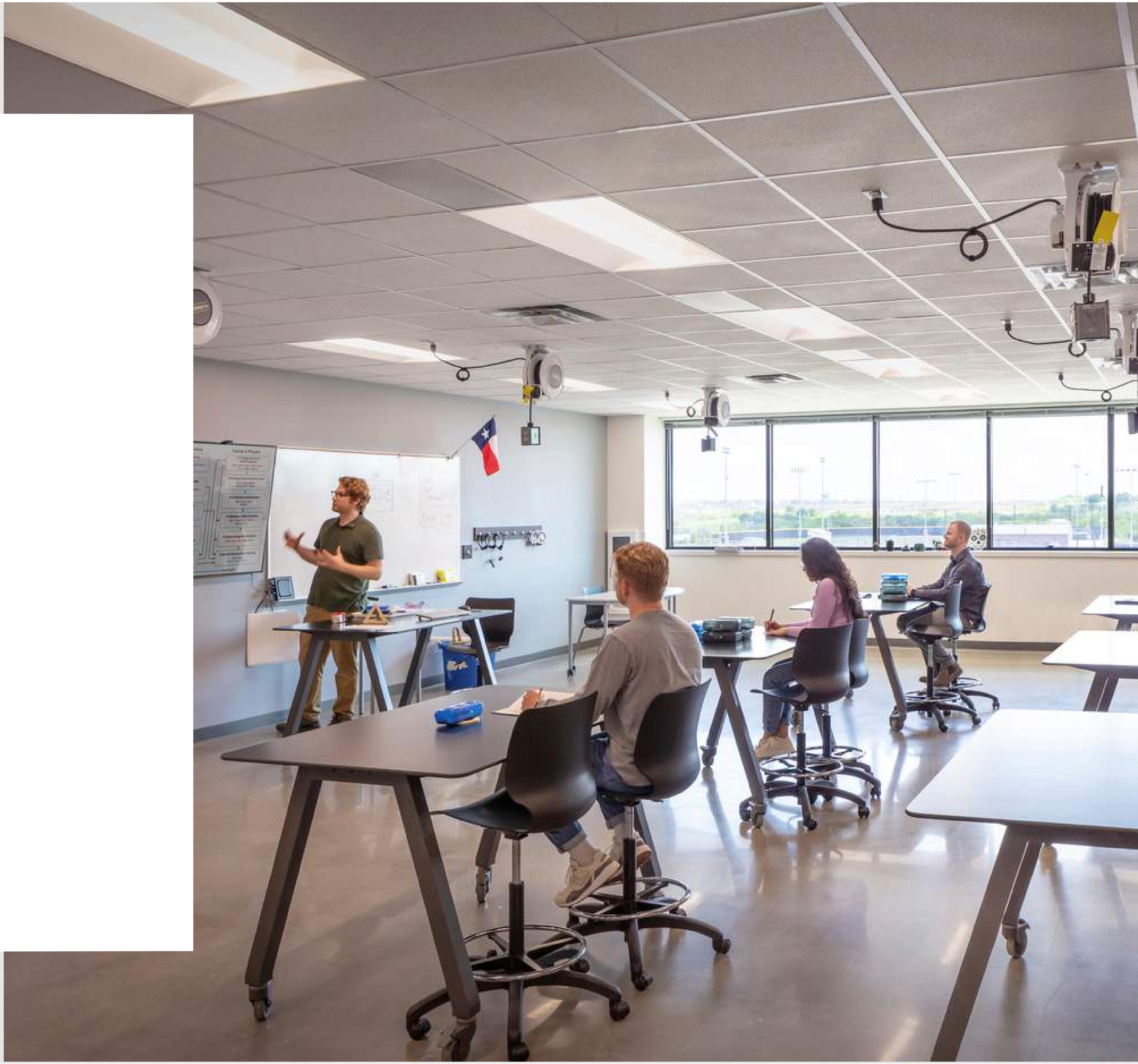


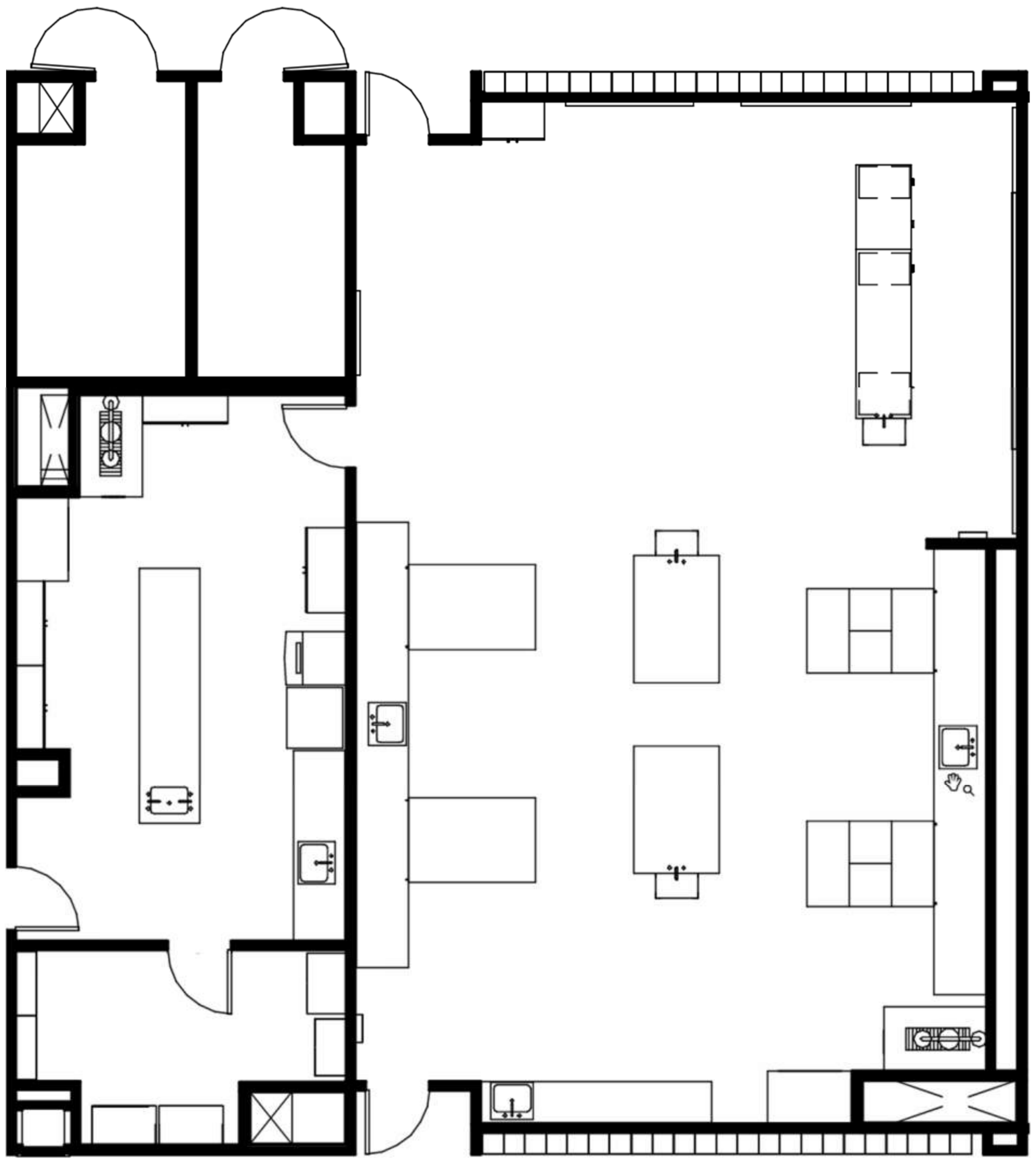
❑ **SYNERGY**
CONFIGURATION 3

Panther Creek High School

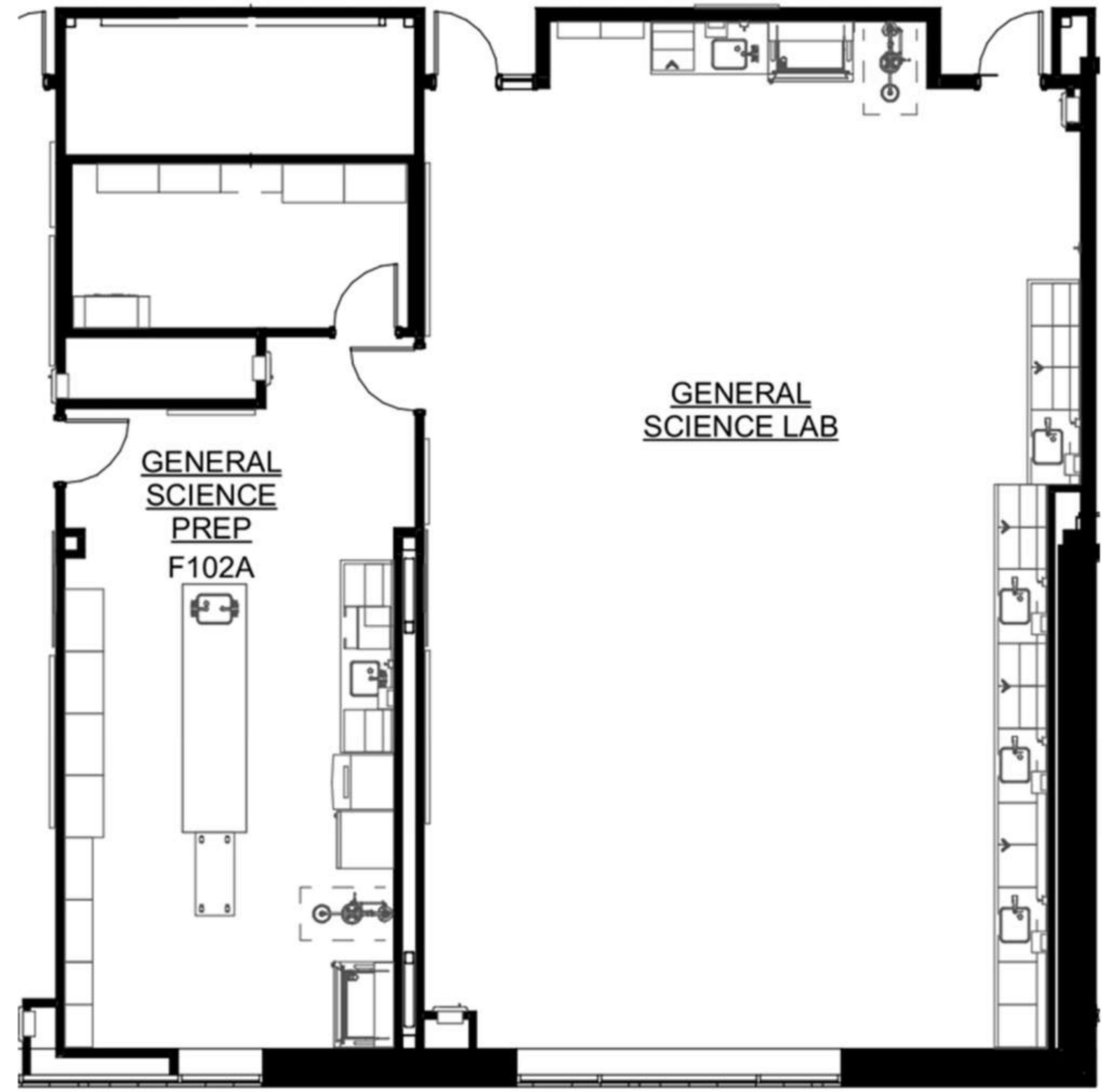
Project Case Study

FLEXIBLE AND MULTIPURPOSE





PREVIOUS DISTRICT STANDARD



CURRENT STANDARD

CORGAN

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