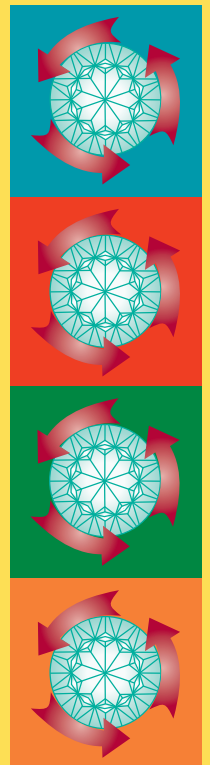


A Guide
Planning for Assessing 21st Century Spaces
for 21st Century Learners

Learning Spaces Collaboratory





Editor

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Learning Spaces Collaboratory (LSC)
<http://pkallsc.org/>

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Fall 2013

To be able to ask a question clearly is two-thirds of the way to getting it answered.

— John Ruskin (1819 – 1900)

This is a guide for planning for assessing spaces for learning, developed under the auspices of the Learning Spaces Collaboratory with support from the National Science Foundation (NSF). It is designed to spark broader and more informed dialogue—on individual campuses and within national communities of stakeholders—about the relationship between the quality of learning and the quality of spaces for learning in the undergraduate setting. It is designed to encourage deeper attention to questions planners should ask in developing new and reshaped spaces that better inform the process of assessing how such spaces impact learning.

In these pages we capture the growing national awareness that space matters to learning and that institutional initiatives to transform the undergraduate learning environment require attention to *where* students learn as well as to *what* and *how* they learn. The stories illustrate how physical spaces embody a community's mental image of how and where learning happens, whether such spaces be single classrooms or major facilities, new or repurposed, or used by a single department or a broader community of learners.

Our commitment to NSF was to develop a template for “planning for assessing” as a guide for those responsible for the quality and character of the undergraduate learning environment—at a single college or university and/or within larger communities of stakeholders. From an understanding of the power of learner-centered planning, the working group of academics and architects began by asking questions about how learning happens, bringing their diverse experiences and expertise in shaping and reshaping learning environments to the table.

Distilling our discussion, it became clear that the foundational question was about becoming: about what our students were to become, and what they would be recognized for becoming and accomplishing. This focus on “becoming” emerged as we realized the biggest planning for assessing questions were about how investments in physical spaces made a difference in how students experienced learning. These experiences enabled learners to become resilient, entrepreneurial problem-solvers well prepared for citizenship and leadership in today's dynamic world.

As this guide evolved, it became clear that return on investment of time, energy, and funds could be measured also in how a campus community speaks about and shares a vision about how learning happens and about why space matters.

Jeanne L. Narum

Jeanne L. Narum, Principal—Learning Spaces Collaboratory
For the LSC NSF Working Group

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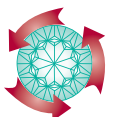
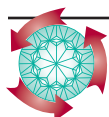


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What do we want our learners to become?

Agents of their own learning

Transdisciplinary: Renaissance people for the digital age

Code writers, code readers, code breakers

Entrepreneurs. Analysts and creators of digital technologies

Reflective practitioners of well-researched pedagogies in their use of space to support learning

Creative thinkers, who recognize there may be a new solution

Tolerant participants, who appreciate diversity of multiple cultures

Effective communicators, with skills for multiple media and venues

Enthusiastic and passionate about interdisciplinary science

Aware that boundaries in science are artificial

Well-trained experimentalists who think critically

Aware of the powerful role they play in their own learning

Connected with faculty, support providers, and peers during the learning process

Digitally literate citizens who communicate about and use technology effectively

What experiences make that becoming happen?

Exchanging learning, mentorship, and discovery between teachers and students

Fusing the liberal arts context and a research-based science curriculum

Immersing students in a world of group learning and cutting-edge instrumentation

Open-door policies regarding student access to faculty offices to promote informal interaction

Becoming exposed to diverse disciplines, ways of learning, pedagogical approaches

Having opportunities to study the effects of a teaching innovation in a pilot setting

Having access to a “laboratory” space to experiment with innovative pedagogies

Learning from the space, not just in the space

Constructing and applying knowledge to relevant problems

Having easy access to cutting-edge visual technologies and staff with relevant technical expertise

Experiencing learning in an environment in which interdisciplinary boundaries are dissolved

Classroom activities that require and reward critical discussion

Having students take ownership of the space— feeling comfortable and in control

— Excerpted from the Profiles



Part I Introduction



For much of the 20th century, learning had focused on the acquisition of skills or transmission of information or what we define as “learning about.”

Then, near the end of the 20th century learning theorists started to recognize the value of “learning to be,” of putting learning into a situated context that deals with systems and identity as well as the transmission of knowledge. We want to suggest that now even that is not enough. Although learning about and learning to be worked well in a relatively stable world, in a world of constant flux, we need to embrace a theory of learning to become. Where most theories of learning see becoming as a transitional state toward becoming something, we want to suggest that the 21st century requires us to think of learning as a practice of becoming over and over again. ... to embrace change and focus on becoming as central and persistent elements of learning.

— Douglas Thomas & John Seely Brown. “Learning for a World of Constant Change: Homo Sapiens, Homo Faber & Homo Ludens revisited.”



Introduction

About the Learning Spaces Collaboratory (LSC)

Research on how people learn offers design professionals and academic leaders intriguing opportunities for shaping and reshaping undergraduate learning environments for 21st century learners. Within and beyond STEM fields, faculty and their administrative colleagues on campuses across the country are making research-based decisions about what their students should learn and about how that learning is to happen.

From the work of these pioneering agents of programmatic and pedagogical change, there is a substantial body of evidence validating that learning is most robust as students begin to realize the powerful role they play in their own learning and become responsible for constructing their learning. This evidence validates findings that deep learning happens as learners become socialized into a community of learners on-campus and develop a sense of identity with a community of practice beyond campus.

The Learning Spaces Collaboratory (LSC) is based on the premise that robust learning happens as students are:

- Actively engaged in evaluating, constructing, and reevaluating their own knowledge
- Actively engaged in a social and supportive community
- Encouraged to assess, reflect, and build on prior knowledge
- Empowered to address problems that are meaningful personally and of import to the world beyond the campus.

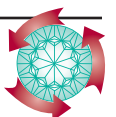
We recognize that as robust learning empowers learners, students are becoming agents of their own learning. They are becoming adventurous, tolerant of ambiguity, eager to ask new questions; they are testing the boundaries and limits of what is known, not known. Thus, robust learning happens when it is:

- Iterative and non-linear
- Provisional, always in a state of flux of becoming
- Scaffolded and transferable
- In turn, social and solitary
- Understood by all—student and teacher—as preparation for what comes next.

~~~~~

We recognize that robust learning happens when those responsible for the physical environment for learning ask questions such as:

- Is what is known about how learning happens from research, and from findings from the work of change agents in other settings, influencing how learning happens on our campus? If so, how and where?
- How might such research and findings about how learning happens, within and beyond our campus, help us fulfill our responsibilities as planners more creatively, efficiently, and cost-effectively?
- How do 21<sup>st</sup> century mental images of how learning happens differ from those held by previous generations of planners? How do mental images about learning influence our planning?
- Beyond these findings on how learning happens, what other contextual issues must be identified and addressed in giving attention to spaces for learning on our campus, now and into the future?<sup>1</sup>

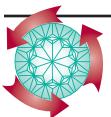




# Part I: Introduction

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# About this Guide

With support from NSF, a working group of academics and architects convened by the Learning Spaces Collaboratory (LSC) developed this guide. It is a prototype a work-in-progress resource by and for those involved with imagining and planning, designing and constructing, using, and assessing learning spaces in the undergraduate setting. Institutions featured are public and private, large and small, representing different missions and contexts. Their stories offer a lens through which to examine how visions of 21<sup>st</sup> century learners and learning are reshaping and transforming physical environments for learning on campuses across the country.

21<sup>st</sup> century spaces for learning must be more than mere containers; they must be functional and dynamic, supporting the desired human interactions and other experiences essential for robust learning. At their best, spaces can be transformational, enabling something interesting, important, and often unexpected to happen.

Some of the built environments featured here are new buildings that have become the center of a campus, bright and inviting, serving a broad community of learners, anticipating the future. Others involve repurposing a corner in an existing building, creating a sandbox for exploring innovative approaches to transforming what, how, and where students learn.

No matter the context or scope of a particular institutional story, each responds to the central question to be addressed by planners:

- ***what do we want our learners to become?***

This is not a new question. Thoughtful and provocative responses to such a question have been informing efforts toward institutional change on campuses across the country for decades. From within and beyond academe, there is an emerging vision about what 21<sup>st</sup> century undergraduates should be recognized for becoming in their life and work upon graduation.

The confluence of national calls to action, research in the learning sciences and in cognitive science, together with findings from the work of pedagogical pioneers is fueling these efforts.<sup>2</sup>

[O]ur students will carry away with them knowledge, skills, habits of thought, and experiences that will enable them to continue to grow and thrive as global citizens, and will possess the creativity and entrepreneurial spirit to respond responsibly and imaginatively to the challenges of the 21<sup>st</sup> century.

— University of Maryland College Park <sup>3</sup>

[W]e need a whole generation with the capacities for creative thinking and for thriving in a collaborative culture.... People are not born with inherent innovation skills, but they can learn them. They can acquire the skills to work in diverse, multidisciplinary teams, learn adaptability and leadership.

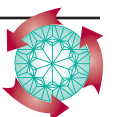
— Council on Competitiveness <sup>4</sup>

Essential learning outcomes are that students acquire knowledge of multiple disciplines, skills of inquiry and critical thinking, are able to assume personal and social responsibility, able to integrate and apply disciplinary and cross-disciplinary learning in new contexts as they seek better and more responsible solutions to problems [to be] encountered in work and society.

— Association of American Colleges and Universities <sup>5</sup>

There is now a deeper understanding within communities of academics and architects that such learning outcomes are realized when planning and assessment is learner-centered. This happens as planning is grounded in evidence from research and findings from the field that learning is more robust when students are actively engaged in a social and supportive community; empowered to address problems that are meaningful personally and of import to the world beyond the campus.<sup>6</sup>

What is perhaps new is an awareness that questions about what students are to become should drive the process of transforming the physical environment for learning.<sup>6</sup>



Reports and reflections in this guide illustrate how research findings are influencing campus-based programmatic and pedagogical change, transforming what and how students learn. They also present evidence of how such findings inform the process of transforming the physical spaces where students learn. They signal how attention to the central question about becoming prompts further planning questions:

- ***What kind of learning experiences enable that becoming?***
- ***What kind of learning spaces enable such experiences?***
- ***How do we know?***

The final one is perhaps the most challenging. In contrast to the substantive, consolidated, and accessible research about how learning happens, research on how space matters to learning is an emergent field—with significant pioneering work underway on some campuses and within particular communities of practice.<sup>7</sup>

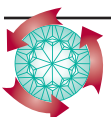
As a prototype, this guide is intended to prompt greater attention to how do we know questions in the context of shaping physical learning environments, questions such as:

- By what measures can we assess the impact of learning spaces on the learning experience?
- What are the qualities and affordances of spaces for learning that reflect communal awareness of research-based evidence about how people learn?
- What are the qualities and affordances of spaces for learning that reflect communal awareness of societal and institutional goals for what 21<sup>st</sup> century students are to become?
- What difference will it make on our campus and to whom if we explore the question of how do we know in the process of planning new and repurposed spaces for learning?
- How does attention to assessing enrich the process of planning?

Answers to such questions are explicit and implicit in the institutional profiles and essays that follow. You will note a diversity of assessment approaches and of evidence being gathered and analyzed, as well as of how that analyses has informed future action.

These questions, particularly the one about enriching the process of planning, broadens the discussions. It connects attention to space to the larger institutional vision and mission. It requires an intentionality within an identified team of planners for a specific project toward shaping a common language, identifying, and exploring contextual questions, agreeing on a common set of metrics for assessing.

These questions also call for attention to assembling the planning team, engaging persons with diverse expertise and experience, and from different spheres of responsibility across campus as well as from beyond the campus. You will find evidence of how a process for planning a particular space or set of spaces has begun to transform policies and practices campus wide, how questions about how space matters to learning are being integrated into strategic planning initiatives for the future.



# How to Use this Guide

## Reflections

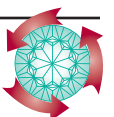
### *How Campus Planners Might Use This Guide*

Cathy Wolfe, George Mason University

As a chief facilities planner, I see this guide as a useful resource in working with the diverse constituencies on my campus who have opportunity or responsibility (or both) to shape and sustain a physical environment for learning that serves our community today and into the future, including:

- Members of the facilities office team, the planners and project managers responsible for planning, designing, constructing and maintaining our academic and instructional facilities. This guide will be a tool for engaging the team in discussions about the importance of each stage of the process, from the initial planning through the evolution of the space over time.
- Faculty looking for adaptable examples of more creative thinking about spaces that strengthen learning. Whether their attention is on a particular classroom or a major new facility, this guide will be a good starting point for all involved to think about questions to be asking, and about how to translate answers to those questions into designs for spaces— new or renewed.
- Administrative officers with responsibility for the environment for learning on our campus, including the chief academic officer, the director of assessment, director of IT and the Center for Faculty and Teaching Excellence. From examining real-world stories from a range of colleges and universities, a shared language will emerge about best practices in shaping and sustaining a physical environment that enhances the quality of student learning.
- Senior administrators, including officers for development, community and government relations. This guide will enhance their awareness of what it takes to create transformational learning experiences that are collaborative, technology-rich, experiential, and problem-based, giving them the language about and rationale for securing ongoing financial support for the University from our broad constituency and for or many stakeholders at the local, state, and federal levels.

This guide provides good insight into designing “signature” learning spaces that inspire faculty and students to think creatively about pressing intellectual issues. It will also inspire all involved to take personal responsibility for shaping spaces that matter for their learning community.



## An Agenda: Identifying Stakeholders

The process for planning is grounded in the intent to serve the institutional mission. Toward that end it is essential that all voices be heard. A mental image of the community of planners as a community of learners ensures that the process of making decisions is transparent, with those responsible, clear about the clarity, relevance, and urgency of the vision about learning that drives the project. Essays from the campuses featured here document the value of capitalizing on the experience and expertise of an intentionally diverse cadre of campus colleagues, as well as of stakeholders beyond the campus. Those to be involved include:

- *Learners:* All members of the learning community, including students, who have valuable insights and wisdom about how learning happens and about spaces that enhance or impede the learning process, from their perspective as a 21<sup>st</sup> century learner.
- *Faculty:* Those who will be future users of the new/repurposed spaces, with particular involvement of faculty at an early career stage whose future contribution to the life and learning of a community will be enhanced by spaces resulting from the planning. Recognizing the increasingly interdisciplinary world of learning, faculty from a wide range of disciplines should be invited to serve in an advisory capacity.
- *Researchers:* Within many campus communities there are faculty with expertise in the learning sciences, cognitive science, the nature of community and social organization. Their voices will contribute to planning discussions. Administrators with assessment responsibility should also be at the table, from the first.
- *Administrators:* Those in particular spheres of responsibility (beyond assessment professionals), such as facilities and finance officers, directors of centers of teaching excellence, information commons, the office of information technologies, student life, etc. should be engaged as relevant to the particular project.
- *Advancement officers:* Those who must be empowered to make the case to external supporters about why space matters.
- *Representatives of external agencies:* Those who can be engaged in exploring and supporting trends in the design and redesign of 21<sup>st</sup> century learning spaces, understanding how this process is an investment in the future of society.

This guide is also intended as a tool for members of the architectural and construction communities, affirming and informing what they bring to the table about why space matters to learning.

### Reflections

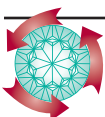
#### *How Business Officers Might Use This Guide*

**Sally Grans-Korsh, National Association of College and University Business Officers**

Space matters in the financial ramifications of an institution as well as in its mission of learning. Higher education spaces in this country encompass over 5 billion square feet. The embodied capital replacement cost of that space is over \$1.7 trillion and the annual cost of operations, utilities and maintenance is over \$20 billion. Integrating attention to why space matters to learning in the process of ongoing facilities renewal with the current budget and in the process of planning for and undertaking major capital facilities renewal. The goal is to establish and meet goals for maintaining a physical learning environment that is efficient and cost-effective over the long-term.

Capital budgets for facilities are tight, thus it is essential to “get it right” the first time. We are all intent on avoiding costly facilities redos when it becomes clear that learning is not enriched by new or renovated spaces. Understanding how others have asked questions about what, how and where students learn in the process of planning will inform your exploring and determining what kind of spaces will work for your community.

Many stories illustrate how incremental steps transform existing spaces, with changes in furnishing, technologies, and other affordances. Think of the power of having a “sandbox” space for experimenting at modest cost, setting the stage for scaling-up what works in ways that serve your institutional strategic initiatives. From a sustainable perspective (since there is so much existing square footage) it is critical to assess and convert/renovate existing spaces to become vibrant new learning spaces. Anticipating new construction, this guide can spark a robust discussion of the ramifications of the scope of a project; the initial cost as well as the total cost of ownership via the incremental cost of operations and ongoing adaption in the future.



# How to Use this Guide

## An Agenda: Planning for Assessing

- Assemble a planning team that includes as many representatives of stakeholders as possible.

Discuss what assessment means to you as a team. What do you want to know? Why is knowing that important and to whom and why? How will what you learn about the relationship of learning spaces to learning experiences inform current and future space planning?

Assess from the point of view of each of the stakeholders. What does a faculty member need to know about how space enables learning experiences, given their understanding about how learning happens? How can facilities officers ascertain whether resources are being used efficiently in the pursuit of institutional goals? How will the architect and builder judge whether the environment they construct is making a difference in the experience of learning on your campus?

- Collect as much information as possible about how and where assessment happens now on your campus and beyond.
  - Contact administrators with formal assessment responsibilities, such as those working with external agencies like NSSE8; work with them to extract promising insights about learning experiences and spaces from existing data.
  - Seek out recognized pedagogical pioneers on your campus; extract relevant information about learning experiences and spaces from their data.
  - Examine the “how do we know” bullets and review the essays in this guide for insights and information about process and value of assessment. Identify similar experience and expertise on your campus.
  - Leverage and piggy-back the assessments connected to your project to other strategic initiatives on your campus, making best use of current resources and expertise toward shaping a broader “assessment” community.

## Reflections

### *An Architect's Perspective on Using This Guide* Kent Duffy, SRG Partnership Inc.

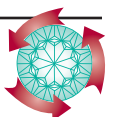
We all are striving for inspiring learning environments and we all are constantly gaining new insights about this journey. The goal for which we are striving is always moving further out in front of us even as we make substantial strides toward it.

Use this guide to enhance the experience of exploring new ideas and searching for fresh insights, recognizing that we often do not understand what we have uncovered until we have evaluated it from many points of view, bringing the vital properties of a space into focus.

Be inspired by these examples of what is possible; be inspired to create places that inspire your faculty and students and the rest of us to keep moving the goal further out there so that we all can keep rising to the challenge: making spaces that encourage people to feel alive, curious and connected, inspired also for their journey as learner.

- Just start; start small and practice assessing. Take a particular institutional profile and essay from this guide, perhaps one close to your project. Translate that story, perhaps focusing on a single “goal/experience/space,” into a template for canvassing your existing spaces.

Become increasingly intentional and sophisticated as you practice becoming a team of assessment colleagues, learning from and with each other along the way. Understand that assessment and evaluation can be done without getting too scientific.
- Keep the focus on learning: on how learning spaces enable the learning experiences desired by individual faculty, by departments, and at the institutional level.



# How to Use this Guide

- Communicate and celebrate. Share what you are doing and learning; invite ideas and critique and be transparent at every stage. Find and engage the outliers and skeptics, remembering that ultimate users of the space will need to own it, and participate in assessing its value to themselves and their colleagues.
- Pay attention to what makes space attractive and inviting: furniture, windows, color, and pattern. People will use and learn more in a space where they want to be.

Remember, as noted by Kinzie, that assessment is never static, that as more stories, data, and other evidence are collected and analyzed on your campus, the process becomes more intuitive, and hopefully questions about why space matters to learning will begin to arise naturally when campus planning initiatives, major or minor, are under way.

Don't forget to involve students. Interviewing students should be an integral part of the earliest stages of planning, and their voices should be heard throughout the process.

Today's learners, in significant ways, are distinctly different from today's faculty members or administrators—or perhaps even alumni. Just because learning in an auditorium worked for a current, about-to-retire department chair, does not mean it will work for contemporary students with a very diverse set of career aspirations and a very challenging societal context.

We could seat children in rows and talk at them when we were going to expect them to work in rows in factories, mills, and farms.

— Author unknown

## Reflections

### *On Practical Applications in the Field: The Virtuous Cycle* Alison Williams, SPIRES (UK)<sup>9</sup>

This is an intensely practical document. I would use it to spur ideas of what could be done differently in my institution. I would interrogate the guide to find out:

- What are the underlying principles applicable to my institution?

The question *what do we want our learners to become* gives me a principle-based, learner-based starting point for this query.

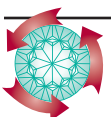
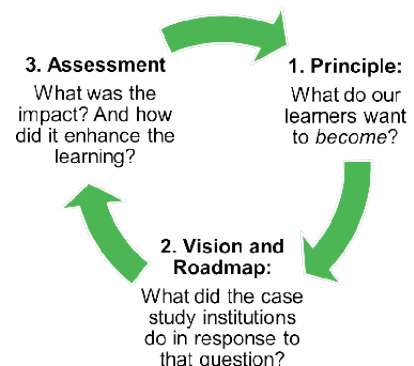
- What did the featured institutional do in response to that question?

The profiles and essays in Part II give me a detailed and specific roadmap detailing how each institution approached the particular issues they faced and drove the vision they held.

- What was the impact of asking that question? How did it strengthen learning?

The essays (Part II) describe different approaches to assessing the impact of the changed spaces. They set out how the design of the physical spaces, new approaches to teaching and learning, and enhanced technological or social environments supported a common vision of what they wanted their learning to become.

Simply put, they engaged in the virtuous cycle of planning for assessing.





# How to Use this Guide

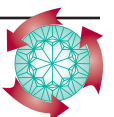
## Reflections

*Using this Guide to Create Institutional Change:  
A View from a Higher Education Change Scholar*  
Adrianna Kezar, University of Southern California

The guide's advice to "keep the focus on learning" is apt for thinking about how to use this guide to create organization change. One of the best ways campuses can encourage deep and lasting change is by creating organizational learning around new learning spaces. The various steps in this guide will lead to such learning including:

- Organizational learning starts by creating a focus – what do we want to or need to learn more about which is where the institution needs to collect and gather information. Starting with the desired learning outcomes is a focus and direction for learning.
- Collecting data on learning outcomes and assessing learning spaces are key steps in organizational learning – campuses need to identify data needed to make good decisions that are specific to the campus context
- Create diverse, thinking teams to interpret data. Data alone will get you nowhere. You need people on campus with the appropriate perspective to think together about the right learning spaces and this should include – architects, facilities managers, faculty (representatives of all faculty both tenure track and non-tenure track), students, institutional researchers, librarians, graduate students and others. Assembling the right thinking team is one of the most important steps toward creating change.
- Examine the data and information infrastructure. Often we make decisions based on information we have rather than create more robust data systems or gather more information to inform decisions. If initial discussions demonstrate you do not have enough information from the architect, related to facilities challenges, or on student learning, slow down and get better data.
- Practice learning together to make change and leaders should put a good team facilitator in place. It is not easy to listen to multiple voices especially when looking at the same information, but coming up with different conclusions. Often there is tension among planning groups and then the loudest voices win out. The team leader will be key in helping the diverse perspective on new planning spaces emerge.

Change is all about learning and learning happens only when campus leaders set up the right circumstances. This guide provides the steps to create learning.





# Assessing Learning Spaces: Purpose, Possibilities, Approaches

Jillian Kinzie, NSSE/Indiana University Center for Postsecondary Research<sup>10</sup>

## About Assessment

The deep interest in knowing what would improve the quality of learning is driving assessment into every nook and cranny of colleges and universities. Colleges and universities are more accountable for educational effectiveness and for the performance of their students and graduates. Thus, concern about improving educational quality, coupled with the need for individual campuses to demonstrate learning outcomes, has made assessment an unavoidable activity on campuses since the 1980s.

Renewed efforts to enhance quality and increase persistence and success for all students—particularly under-represented minorities—has made it essential to collect evidence on a regular basis of the extent to which effectiveness has been achieved, evidence intended to mobilize attention to improving educational conditions in light of the findings.

Assessment has always been a critical component in teaching and learning. Educators regularly assess at the individual student level, evaluating student work and giving grades, and some aggregate this information to guide improvements efforts at the level of an individual course. Assessment also moves beyond the course when faculty consider strengths and weaknesses of students' work in relation to departmental learning goals. The department can then use these findings and other data, such as a graduating senior survey, to inform decisions about curriculum, pedagogy, and perhaps to prepare for a specialized accreditation review or an institutional review.

The demand for information from assessment has broadened its definition and purpose, now embracing the collection and analysis of student learning outcomes and other institutional outcomes, including cost-effectiveness, satisfaction, and the achievement of standards—all to determine the impact of educational programs, practices, and policies.

Good information in the right hands can be a vitally important lever for change. When done well, assessment can provide a foundation for wise planning, budgeting, improvements to the curriculum, pedagogy, staffing, programming, and ensuring that resources are dedicated to what is most effective.

## Assessment Purpose and Framework

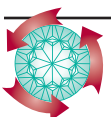
To achieve its practical aim, assessment has been conceived of as an iterative process—an assessment loop that involves setting goals and asking questions, gathering data and evidence, analyzing results, sharing and applying results, and using results by taking action.



Figure 1. Assessment Cycle

The full cycle of assessment must be executed to really do assessment well. Too often things get hung up at the phase of gathering evidence. Sometimes the cycle stalls here for want of better or more definitive data, and other times it is a failure to develop and implement an action plan based assessment data.

If assessment is to inform future practice and the activities of assessment—asking questions, and gathering and analyzing evidence—are similar to the goals of research, assessment is a particular kind of “action research.” It focuses on collecting data to demonstrate impact and to plan for improvement, with the practical goal to inform local action. The framework for assessment advocated for learning spaces flows from this standard statement of purpose.



# Assessing Learning Spaces: Purpose, Possibilities, Approaches

## Reflections

### *An Architect's Perspective on Assessment* Timothy Winstead, The Freelon Group

When I look back at the projects with which we have all been involved, my sense is that although we find it easy to share experiences about the tangible process of planning, of imagining and designing spaces for learning, it is more difficult to talk about the less tangible process of assessing how the resulting spaces work in the service of learning. When the project is complete and all goes well, we consider the project a success. In part, this is because most new or redesigned spaces do not hit their stride for some time. It takes time for users of the spaces come to understand how they work or what spaces will allow them to do. This is perhaps similar to the notion that the look and feel of something new (that works) always makes a good impression, much like the smell of a new car. Unfortunately it is too often we short-circuit the arc from *planning to assessing*, on the premise that if the goal of the project is preparing students for their future, it is far less easy to measure.

I feel strongly that the vitality of a place influences the energy of the people who experience it, that more social and interactive spaces increase the nature of collaboration and productivity. This is being measured and documented in regard to corporate, health and research facilities, and there are important lessons to be learned from the work of professionals beyond academe about the impact of space on learning.

After more than twenty years of our collective efforts to get the planning right—evidenced by the growing number of spaces that are demonstrably effective in the service of learning, including those featured in this guide—it is time. We should be intentional in gathering evidence about whether the spaces we design are making a difference, if the goals set for the project were measurable and met. This should be a collaborative effort engaging users and designers, those involved with a particular project and in ways that engage us all as a community.

In producing this guide, it has become clear that it is not only possible to capture, distill, share, and advance what we are learning about how space matters to learning, but that it is imperative to do so.

## Assessment and Learning Spaces

The assessment of learning outcomes—defined as what students will know, be able to do, the skills and competencies that they can forward—is the current coin of the educational assessment realm. However, when it comes to the issue of the physical environment, we must ask:

- *what is important and possible to measure about the impact of space on the experience of learning?*

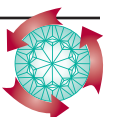
Assessment results should ultimately answer this question: how we will know the spaces we are planning will make a difference, or how do we know what difference current spaces are making in regard to the quality of the learning experiences of our students?

The assessment loop can be applied to all phases of designing learning spaces—from planning to post-occupancy, ongoing assessment and redesign of spatial affordances. In fact, planning for assessment should be intentionally integrated into each stage of planning, designing, and using learning spaces. Take care, however, that assessment results not dictate final decisions; professional judgments must be applied in interpreting evidence and taking appropriate action.

As with all assessment undertakings, assessing learning spaces is fundamentally about asking the right questions. To address the current pressure for accountability for student learning, it is critical that learning spaces go beyond traditional measures of use, efficiency and service, and detail the extent to which the space enhances the experiences of learning and teaching.

From stories featured in this guide and the experience of other reflective practitioners, valuable questions to be incorporated into the process of planning include:

- Time and resources are being spent on designing spaces to help students learn more effectively and creatively. What evidence exists on our campus and in other settings about the physical affordances of spaces that accommodate research-based pedagogical approaches? What evidence will we be seeking as these spaces are being used in the future?



# Assessing Learning Spaces: Purpose, Possibilities, Approaches

- 21<sup>st</sup> century students are expected to become creative risk takers, skilled as communicators, integrative learners, and resilient experimenters. What will be our measures of success in achieving spaces that achieve such learning outcomes? What spatial affordances nurture leaders for the future?
- Learning spaces are designed to enable students to tackle ill-structured problems, actively engage in real problem solving, and interact with peers and faculty. Where is there evidence that such learning experiences can be facilitated by the physical learning environment?
- Research shows that today's students benefit when they perceive a sense of belonging, can focus on hands-on learning, and participate in team-based approaches—to what extent does space contribute to these goals?
- Learning spaces are part of the larger palette of physical spaces on a campus, many with potential to serve as formal and/or informal settings for multiple constituencies, reflecting the 24/7 reality of 21<sup>st</sup> century learning. What do we need to know about how our emerging project contributes to the larger good? Where does our project fit? How will our planning and this project inform the future of learning spaces on our campus? What evidence will we look for to answer such questions?

The *how do we know* findings presented in the profiles of case studies featured in this handbook illustrate the diversity of possible assessment approaches and findings. Note that some present results as quantitative increases: the number and quality of student majors in particular field, significant (dramatic) increases in faculty/undergraduate research, as well as activity and interest in interdisciplinary fields. Information is presented about greater numbers of prospective employers and/or external partners connecting to the campus, particularly in STEM fields. An increase in the number of domestic students of color and women graduating with a STEM major is documented in many cases.

Findings that are more perceptual are woven throughout the profiles and stories, about how students feel more comfortable and productive as learners in a particular space, about how they seeing spaces as conducive to teamwork, collaboration, as “their” spaces.

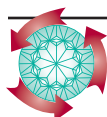
## Reflections

### *How Campus Classroom Managers Might Use This Guide* Jeremy Todd, University of Minnesota

One thing we have begun to challenge ourselves with is getting people on the same page with how they perceive space. I think a key trick to assessment is making it intuitive as well as defining a consistent vocabulary for everyone involved. During a SCUP presentation, I talked about the learning space spectrum—a range from focus work (quiet and reflective, to social, to collaborative (more noise, more energy).

We also began to look at the first impression of space and how it affects students' opinion of that space. The sociability of space in environmental psychology asks “how friendly is that space.” We find that spaces, like people, cause us to create a first impression. Those first impressions affect how much we trust the space or person. When we talk about collaboration being based on trust we have started to add concepts of the intimacy gradient into our conversations. This is the idea that we like to navigate space from public to private. Many buildings offer a first impression that feels as if you walked into a quiet/focus zone that does not foster interaction and collaboration.

There are also some ideas that I have had about how we could make the assessment process into an application that would allow faculty and students to capture spaces and rank them. It would allow people to begin to define the spectrum of what is working and what isn't. It would also account for the idea time matters. Libraries that are largely focus zones during the day convert to collaborative zones in the evening (as long as the space is flexible.)



# Assessing Learning Spaces: Purpose, Possibilities, Approaches

## Types of Assessments and Measures

Although it is easy to be preoccupied with the array of assessment methods and types (Figure 2), the selection of measures should flow from assessment goals, needs, and questions. For example, assessing learning spaces designed to foster student-faculty discourse and interaction to spark new areas of interest could include:

- Collecting counts and observations of interactions within the spaces.
- Reviewing data from faculty activity reports documenting exploration of new ideas within the space.
- Reports of pedagogical modifications enabled by the spaces, supplemented with in-depth examples elicited through interview with student/faculty focus groups.
- Student survey measures of satisfaction with the space in regard to the quality of interaction, flexibility, etc.

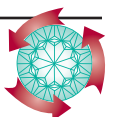
Such evidence reflects a combination of quantitative and qualitative data, as well as *direct measures* including observations of space use and documentation of new ideas and approaches explored and *indirect evidence*, such as student survey results about perceptions and behaviors. Combined, this evidence provides information that can be used as part of the assessment protocol established during the planning process.

The assessment loop suggests that assessment is ongoing and almost always a work in progress. As the needs of students and faculty change and space needs change, new assessment questions will emerge. Learning space assessment is essential to ensuring that spaces continue to contribute to learning and to serve institutional goals. Even more, assessment is critical to making the case for requisite investments in the physical plant, perhaps the most significant capital investment beyond investing in the intellectual capital of a college or university community.

Genuine assessment requires time to take root and influence practice. It can be sustained only if planning and implementation occur in an atmosphere of trust, when there is real commitment to using the evidence from assessment for shaping and reshaping learning spaces.

Figure 2. Types of Assessment

|                                                               |                                                                                                                                                                                                                                                                                                            |
|---------------------------------------------------------------|------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------------|
| Needs Assessment                                              | Identifying student needs (e.g. student perceived, or research supported).                                                                                                                                                                                                                                 |
| Tracking                                                      | Monitoring who uses programs, services and facilities (e.g. raw numbers, frequency, age, class standing, gender, race, residence, etc).                                                                                                                                                                    |
| Satisfaction Assessment                                       | Measuring the level of satisfaction with programs, services, and facilities.                                                                                                                                                                                                                               |
| Student Cultures and Campus Environments Assessment           | Assessing the collective perception of campus and student experience (e.g. campus climate, academic environment, nature and quality of student-faculty interaction, residential quality of life).                                                                                                          |
| Comparable Institution or Standards Assessment (Benchmarking) | Identifying how the quality of programs, services and facilities compare with peer, aspirational institutions; or using national or specialized standards to assess programs and services (e.g. national assessment inventory— Educational Benchmarking Inc., or departmental review by consulting group). |
| National or standardized Assessments                          | Using nationally available accepted surveys, tests or rubrics.                                                                                                                                                                                                                                             |
| Cost Effectiveness Assessment                                 | Determining whether programs, services and facilities are worth the cost.                                                                                                                                                                                                                                  |
| Learning Outcomes Assessment                                  | Measuring the impact of services, programs and facilities have on students' learning, development, and success (e.g., retention, grades, graduation, time to degree).                                                                                                                                      |



## Reflections

### *Assessing Learning Spaces*

Joan Lippincott, Coalition for Networked Information

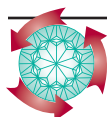
#### **Assessment Planning**

A campus group may be charged with developing an overall plan for the assessment of learning spaces that are slated for building or renovation throughout the institution; this may be a sub-group of a committee working on campus-wide facilities planning. The group may contain members from the university administration, facilities operation, faculty, student body, and other relevant services such as information technology and libraries. If such a group exists on campus, the individuals planning for an assessment of an information commons or new or renovated library facility should dovetail their work with that of the overall group. The same sectors listed above could be invited to participate in a planning group for assessment of an information commons. It would be very useful to have the perspectives of academic administrators, facilities planners, faculty, students, and other units as the overall objectives of the facility are discussed and various strategies for assessment are debated. In addition, campus assessment experts should be included, or outside assessment experts could be recruited to join the group.

#### **Assessment Tips**

Assessment often proves to be time-consuming and resource-intensive for institutions. In discussing assessment with representatives from many institutions, some key factors are apparent that could help those involved. They include: focusing on the big picture, particularly in aligning the assessment goals with institutional goals. If the institution has a particular emphasis on themes such as success for first-year students, development of a sense of campus community, or student involvement in research, the assessment planners should incorporate ways to measure the facility's contribution to the achievement of those institutional goals.

Understanding the potential audience for the assessment results and the ways in which the results will be communicated to various audiences should also inform the assessment planning process. Involving individuals from a variety of stakeholder sectors can assist with understanding the potential audience or the assessment results and the types of communication mechanisms that might be most meaningful to them. Those involved in assessment planning will often need to be persistent since this topic, while on the "to do" list of many of the parties involved, is often at the bottom of that list and therefore the implementation can be postponed time and again. Working with assessment experts, found on many campuses in offices of institutional research, in educational improvement units, or in departments of statistics, particularly within schools of education, can greatly aid the work of assessment planning groups. These experts will assist the planners to clarify their assessment objectives, make informed choices on methods of assessment, and identify key questions or modes of inquiry. They may be available, often for fees, to develop the measures used, deploy them, and do the preliminary analysis of the data. Once the assessment is completed, it is important that there be a mechanism for ensuring the implementation of at least some of the recommended outcomes.<sup>11</sup>



# Planning for Assessing: Spaces for Becoming

## Reflections

### *What Do We Want Our Learners to Become?*

Spencer Benson, University of Maryland/University of Macau

Speaking as a biologist and as a director of our University's Center for Teaching, it is clear that, irrespective of discipline, learner-centered approaches in classroom and lab result in deeper and more transferable learning than do those that are teacher-centered. While most educators agree that lectures have utility and a place in the learning process, they also agree that lecturing as traditionally practiced is marginally effective as a single tool to engage students in their learning, and to give students ownership of the process of learning.

From research in the learning sciences, as well as from decades of research within diverse pedagogical and disciplinary communities, there is a solid body of evidence about how learning happens. What we are beginning to understand about the physiological, biochemical and molecular basis of learning provides further evidence about how learning happens. The challenge for the broader community is to connect the dots between that research and evidence to the process of shaping 21<sup>st</sup> century learning environments—intellectual and social, as well as physical. Why?

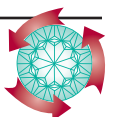
In the educational process we are concomitantly shaping and enabling citizens for the future. The essential skills and competencies for success as an undergraduate learner are precisely those needed to prosper in the world beyond our campuses. 21<sup>st</sup> century students need to learn how to learn—how to find, process, create, and use information in ways quite different from (or impossible in) past generations of undergraduates.

The University of Maryland has a daunting vision for our undergraduates, that they graduate prepared...*to continue to grow as global citizens, possessing the creativity and entrepreneurial spirit to respond responsibly and imaginatively to the challenges of the 21<sup>st</sup> century.*<sup>12</sup>

Behind this vision is a set of learning goals that challenge us to think differently about what our students are able to do, and what our graduates will be recognized for being and becoming. We want and need our graduates to become:

- Empowered self-learners, innovating, risk-taking and ethical entrepreneurs.
- Problem definers and problem solvers, recognized for their abilities in addressing the complex issues facing our society.
- Self-reflective, self-critical and self-motivated.

Such learning goals are reflected in the institutional profiles and essays presented in this guide. Collectively they illustrate how the process of purposely and thoughtfully designing learning spaces is a creative response to the challenge of educating today's students for 21<sup>st</sup> century work and life.





# Planning for Assessing: Spaces for Becoming

## Introduction

We shape the future by the questions we ask.  
—John Wheeler, Physicist

Attempting to shape the future by shaping and reshaping the physical environment for learning is an opportunity to shape and enrich the learning community on a campus into the future. Thus, in the process of planning, building should be seen as both noun (the resulting spaces) and verb (the community served by those spaces).

In reviewing these pages, you will find how, in undertaking planning spaces of different scope and intent, the involved institutional teams were aware that informed discussion around critical questions is a key characteristic of community. Taken together, their experiences suggest characteristics of a community that aspires to realize spaces that enable learning.

It is a community that:

- Has a clear understanding of 21<sup>st</sup> century learners, what they bring to the campus and their aspirations for life and work beyond the campus.
- Is aware of the 21<sup>st</sup> century challenges and opportunities that students will face and that influence how institutions prepare students for that future.
- Understands key questions to be asked at each stage in the process of planning and asks them in a context of mutual respect and shared commitments.
- Is willing to take risks, seeking collaborators and partnerships within academe and within the larger community of stakeholders.
- Keeps broadening the discussion, redefining the problem, committed to shaping a community of learners that serves the national interest.<sup>13</sup>

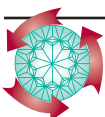
## Language of Learning Spaces

The repurposing of the lower level of Perkins Library at Duke University was driven by questions about the future of technology-rich learning and learning spaces at Duke, about how to assess what works and why. It was imagined as a metaphorical and actual link—spaces in which formal and informal learning were linked, in which technology-enabled pedagogical explorations were linked, in which learners could link to the world beyond the Duke campus.

It was also a link from the present to the future. As Duke prepares to undertake a significant amount of classroom construction and renovation in the immediate future, this project was a significant opportunity for evaluation and assessment to inform the many academic space planning decisions that lie ahead.



Signaling the meaning of Link, Duke University



# Planning for Assessing: Spaces for Becoming

At the Georgia Institute of Technology, the opportunity facing the planning team was to design both program and space for a biomedical engineering (BME) initiative being developed with support of a major foundation grant. This was a unique challenge, enabling planners to start from scratch, to give integrated attention to questions about what it is that 21<sup>st</sup> century biomedical engineers do, what we know from research about how students learn, and what kind of spaces 21<sup>st</sup> biomedical engineers practice their profession.

Understanding that a predominant reasoning strategy of engineers is to create diagrammatic and mathematical models, they recognized the need for that supported this practice among undergraduates; thus emerged the spaces for problem-driven learning, a series of small rooms with wall-to-wall white boards, in which learning of student teams is guided by a faculty coach. Wendy Newstetter, a cognitive scientist embedded in the BME community, calls these “exercise rooms”:

Just as people go to the gym to strengthen their athletic skills, these are spaces for exercising and strengthening their skills as a biomedical engineer.



Problem-driven learning spaces, Georgia Institute of Technology

Aware of the value of mental images, some of these spaces are identified by names signaling what the space is about.

The Discovery Learning Center at the University of Maryland Baltimore County (UMBC) is the response to a question asked by Bill LaCourse and his colleagues: How can the pedagogy and the learning space facilitate the students responsibility in the learning process? This question was prompted by examining the current reality at UMBC—the how and the where of student learning—and realizing that space was the problem!

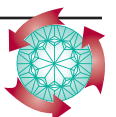


The space that was the problem, University of Maryland Baltimore County

The Digitorium in the Griffin Hall of Informatics at Northern Kentucky University (NKU) is a significantly high-tech discovery center. Kevin Kirby explained that the driver for programmatic design was the question: *How can NKU prepare students in diverse fields to move from being mere consumers of digital technology to becoming analysts and creators with digital tools?* Interestingly, the Digitorium is embraced at the upper level by NKU's version of the Georgia Tech exercise rooms.



Digitorium multi-level common area, Northern Kentucky University





# Planning for Assessing: Spaces for Becoming

The challenge of how to capitalize on the power of emerging technologies for teaching and learning drove colleagues in art history and archeology at the University of Maryland College Park to imagine how to reconfigure existing spaces. Beginning with exploratory conversations in the existing workroom, faculty developed an intellectual and social collaboratory from which a vision of a physical collaboratory emerged.



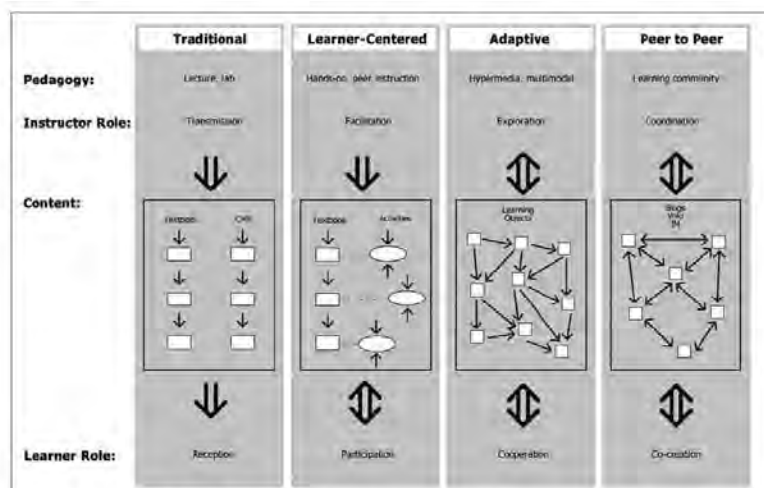
A static depiction of video of maps of China and of the Silk Road, Michelle Smith Collaboratory for Visual Culture, University of Maryland College Park

Translating that vision into reality began with a prototype for the cluster of spaces that became the Michelle Smith Collaboratory for Visual Culture. The experience of the collaborators, comprising in-house teams of faculty and staff, provides evidence that modest renovations can have major impact, transforming the learning experience of faculty and students within particular fields; such experiences can also become prototypes for further space renewal at the institutional level.

Weigle Commons, a repurposed space in the library at the University of Pennsylvania, also capitalized on the potential of technologies for deepening learning, but here more quietly pervasive than within the Digitarium or Collaboratory. Responding to the question, “How do the students come to feel a space as their own?” The Commons reflects a mental image of learning as inherently social, an awareness that students learn best with and from each other, and when learning is fun. Perhaps, as suggested by Scott Bennett, the Commons illustrates how libraries are being transformed into “laboratories.”<sup>14</sup>

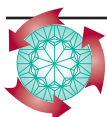


Student-owned spaces, Weigle Commons, University of Pennsylvania



Moving from left to right, the models go from hierarchical to democratic. In the “Traditional” model, CMS is a course management system. The nature and organization of course content mirrors the philosophy of the instruction. Effective teaching avoids pure transmission but can draw judiciously from all the silos. Peer-to-peer models do not remove the authority of the instructor but adapt the progress of the course according to student performance and feedback.

—Four Schema for Pedagogy with Different Roles for Student and Instructor. Chris Impey. “Chapter 5: Science Education in the Age of Science.” American Academy of Arts & Sciences. *Science and the Educated American: A Core Component of Liberal Education*. Cambridge, MA. 2010.



# Planning for Assessing: Spaces for Becoming

Another reconfigured space (or set of spaces) within a library is the Noel Studio for Academic Creativity at Eastern Kentucky University (EKU). As with other featured institutions, the process of designing and equipping this studio was aligned with focused university-wide initiatives to develop informed, critical, and creative thinkers who communicate effectively. As planners were reconceiving a forgotten room in the EKU library, exploring this question: What kind of spaces nurture creativity? The concept of a studio emerged.



Noel Studio for Academic Creativity, Eastern Kentucky University

## Spaces for Science

The transformation of roles for instructor and learner, as illustrated earlier, is becoming most deeply rooted in STEM disciplinary communities. This reflects the attention over the past three decades of STEM pioneering agents of change, including exploration of emerging research on learning and experimentation with programmatic and pedagogical initiatives based on that research. It also reflects the attention over the past three decades of STEM pioneering agents of change in exploring emerging research on learning and experimenting with programmatic and pedagogical initiatives based on that research, about the power of learning in community.



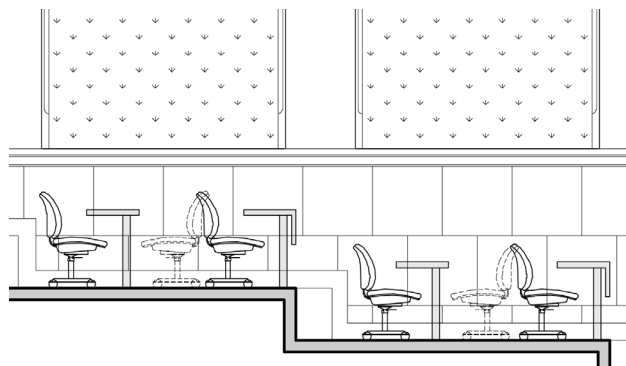
Science Corner in Sabine Hall, Richland College

Building from the pioneering work of Uri Treisman validating the power of team-based learning, Becki Williams and colleagues, responsible for Richland College's Sabine Hall Science Building, had a mental image of students learning in a community, with spaces that were transparent and that fostered connections among students and faculty across disciplinary communities. Having informal spaces—a Science Corner—owned by students promotes the collaborating and mentoring that enliven engagement in classrooms, the formal learning spaces.

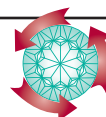
Truly creative spaces are flexible. They are easily reconfigured, modular, and responsive to the needs of different people and different projects. Creative places make it easy for people to discuss, share, and argue ideas, whether in the laboratory or the cafeteria. By maximizing both formal and informal contact between individuals, such spaces encourage cross-fertilization of thinking.

— Report on Places of Invention: The First Lemelson Institute from The Lemelson Center for the Study of Invention & Innovation. 2007.

The Science Corner in Sabine resulted in exploring the question: *What do we know about how students learn best?* A similar question inspired the 250-seat large enrollment classroom for introductory chemistry at the University of Notre Dame: *What do we know about how today's students learn?* Insights from the experience of Harvard's Eric Mazur<sup>15</sup> prompted faculty attention to personal response systems (clickers) as a means of transforming the traditional large-enrollment, steeply tiered auditorium into a multi-tiered space for team-based learning—again establishing new kinds of relationships between instructor and student.



Swivel chairs in team-based learning classroom, University of Notre Dame





# Planning for Assessing: Spaces for Becoming

Evidence of the impact of involving students in research-like activities from their earliest days as undergraduates is threaded throughout this guide.

At Grinnell College, planning their multi year STEM facilities renewal initiative involved a continuing commitment to undergraduate research. Seeking to understand what difference undergraduate research make to the learner was a critical part of their planning process. By carefully assembling and analyzing data from students involved with different kinds of research/ research-like experiences at different stages in their undergraduate career, they validated the design of spaces in which students could clarify their career path, begin to understand how scientists think, and most important become part of a learning community.



Undergraduate research students, Grinnell College

This and other documentation of the impact of a particular pedagogical approach (undergraduate research) has contributed significantly to the community's knowledge base about how learning happens influencing pedagogical practice in many disciplinary fields within and beyond STEM. But efforts to document what is known about learning in a particular context, for a particular group of students, have been more extensive in STEM fields.

The story of the evolution of SCALE-UP, from its inception at North Carolina State University to a world wide network of engaged adapters, is one example of the growth and impact of pedagogical approaches based on learning science and grounded in cognitive science research. It also reveals the evolution of spaces and furniture essential for such approaches to succeed. Bob Beichner notes that tables are the more important “technology” in SCALE-UP settings.

The tables were designed—not too large and not too small—to address the particular problem of facilitating interaction between the instructors and large numbers of students.



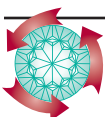
Before and after, SCALE-UP, North Carolina State University

The active-learning classroom (ALC) initiative at the University of Minnesota exemplifies an institution-wide commitment to more student-centered models for undergraduate learning and teaching. A major new facility is evidence of this commitment. Another is the establishment of campus wide policies and practices, with a collaborative team of faculty, administrators responsible for faculty development, learning environments research, and facilities with collective responsibility for “managing classrooms.”

Their efforts toward planning for assessing evolved from a single pedagogical pilot for introductory biology in a window less, renovated basement room to become a national model for planning for assessing in reshaping STEM learning environments. Integration—of faculty development, research on learning and learning environments—is a core concept of the ALCs.



Students in an Active Learning Classroom, University of Minnesota



# Planning for Assessing: Spaces for Becoming



Faculty as learners, Discovery Learning Research Center, Purdue University

The Discovery Learning Research Center (DLRC) at Purdue University is another institution-wide initiative to revolutionize undergraduate learning. Its home is within the university's Discover Park, established to advance interdisciplinary research across a variety of disciplines. Learners within the DLRC are faculty involved in interdisciplinary research on STEM learning and teaching. Its "black-box," theater-like spaces provide faculty opportunity to explore and document how different kinds of spatial configurations and technological affordances influence learning.

Participating faculty become intellectual capital within the DLRC and for the entire Purdue community, as they transport lessons learned and research findings from their DLRC experiences back to their departmental or programmatic homes.

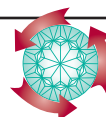
There is no single measure by which to determine what difference new or renewed spaces have made. As illustrated in the profiles and essays, featured projects have had a demonstrable impact on the experience of the learning of undergraduates at a particular institution. They provide spaces for mentoring, constructing one's own learning, becoming part of a larger community of learners and practitioners, and for developing the self-awareness essential for meaningful life within and beyond the campus. Planning for assessing the impact on the learning experience requires conscientious auditing from the start. Seeking such evidence is the collective responsibility of individual faculty as well as departmental and institutional colleagues.

But there are other, equally critical ways to measure the impact of the process of planning. One is by the difference a project is making at the institutional level. Here again, specific goals can be articulated from the start: creating a living room for the entire campus community, establishing a new center of gravity for enhancing interdisciplinary research and learning, signaling a deep commitment to stewarding natural resources, opening up the campus to the world beyond.



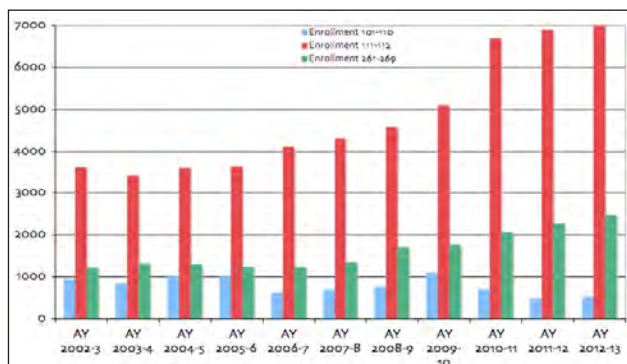
Campus "living room" in the Integrated Science Complex, College of the Holy Cross

Developing an intellectual neighborhood, beckoning all to "come inside, stay inside" became the mantra for planning the Integrated Science Complex at the College of the Holy Cross. Although severely outdated labs catalyzed the project, as planning evolved planners embraced the opportunity to re-envision the place of STEM learning in the liberal arts setting in the 21<sup>st</sup> century. Those responsible for planning knew that "science for all" required spaces quite different from those designed for the self-identified entering major. Welcoming corners are sprinkled throughout the hallways, balconies, and lobbies of the complex, with easy access to the all-important food cart. But they also recognized that science for majors required spaces accommodating 21<sup>st</sup> century instruments and equipment as well as attention to the acoustics of too-often noisy chemistry labs.



# Planning for Assessing: Spaces for Becoming

Awareness of the changing context and increasingly interdisciplinary world in which STEM research is practiced drove both planning and design of the Integrated Science Building at the University of Massachusetts Amherst.



Increased enrollments of non-majors in chemistry: blue bars (Chem 101- 110; red bars (Chem 111 - 112); green bars (Organic). University of Massachusetts Amherst

Beginning with a shared commitment to plan for the future, a group of committed alumni and faculty articulated a lofty dream: that the learners (faculty and students) using the spaces would interact, connect, and communicate across disciplinary boundaries in ways that mirrored communities of 21<sup>st</sup> century STEM practitioners. One evidence that their dream has been realized is UMass Amherst's new Integrative Experience (IE) general education requirement; another is the new concentration: iCons (Integrated Concentration in Science), which could not have happened without the ISB.

At the heart of interdisciplinary is communication—the conversations, connections, and combinations that bring new insights that bring new insights to virtually every kind of scientists and engineer. Without...special effort by researchers to learn the languages and cultures of participants in different traditions, the potential of interdisciplinary research might not be realized and might have no lasting effect. Learning a new field is always hard work, and it must be catalyzed by both formal efforts, such as institutional policies that support new programs, and informal efforts, such as cafeterias, collaborative spaces, and common rooms that encourage mingling and conversation.

— *Facilitating Interdisciplinary Research*. National Academy of Sciences. The National Academies Press, 2004.

By incorporating elements that make efficient and cost effective use of natural resources, such facilities can also be a tool for advancing campus wide awareness of how learning happens and how buildings work.

The characteristics of community— a predisposition to share ideas, to challenge precepts, and to revel in exploring unfamiliar territory—relate directly to the endeavor of collaborative planning. How can this be? Think about how a true community exhibits the willingness, even the drive, to discuss matters of the moment informally with colleagues in the lounge, or to explore issues in formal, regular sessions with peers. Community is the spirited enactment of the conviction that ideas are important, and that they gain life when people bring different perspectives to their consideration. Communities embrace a common vision, yet allow— even promote—diffcult dialogues. This is the challenge to leaders, within the faculty and the administration, as your planning proceeds.

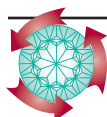
— From the LSC Archives

Planning for the Stuart and James Hall within the Rector Complex at Dickinson College was grounded in an institutional vision of spaces that signaled “this is about the doing of science in the 21<sup>st</sup> century.” The visible bioswale and external treatment of windows and walls to the less visible enthalpy wheel are physical evidence of how that vision was realized. The siting of the building and its intentional transparency were also means by which to make the doing of science a central part of the experience of learning on this liberal arts campus.

The spine that is the social heart of the science complex is open to the street and directly across from the dining hall, serving another project goal, that every Dickinson graduate no matter his or her major would be deeply aware of how scientists work, how science is done.



The spine of the Rector Science Complex, Dickinson College





# Planning for Assessing: Spaces for Becoming

All the spaces featured in this guide from the problem-based learning rooms to major new STEM facilities are bridges to the future. The most obvious bridge is that for students, a bridge constructed by virtue of the vision of planners of what learners are to become, be able to do upon graduation.

The BRITE Center at North Carolina Central University can be described as a network of intersecting bridges. Learners at all levels from middle school, high school and community colleges to undergraduate and doctoral students are all headed toward a workplace of the future that has been defined, and is supported by the regional corporate community.



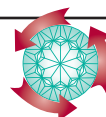
A bridge to the Campus, BRITE Center, North Carolina Central University

The BRITE story also illustrates how planning for assessing can be a bridge to the future for the broader institutional community. Some dimensions of this impact can be measured easily, for example, by examining data about student persistence and alumni achievements.

[O]ne of the most powerful concepts framed through the civic renewal effort is the concept of “stewardship of place,” or an ongoing partnership between higher education and local communities that is designed to tackle and ameliorate festering social problems and inequities. When these kinds of reciprocal, long-term, collaborative efforts are formed, they provide a very powerful locus for both faculty and student engagement in civic inquiry and problem solving. They provide extraordinary opportunities for the academic community to learn from the insights and judgments of civic communities, with their multiple sources of perspective, energy, skepticism, disagreement, wisdom, and grass-roots decision making. These collaborative civic problem-solving partnerships model democracy in action. But they also bring a new rigor about evidence to the work of civic inquiry, analysis, and decision making. And rigor about the evidence we use to make decisions is urgently needed.

When we think about civic inquiry and learning in these terms—scholars, students, and staff working with community partners, taking a long-term responsibility for the quality of our lives in community—then, in my view, we begin to see the outlines of a twenty-first-century argument for the future of our colleges, universities, and community colleges as dedicated inquiry communities that are anchored in specific geographical places and responsibilities.

— Carol Geary Schneider. “To Democracy’s Detriment: What Is the Current Evidence, and What if We Fail to Act Now?” *Civic Provocations*. Donald W. Harward, Ed. Bringing Theory to Practice: Washington DC. 2012. [http://www.aacu.org/bringing\\_theory/documents/CivicProvocationsmonograph\\_000.pdf](http://www.aacu.org/bringing_theory/documents/CivicProvocationsmonograph_000.pdf)



## Reflections

### *Vision and Language of Learning Spaces*

Malcolm B. Brown, EDUCAUSE Learning Initiative (ELI)

Institutions may need to rethink their vision for learning and the spaces in which it occurs. Creating a vision for learning and learning spaces is a powerful leverage point; it informs almost all other decisions about learning space design. A vision also allows us to effectively articulate to all constituents what we are trying to accomplish. The vision helps organize all participants in the design and implementation of these spaces as well as the activities they support. Simply installing wireless access points and fresh carpeting isn't enough if done in isolation; such improvements pay real dividends only if they are in concert with the institution's overall teaching and learning objectives. It is the vision that generates the design principles that will, in turn, be used to make key decisions about how learning spaces are configured.

One important implication is that the vocabulary we use to describe what learners do in these spaces must become active. We must go beyond describing ways to help the instructor to be active; we must include students as well. The vision and design principles should emphasize the options students have as active participants in the learning process. Design principles should include terms such as analyze, create, criticize, debate, present, and classify—all directed at what the space enables the students to do. For example, students should be able to present materials to the class. Outside class, they should have access to applications and materials that directly support analysis of data, text, and other media. Forums for discussion and critical debate, both real and virtual, are key to encouraging learning and will be looked for by Net Gen students.

Learning spaces should accommodate the use of as many kinds of materials as possible and enable the display of and access to those materials by all participants. Learning space needs to provide the participants—instructors and students alike—with interactive tools that enable exploration, probing, and examination. This might include a robust set of applications installed on the computer that controls the room's displays, as well as a set of communication tools. Since the process of examination and debate leads to discovery and the construction of new knowledge, it could be important to equip spaces with devices that can capture classroom discussion and debate, which can be distributed to all participants for future reference and study.

Learning does not stop once the instructor has left the classroom. Instead, the end of the class meeting marks a transition from one learning mode to another. As a result, institutions must address real and virtual spaces outside the classroom to ensure that they, too, encourage learning. For example, there should be access to class materials (which are increasingly digital) so that the active and social work of learning can continue outside the formal classroom. The design of “neutral” spaces, such as hallways and corridors, could be rethought and re-equipped to promote learning. Some institutions provide small discussion spaces in corridors so that discussion begun in class can continue when class ends. As for the virtual space, institutions should consider well-integrated work environments that support collaborative projects and resource sharing.

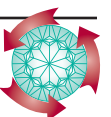
Informal learning spaces—those outside the classrooms—present particularly intriguing opportunities for pioneering and cultivating new teaching and learning practices. These spaces, while informal, are key areas for student academic work. Students spend far more time in these spaces than they do in formal classrooms. Research, Web browsing, writing, statistical analysis, and compiling lab reports all take place in the library, study hall, media center, dorm room, and learning commons. Because of their enthusiasm for IT and their experiential, hands-on approach to learning tasks, Net Gen students will easily “tune into” the virtual aspects of informal spaces. Well-designed and integrated physical layouts and IT “tool sets” will find a ready audience with Net Gen students.<sup>16</sup>



Best take-home ideas from workshop participants (2009)

- That planning is directed toward achieving spaces that will last beyond the current generations of planners and users, so the planning must be focused on the future.
- The ideas about how rich an intentionally diverse planning team can be—one involving students, our visual and creative arts faculty, as well as our custodial staff—as well as the importance of having campus “big-picture” thinkers are at the table (and of the importance of avoid those with narrow interests and an inability to imagine a different future).
- The need to keep moving toward a common language within the planning team—to press the design professionals to explain their terms and to be certain that campus-based team members press colleagues to clarify on what they mean, for example, as “engaged learning.”
- Begin by thinking about the end result. Clarify project goals. Demonstrate the value of the effectiveness of current projects.
- Link assessment of facilities planning (learning spaces) to larger institutional assessment structures and initiatives.
- Most simply, to ask faculty if their spaces for learning served their goals for learning?

— From the LSC Archives





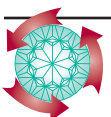
# Part II-A

# Institutional Profiles



Spaces in which humans grow:  
a learning community...  
where mind and sensibility are shared...  
a place to learn together about the real world,  
and about possible worlds of the imagination,  
of materials and learn the power of doing  
these things together.

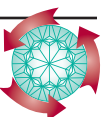
—Jerome S. Bruner, *Toward a Theory of Instruction*.  
Harvard University Press, 1996.



### Methods of Teaching and Learning

If what is taught has become a matter of concern, the question of how learning takes place has become an even more widespread and urgent concern. Though more is known about effective pedagogy than about the results of curriculum choice, numbers of writers conclude that the existing faculty emphasis on undergraduate teaching, such as it is, is misplaced and that more attention should be devoted to student learning rather than teaching. The goal and outcome of a successful undergraduate experience, the critics argue, should be learning, to which teaching makes a major contribution. But teaching is the means, not the end, of education. Learning is the product of education and teaching is but one means—though a significant one. To devote faculty time to tinkering with course requirements, to the neglect, some argue, of the learning outcomes associated with them, may be as inappropriate as the preoccupation and reimbursement of hospitals for length of patient stay rather than the beneficial results of patient care. The emphasis on teaching as an end in itself, rather than a means of learning, reflects a wider neglect of interest in pedagogy. The heavy reliance on the conventional lecture format—representing, some critics argue, almost everything that is the antithesis of what we know about the best methods of effective learning—is an unhappy example.

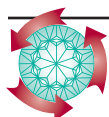
— Frank H.T. Rhodes. "Chapter 2: Science as a Liberal Art." American Academy of Arts & Sciences. *Science and the Educated American: A Core Component of Liberal Education*. Cambridge, MA. 2010.



# Part II-A: Institutional Profiles

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# Integrated Science Complex College of the Holy Cross

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Accomplished scholars, grounded thinkers.
- Rooted learners, striving explorers, agents of discovery.
- Inspired leaders, informed trailblazers.
- Involved citizens, collaborative workers, cutting-edge scientists.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Exchanging learning, mentorship, and discovery between teachers and students.
- Fusing the liberal arts context and a research-based science curriculum.
- Immersing students in a world of group learning and cutting-edge instrumentation.
- Collaborating with broadly trained teacher-scholars pondering today's pressing questions and vexing problems.
- Engaging in intense, team-based research that yields presentable, publishable results.
- Triggering "a-ha moments" by the serendipitous collision of ideas.



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- “Super Lab Suite”: promotes inquiry and dynamic exchange.
- “Super Quiet”: efficient, sustainable ventilation system hushes hoods and enables chatter.
- “Clear Sightlines”: glass-walled labs and write-up rooms enhance safety and put science on display.
- “Scaled Sizing”: venues tailored to their purposes– large group discussion, small team study, ample benches and clustered laboratory instrumentation, informal gathering.
- “Mobile Dexterity”: reconfigurable furniture, state-of-the-art technology supports the shift and turn of theory and practice.
- “Intellectual Neighborhood”: a vibrant building beckoning all to “come inside, stay inside.”

## HOW DO WE KNOW?

- The five-building Integrated Science Complex (ISC) is now a leading campus destination, utilized heavily by science majors and non-science majors alike.
- Significant increase in student research; average weekly visits to science library double.
- Empirical findings and anecdotal evidence gathered by formal methodologies clearly show widespread and effective use of multimodal ISC venues by the Holy Cross community.
- Integrated Science Complex now a highlight on Admissions Office campus tour.





## Stuart Hall and James Hall Dickinson College

### WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Independent and inquisitive learners.
- Creative thinkers and problem solvers.
- Active researchers with an appreciation for interdisciplinary perspectives.
- Scientifically literate and engaged citizen-leaders for the nation and the world.

### WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Exposure to a model of teaching that focuses on the connections between the sciences and existing and emerging disciplines.
- Opportunities that provide hands-on exposure to assist faculty directly in their research, creating new knowledge and new frontiers of intellectual inquiry.
- Assignments of projects to groups of students, not individuals, to foster a spirit of collaboration and teamwork in problem-solving.
- High visibility of the sciences on campus to draw in more students.
- Open discourse between faculty and students to spark new areas of interest and develop strategies to independently explore these areas.
- Open-door policies regarding student access to faculty offices to promote informal interaction.



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Faculty offices adjacent to those from different departments to encourage conversations about different research topics.
- Faculty research labs sized to be shared by two faculty, allowing a student to work directly across from another who is researching something entirely different.
- Transparent interior spaces that promote interdisciplinary research and high visibility between classrooms and laboratories.
- Centrally-located social spaces to allow for group study, project displays and informal “intellectual collisions.”
- Multipurpose rooms capable of exposing students to a variety of academic programs.



## HOW DO WE KNOW?

- Percentage of undergraduates in science majors increased from 15% in 2009 to 20% in 2012.
- Percentage of students pursuing a minor (all disciplines) increased from 29% in 2009 to 34% in 2012.
- Psychology and Biology went from the fourth and sixth most popular majors, respectively (2008), to the third and fourth most popular majors, respectively (2010).
- In a post-graduation survey of the class of 2010, 81% said they regularly apply “Information Literacy and Research Skills” gained at Dickinson to their professional lives.
- Students are surveyed at start of freshman year and at graduation to track goals, expectations, and outcomes of various aspects of academics, student life, professional development, and overall satisfaction with the school.
- Faculty surveyed to gather information on experiences, concerns, job satisfaction, workload, teaching practices, and professional activities.





## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Empowered by enhancing their capacities for reasoning.
- Empathic by developing intellectual and interpersonal skills.
- Enlightened by encouraging multi-disciplinary collaboration.
- Risk takers by promoting experimentation and out-of-the-box thinking.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Engaging in learning that is collaborative, authentic, project-based.
- Using interactive technologies with increasing intensity.
- Exploring into the complete process of learning, within and beyond class time.
- Becoming exposed to diverse disciplines, ways of learning, pedagogical approaches.





## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Flexible, interdisciplinary learning environments.
- Co-location of formal/informal learning spaces and flexible classroom features.
- Located with convenient access to technology, services, and support.
- Space that supports experimentation to inform future development of learning environments.

## HOW DO WE KNOW?

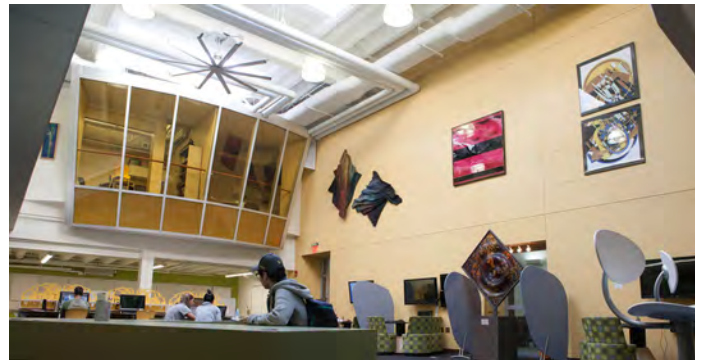
- High levels of satisfaction with the design and aesthetic are important.
- Features like whiteboards and glass walls are conducive to collaboration and learning.
- The permeable boundary between the classrooms and study spaces results in tangible benefits to teaching and learning experiences.
- Student levels of engagement and enthusiasm increases.
- Demand for use exceeds supply.



## Noel Studio for Academic Creativity Eastern Kentucky University

### WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Skilled in creative thinking, able to employ creative thinking to solve a variety of problems, able to use manipulatives to consider multiple perspectives in highly effective communication design.
- Skilled in the design of highly effective communication products, able to gather and use valid information to support communication design, able to employ multiple modes of communication and articulate choices made during the process.
- Skilled at using and producing information with impact, understand creative and rhetorical techniques that can be used to understand many different communication scenarios, willing to explore provisional approaches to learning and communicating.



### WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Collaborating with peers and trained consultants on designing innovative communication products for multiple audiences.
- Interacting informally with peers and instructors on the communication-design process.
- Developing communication practices through studio pedagogy: visual, oral, aural, written, and electronic processes.





## Noel Studio for Academic Creativity Eastern Kentucky University



### WHAT SPACES ENABLE THOSE EXPERIENCES?

- Room for instructors to experiment with pedagogy in a space with flexible seating for 25 participants, guiding group work and facilitating small and large group discussions and idea generation through mobile dry-erase boards and mobile technology.
- Round tables 4' – 5' in diameter, each serving groups of three to four students in a public, high-traffic space.
- Large, touch-screen monitors for viewing and displaying student products as in an electronic gallery space.
- Wall-sized dry-erase boards to facilitate visual invention in a public space and mobile dry-erase boards that students can use on-demand in a variety of learning contexts.
- Access to video cameras, monitors, and software for recording oral communication and demonstrations.

### HOW DO WE KNOW?

- Increased critical thinking skills in written communication projects.
- Increased confidence in helping students identify the thesis and purpose of their assignment, considering their topic from multiple viewpoints, using the information from their consultation, and employing creativity as a result of the consultation.
- Education students who visited the Noel Studio twice for consultations on their electronic portfolios scored, on average, 25% higher when compared to students who did not visit at all.



# Problem-Driven Learning Spaces Georgia Institute of Technology

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Agents of their own learning.
- Integrative thinkers and problem solvers.
- Empowered communicators and leaders.
- Model-based reasoners.
- Resilient experimenters.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

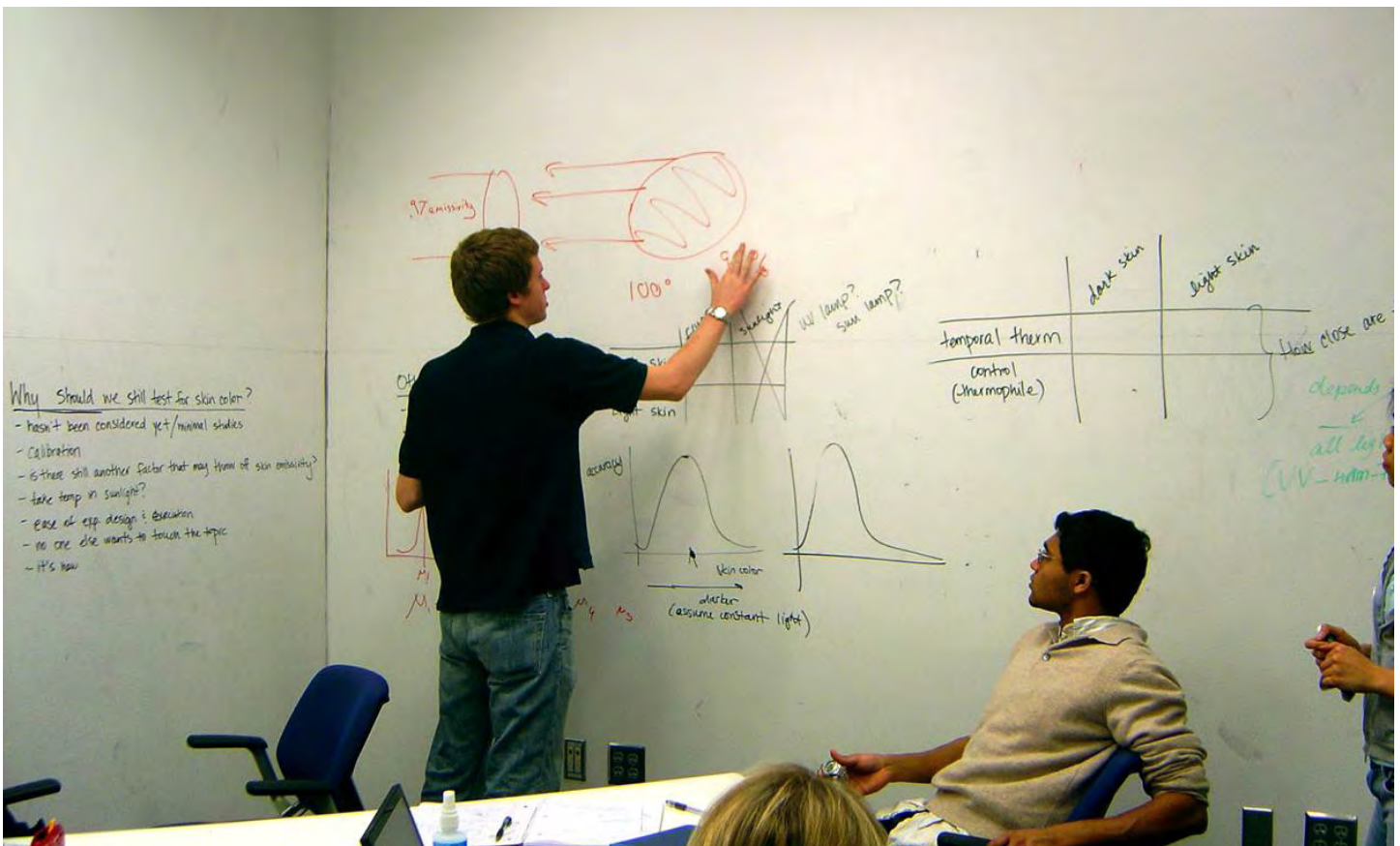
- Tackling ill-structured, open-ended complex problems with others.
- Searching for, finding, and sharing relevant, reliable, and up-to-date data with team members.
- Blending disciplinary concepts, methods, representations toward solving problems.
- Creating, sharing, debating, and defending models (graphical, diagrammatic, mathematical).
- Trying, failing, and recovering.





## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Authorable, responsive, flexible spaces.
- Spaces that invite the articulation and representation of provisional ideas and hypotheses.
- Spaces that support changing, responsive, collective leadership.
- Spaces that support rebounding from impasses and failure.



## HOW DO WE KNOW?

- Since the inception of the GT student Inventure prize, BME students have taken top prizes every year.
- The Director of the GT co-curricular VIP program (Vertically integrated Projects) notes that BME students stand apart from other majors in diving into the projects taking leadership roles.
- In a survey of the alums which garnered a 67% response rate, significant numbers of responders commented on the importance of the PDL approach to their career success.



## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Knowledgeable about basic science.
- Educated about the process of science.
- Able to address complex problems that require multiple inputs and non-linear problem-solving.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Encountering science as scientists do— as a process of investigation and learning— as opposed to a static body of knowledge
- Actively engaging in real problem-solving applying scientific principles to problems of interest to students.

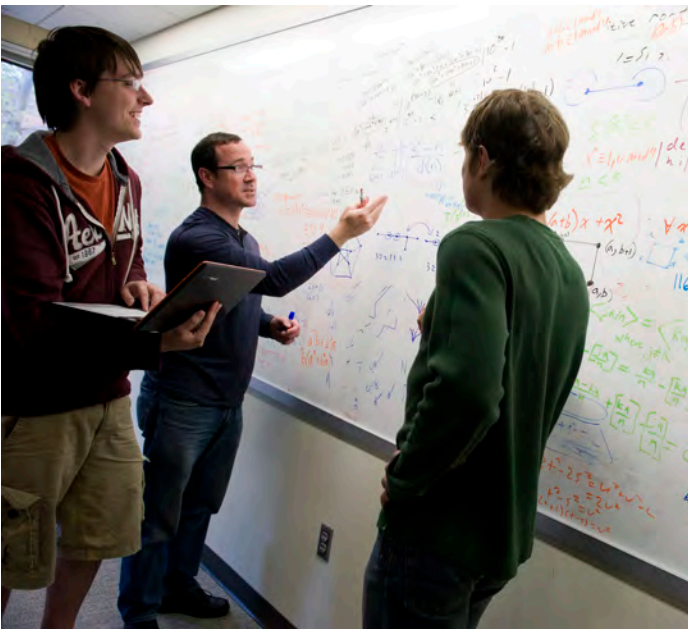




## WHAT SPACES ENABLE THOSE EXPERIENCES?

Classroom evolved from:

- tiered rooms with fixed tablet armed chairs, sending the message that learning is passive and individual.
- tiered rooms with two tables per tier to allow students to work in groups as well as to see an instructor, projected images and demonstrations. They also send a message that our intent is for the students to be engaged.
- Workshop classroom has tables for four students to work in groups, no front teaching wall, and opens directly into the laboratory.
- Teaching labs are designed similar to research labs to support investigation and discovery.
- Informal spaces for students to work and to display research and class project results.



## HOW DO WE KNOW?

- High level of satisfaction of students and faculty with classroom spaces.
- Dramatic increases in engaged pedagogies by faculty and incorporating research or research-like experiences in courses.
- Over 80% of students who start at Grinnell with interests in science graduate with science majors.
- A marked increase in the number of domestic students of color and women graduating with science majors.
- Pluralistic pedagogical approaches so that students can select which pedagogy best matches their learning styles.



# Biomanufacturing Research Institute & Technology Enterprise (BRITE) North Carolina Central University

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Self-motivated, industry-focused researchers.
- Inquisitive learners, self-driven to success.
- Evolving and adaptable to the changing world around them.
- Goal-oriented, skilled with a future focus.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Active mentoring between students and faculty researchers.
- Hands-on learning with industry leaders in biotech fields.
- “Choreographed” chance encounters between teachers and learners.
- Dynamic, ever-changing research environment which leverages latest technology with “real world” experience.
- Multigenerational learners which challenge and motivate each other to succeed.
- Jobs-based focus with industry partners who provide skilled mentors and instruction.





# Biomanufacturing Research Institute & Technology Enterprise (BRITE) North Carolina Central University



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Open laboratory spaces: enables seamless interactions between students, research staff, and faculty members.
- Technology-enabled classrooms extend students reach to the global realm.
- Hands-on training labs configured similarly to those found in the biotech industry.
- Built-in flexibility allows for easy conversion of labs to industry relevant stages for learning.
- Those with carefully planned connections to the variety of formal and informal spaces essential for becoming a STEM learner, a STEM practitioner

## HOW DO WE KNOW?

- Students exceed 80% placement rate into biotech industry and advanced degrees.
- Industry demand for graduates exceeds supply.
- Strong advocacy for historically under-represented minorities.
- Notable publications and patent applications attributed solely to research conducted at BRITE.
- Provide economic stimulus to both public and private realms: creation of spin-off company and ongoing research grants generating millions in direct cost annually.



# Student-Centered Active Learning Environment with Upside-Down Pedagogies (SCALE-UP) North Carolina State University\*

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Skilled with the use of technology, able to use simulations to develop mathematical models, able to use software and hardware for data collection and analysis.
- Skilled in interpersonal communication, able to explain their reasoning in written and oral forms to peers and to evaluate oral arguments (their own and those of peers), able to demonstrate their knowledge and understanding of physics in writing, able to present a well-reasoned argument supported by observations and physical evidence, able to function well in a group and evaluate the functioning of their group.
- Socialized into the community of physics, aware that understanding physics means understanding the underlying concepts and principles; understanding physics as a coherent framework of ideas that can be used to understand many different physical situations; becoming part of a classroom community of learners.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Collaborating with peers on interesting tasks, opportunity for “hands-on” engagement with solving context-rich problems.
- Interacting with peers and with instructors, experiences reinforcing their ability to function well in a group.
- Interacting with equipment used by physicists to make measurements.
- Presenting and evaluating oral arguments; viewing and critiquing the work of individual teams.

\* and peer institutions





# Student-Centered Active Learning Environment with Upside-Down Pedagogies (SCALE-UP) North Carolina State University\*



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Room for instructors to circulate and work with students as teams and as individuals, engaging them in Socratic-like dialogue.
- Round tables 6' or 7' feet in diameter, each serving three groups of three students.
- Networked laptops for viewing work of individual teams at each table.
- White boards to be used as public “thinking” spaces all around the room; individual white boards for each team.
- Ubiquitous access to the web.

## HOW DO WE KNOW?

- Students’ ability to solve problems is improved.
- Their conceptual understanding is increased.
- Their attitudes are better.
- Failure rates (especially for women and minorities) are drastically reduced.
- “At risk” students do better in later courses.



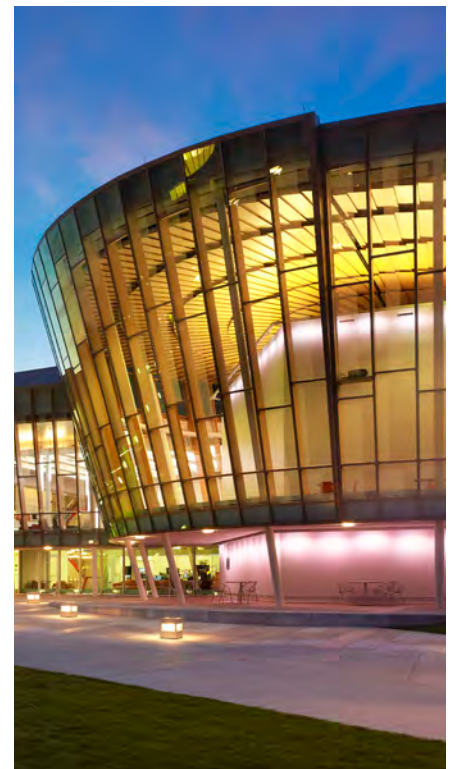
# Griffin Hall Center for Informatics Northern Kentucky University

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Transdisciplinary: Renaissance people for the digital age.
- Code writers, code readers, code breakers.
- Ethical actors, deep thinkers, agile creators.
- Lifelong learners and lifelong teachers.
- Leaders with an ethic of work and a sense of play.
- Entrepreneurs.
- Analysts and creators of digital technologies.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Performing before peers, teachers, and an external audience.
- Competing in real space and real time.
- Exploring visualization.
- Working through project lifecycles with external clients.
- Self-directing study and research.
- Observing, sharing, and collaborating in informal groups.





## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Digitorium: reconfigurable space, two story microtile rear-projection wall, opera box—problem workrooms.
- Collaboratories: decentered, clustered, mobile computing friendly spaces with write-on walls.
- Flex spaces: hangouts where students and faculty interact with the community, from middle school students to CEOs.
- Cybersecurity lab: a science lab where spigots of power and data replace water and gas, and racks of routers replace racks of chemicals.
- Commons: open, sunlit, multi-level community area surrounded by a panorama of eye-catching learning spaces.



## HOW DO WE KNOW?

- Surge in enrollment in all programs (9 bachelors, 5 masters): 8% growth in the year since the building opened.
- Increase in external partners working with our students in the Center for Applied Informatics.
- Launch of a major startup accelerator (UpTech) with a large footprint in Griffin Hall.
- Sharp increase in press coverage and buzz.



## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

Our “learners” are faculty who will become:

- Reflective practitioners of well-researched pedagogies.
- Aware of the many ways that learning spaces can influence student learning and creativity in their use of space to support learning.
- Knowledgeable about the evolving learning preferences of students.
- Willing to approach their teaching in a scientific way— gathering evidence and using it to influence their own practice.
- Empowered to think about the needs of their curriculum and how those needs can be met by different uses and configurations of learning spaces.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Having opportunities to study the effects of a teaching innovation in a pilot setting.
- Seeing data about the benefits of different pedagogies on student learning.
- Having access to a “laboratory” space to experiment with innovative pedagogies with flexible furnishings, lighting, layout, and configuration.
- Learning *from* the space, not just *in* the space.





## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Flexible, black-box spaces that invite creativity.
- Infrastructure that serves present technologies and also enables the exploration of technologies of the future.
- Spaces able to adapt and evolve, as users continue to experiment with pedagogies and technologies that enhance learning and teaching.
- Spaces with usable lifetimes that outlast the current “standard” configurations of classroom spaces.



## HOW DO WE KNOW?

- Research shows that today’s learners prefer curriculum that focuses on hands-on learning in a team-based atmosphere.
- Research shows that more effective learning takes place when students can actively and collaboratively engage in the learning process.
- Case studies demonstrate that space can influence collaboration and teamwork by encouraging interaction and providing teaching resources that use technology to share and capture ideas.
- The professional work environment is moving to more open and collaborative office settings; learning environments need to mimic these real-world practices to prepare students for their future careers.



## Science Corner at Sabine Hall Science Building Richland College, Dallas County Community College District

### WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

Lifelong learners who possess:

- a growth mindset, who know that learning is learnable.
- critical curiosity with the energy and desire to figure things out.
- creativity with the ability to look at things in new and different ways.
- strategic awareness— pursue learning with a purpose.
- resilience— able to invite challenge and persist through difficulty.
- the ability to learn from others, with others, and alone.
- the ability to make meaning— make connections, find patterns, integrate ideas.

### WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Interacting with other learners— faculty, tutors, and peers— who make thinking visible.
- Formulating questions, learning from mistakes, and checking for understanding.
- Learning with others who display the dispositions of lifelong learners.
- Observing faculty commitment to students and their learning.

### WHAT SPACES ENABLE THOSE EXPERIENCES?

- Spaces that allow for reconfiguration to serve current needs.
- Spaces that encourage a variety of visual communication methods.
- Spaces that enable transparent connections between faculty, students, and disciplines.
- Spaces that are “owned” by the students, that are not scheduled/controlled by the institution.



## Science Corner at Sabine Hall Science Building Richland College, Dallas County Community College District



### HOW DO WE KNOW?

- Visual confirmation: the space is always full with students working, teaching, and learning.
- Engagement: students assembled in active, diligent learning teams with faculty mentors. 1483 visits were recorded in Fall 2010. 2617 visits were recorded in Fall 2012, a 57% increase!
- Results: improved retention and success rates. Fall 2012 data— the % of students who successfully completed a Biology, Chemistry, or Physics course with an A, B, or C grade was over 10% better for students who took advantage of tutoring. While 10.28 % of Biology, Chemistry, and Physics students who participated in science corner tutoring withdrew from class, 16.18 % of students who were not tutored withdrew.
- Inspiration: Faculty inspired to support students with a clear commitment to teaching. Many faculty from other disciplines witnessed the impact of the tutoring center in the new Science Building and developed similar open learning spaces for Economics, English for Speakers of Other Languages (ESOL), and English.
- Behavior: students are clearly committed to learning and inspired to support/mentor each other.





# Chemistry Discovery Center University of Maryland, Baltimore County (UMBC)

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Committed, passionate, life-long learners.
- Practitioners in a community of scholars.
- Informed risk takers, entrepreneurs, empowered agents of change.
- Responsible and compassionate citizens— leaders of tomorrow.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Communicating, discussing, and debating concepts and ideas.
- Constructing and applying knowledge to relevant problems.
- Exploring possibilities, discovering relationships, and owning knowledge.
- Sharing common goals and challenges.



## Chemistry Discovery Center University of Maryland, Baltimore County (UMBC)



### WHAT SPACES ENABLE THOSE EXPERIENCES?

- Flexible spaces that facilitate communication and student collaboration.
- Technology-equipped spaces that leverage and enhance human interaction.
- Open spaces that encourage learning, freedom of thought, and mentoring.
- Spaces that sanction students to play, rest, and grow their minds.

### HOW DO WE KNOW?

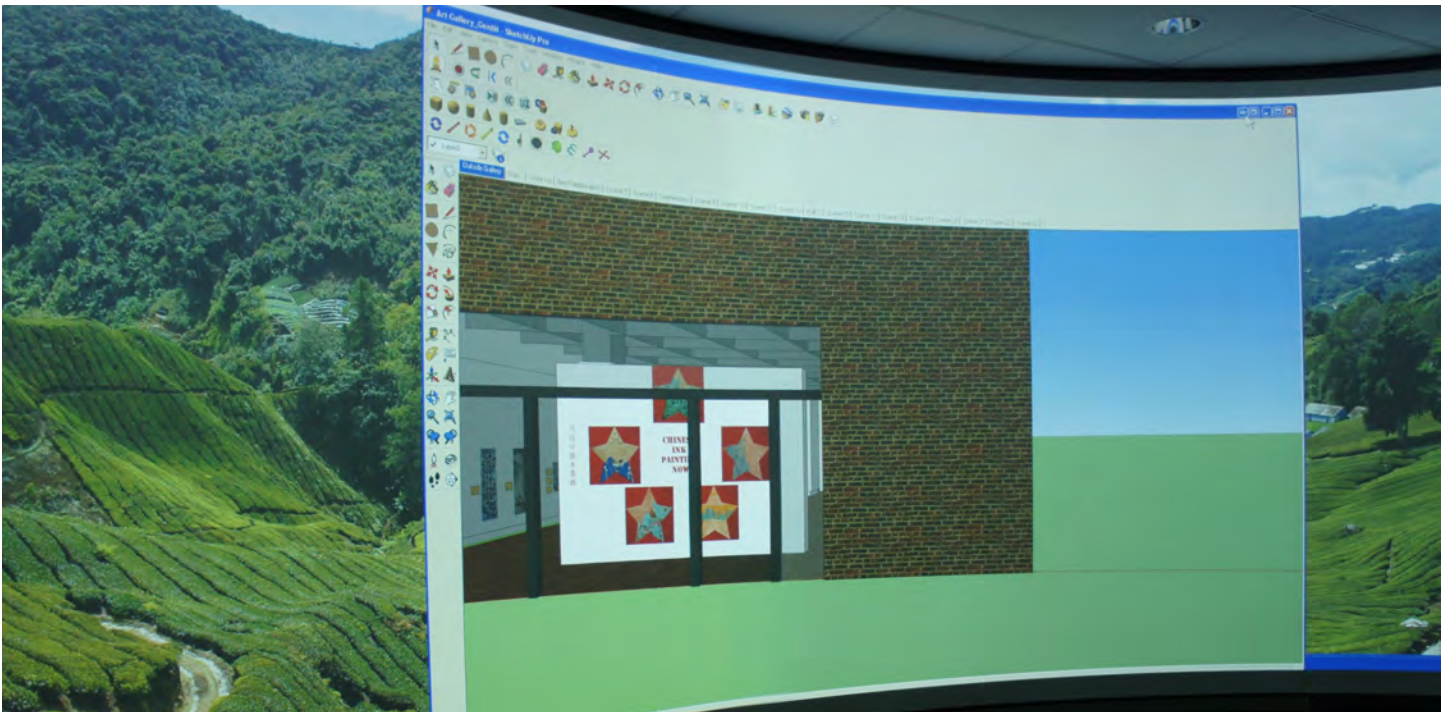
- Improvements in retention and persistence within the class, within the major, and within the university.
- Improved class performance in the present and subsequent courses.
- Spontaneous and enhanced group formation and study groups.
- Observation of signs of self-assessment and personal responsibility for learning.
- Growth in community and collegiality through enhancement enrollments in discipline specific clubs.





### **WHAT DO WE WANT OUR LEARNERS TO *BECOME*?**

- Thoughtful individuals, who search for multiple approaches to problems.
- Inquiring participants, who question to learn.
- Creative thinkers, who recognize there may be a new solution.
- Confident individuals, who appreciate benefits to be gained from collaboration.
- Tolerant participants, who appreciate diversity of multiple cultures.
- Effective communicators, with skills for multiple media and venues.



### **WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?**

- Feeling comfortable in an open, accepting work and classroom environment that encourages experimentation and risk taking.
- Interacting with instructors in a space that eliminates traditional teacher/student hierarchies.
- Working on course projects designed to encourage intellectual exploration, resulting in well-articulated conclusions.
- Collaborating in visualizing ideas and concepts and successfully producing superior outcomes.
- Enjoying a sense of physical freedom, with the ability to get up, move around, join others, demonstrate ideas.
- Having easy access to cutting-edge visual technologies and staff with relevant technical expertise.

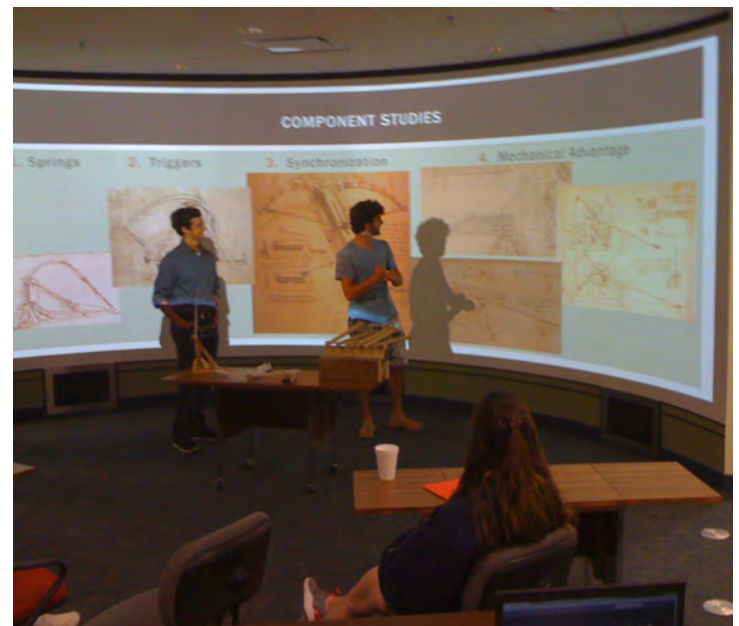


## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Those that take advantage of the possibilities presented by new visual media for enhancing teaching and learning, with interactive projection surfaces, combined with multiple projectors and variable inputs, able to present visual materials of varying types (e.g., Power Point, video, printed materials, Twitter feeds, satellite imagery, web materials, simultaneously, revealing relationships among seemingly diverse subject matter).
- Those accommodating an array of technological resources that students can use in building models— both physical and virtual.
- Those with a technology infrastructure that enables lighting and sound to be adjusted as needed and that will support technologies of the future.
- Those with the flexibility of furniture and other spatial affordances that can be easily configured for varying purposes and different models of interaction.

## HOW DO WE KNOW?

- Quality of student work improves in terms of intellectual depth and creativity.
- Students communicate ideas with better focus and clarity.
- Student course evaluations report:
  - \* New ways of approaching material.
  - \* Using “new” parts of the brain.
  - \* Enthusiasm for course material.
- Students congregate in the space outside of class.





# Integrated Science Building University of Massachusetts Amherst

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Enthusiastic and passionate about interdisciplinary science.
- Aware that boundaries in science are artificial.
- Excellent communicators of science.
- Well-trained experimentalists who think critically.
- Motivated learners.
- Eager to participate in independent research projects.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

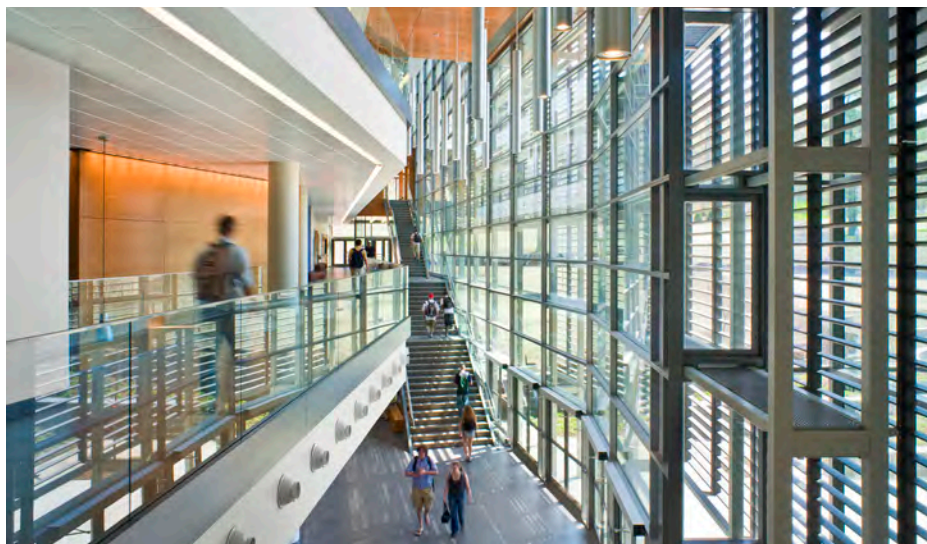
- Experiencing learning in an environment in which interdisciplinary boundaries are becoming dissolved.
- Experiencing learning in a community in which students are introduced at an early stage to the work of advanced students, and advanced students to the work of researchers in the lab.
- Engaging in interactive laboratory experiments that exploit top-notch instrumentation, giving students first-hand experience with how science in the field is done.



# Integrated Science Building University of Massachusetts Amherst

## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Beautiful welcoming laboratories with instrumentation clusters shared between traditionally separate subfields of chemistry and with biologists.
- Traffic flow designed to enhance contact among students from different courses.
- Laboratories and classrooms designed for student participation in discussions among themselves and with instructor.
- Outstanding support spaces optimized to house state-of-the-art instruments.
- An open laboratory floor plan and gorgeous common spaces that encourage student peer learning and interactivity.
- Spaces that reflect the evolving relationship of the chemical and life sciences in the 21<sup>st</sup> century.



## HOW DO WE KNOW?

- Increasing numbers of students matriculating in science courses and choosing to major in sciences.
- Anecdotal information that students now favor interdisciplinary fields such as biomaterials, biophysics, and biochemistry.
- Increased student engagement in Socratic discussions, in and outside of the classroom.
- Placement of students into top-notch graduate programs and employment in cutting-edge disciplines.
- Anecdotal evidence that more students are voluntarily exploring new curricular challenges such as advanced classes (e.g., Drug Design), and programs (e.g., Integrated Concentration in Science, iCONS [[www.cns.umass.edu/icons](http://www.cns.umass.edu/icons)]).
- Growing numbers of undergraduate students seeking to do independent research and at earlier stages.





# Active Learning Classrooms (ALCs) University of Minnesota

## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Fearless, confident, independent learners who don't shy away from intellectual challenges.
- Effective collaborators who embrace team work.
- Sophisticated, discriminating users of information and technology.
- Creative problem solvers.
- Generous teachers who share their knowledge, experiences, and perspectives with others.
- Good moms and dads, good citizens, politicians, bankers, voters, doctors, etc., who have a real understanding of science and scientists.



## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Projects that require authentic application of disciplinary knowledge.
- Projects that require students to collaborate, to choose issues that matter to them personally, and to find creative solutions to solve the problem.
- Grading strategies measure standards-based performance rather than identifying a bell-shaped curve of relative performance.
- Classroom activities that require and reward critical discussion.
- A collegial, respectful relationship between students and faculty.





# Active Learning Classrooms (ALCs) University of Minnesota



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Spaces built on the principles of flexible, reconfigurable design.
- Learning environments incorporating technology that permits display of student work to small groups or to the whole class.
- New spatial configurations that reorient the relationships between students and instructor, and among students themselves.
- Spaces that encourage students to take ownership of their learning, and that are available for informal student use.

## HOW DO WE KNOW?

Controlled studies have shown that new learning spaces:

- Improve students' engagement in the learning process.
- Help students to outperform final grade expectations, resulting in enhanced learning outcomes.
- Affect teaching-learning activities, even when the instructor attempts to hold these activities constant.
- Are most conducive to student achievement when instructors blend lecture with active, student-centered teaching methods.
- Are perceived in a largely positive light by a broad cross-section of students and instructors.
- Require some adjustment to different lines of sight and focal points.



## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Active participants instead of passive learners.
- Self-confident and motivated to continue a lifelong process of learning and discovery.
- Accountable members of interactive learning groups in which participants communicate and negotiate understanding of the sciences.

## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Discussing and analyzing collaboratively.
- Applying science principles and the scientific method of investigation as a method of investigation in other learning environments and situations.
- Taking part in inquiry-based, integrative learning by means of interactive lectures with professor and peers.
- Observing scientific demonstrations that stimulate small group discussion.





## Jordan Hall of Science University of Notre Dame



### WHAT SPACES ENABLE THOSE EXPERIENCES?

- Seamless sequence of spaces that accommodates the collaborative process to continue past class time in spaces outside of the lecture hall, where students have access to resources to further facilitate post-class discussions.
- Large enrollment instructional spaces that:
  - \* incorporate multiple interactive communications methods in real time, yet can be intimate for small student groups.
  - \* provide two rows of moveable seating with fixed tables per tier that can be arranged for lecture activities and rearranged for small group discussion.
  - \* accommodates the individual, reflective learner as well as social learners.
  - \* are equipped with multiple, large scale viewing screens allowing instructors to feed several different images simultaneously from an instructor's computer, live video feeds, and from experiments being conducted at the front of the room.
  - \* have an enclosed fume hood used for demonstration purposes that can occur safely while being filmed and broadcasted on one of the large viewing screens.

### HOW DO WE KNOW?

- Increased enrollment in science majors (9.2% increase the semester Jordan Hall of Science opened).
- Increased science course enrollment by non-science majors.
- Has attracted exceptional new students, faculty, and administrative staff.
- Increased bachelor's degrees awarded (38% increase within two years of Jordan Hall of Science opening).



## WHAT DO WE WANT OUR LEARNERS TO *BECOME*?

- Aware of the powerful role they play in their own learning.
- Effective collaborators and participants in team activities.
- Comfortable asking for assistance and accessing expert advice in a timely manner.
- Connected with faculty, support providers, and peers during the learning process.
- Digitally literate citizens who communicate about and use technology effectively.

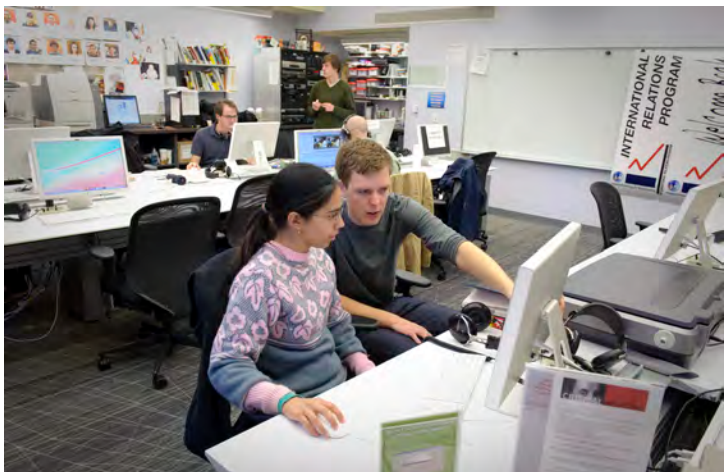
## WHAT EXPERIENCES MAKE THAT *BECOMING* HAPPEN?

- Collaborating in a flexible, technology-rich space.
- Interacting with tutors, peer advisors, faculty, teaching assistants, librarians.
- Preparing, practicing, recording, and receiving feedback on presentations.
- Connecting virtually via video and web conferencing.
- Having students take ownership of the space— feeling comfortable and in control.





# Weigle Information Commons & Education Commons University of Pennsylvania Libraries



## WHAT SPACES ENABLE THOSE EXPERIENCES?

- Bright, cheerful, inviting spaces that provide a relaxed yet study-focused ambience.
- A variety of spaces close together so groups can reconfigure on the fly.
- Space with well-integrated, reliable, and robust technology.
- Clean design with transparent and semi-transparent boundaries between spaces.
- Self-service use models with clearly marked assistance available nearby.

## HOW DO WE KNOW?

- Visual confirmation: the spaces are full and vibrant, with a variety of learning related activities.
- Engagement: students interact with staff and peers in-person, virtually and through social media.
- Inspiration: faculty inspired to explore multimedia use in pedagogy, new types of assignments and course materials.
- Behavior: students ask questions, make suggestions, help each other, present workshops.





# Part II-B

## Institutional Essays



There is one timeless way of building. It is thousands of years old, and the same today as it has always been. The great traditional buildings of the past, the villages and tents and temples in which man feels at home, have always been made by people who were very close to the center of this way. It is not possible to make great buildings, or great towns, beautiful places, places where you feel yourself, places where you feel alive, except by following this way.

There is a definable sequence of activities which are at the heart of all acts of building, and it is possible to specify, precisely, under what conditions these activities will generate a building which is alive. All this can be made so explicit that anyone can do it.

— Christopher Alexander. *The Timeless Way of Building*. Oxford University Press, 1979.



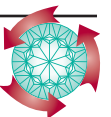
Research from the field of cognitive science provides one answer to two fundamental questions facing today's leaders intent on creating a learner-centered environment:

- why is such an environment needed?
- how can such an environment be realized?

Insights from this research have been a catalyst on many campuses for taking a new look at how students learn. It validates what heretofore had been mostly intuitive: that people learn best by working in teams, when they have personal engagement with what is being learned, and when what they are learning becomes relevant to the intellectual and physical worlds they experience beyond the classroom and lab. Most important, that learning is most effective when there is a visible and supporting community.

A learning environment developed from such insights is distinctly different from one that sees the student as a passive recipient of information transmitted from a teacher.

— From the LSC Archives

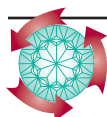




# Part II-B: Institutional Essays

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# Integrated Science Complex (ISC)

## College of the Holy Cross

### The Challenge

The redesign of science facilities at the College of the Holy Cross (CHC) was prompted by a site visit from foundation representatives who made it clear in their report that our aging facilities gravely threatened our capacity to attract the nation's best students and leading teacher-scholars in the physical sciences.

Thus, this project was designated as a leading priority in the College's strategic plan, and a committee of administrators and faculty developed a design explicitly intended to foster specific curricular goals and educational outcomes that reflected the mission and the vision of the College of the Holy Cross.

*Space matters. It can limit what we can achieve in classrooms, laboratories, studios, and other work spaces; or it can open up many exciting new possibilities. It influences the way we interact and even how we feel about ourselves, one another, and our institutions. The quality of our facilities and the way they are maintained also send a strong message about our institutional commitment to excellence.*

— Michael C. McFarland, S.J.  
CHC President (2000 – 2011)

### Design Goals

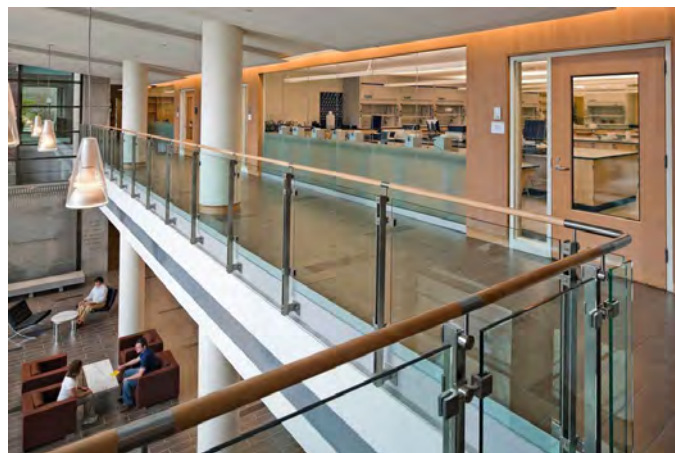
Through a highly inclusive, participatory process, we established four goals that would undergird the design process, giving attention to what would be happening within the spaces and to how the spaces would serve our institution over the long-term, to design spaces that would:

- Say to all, “come inside, stay awhile, see what is going, become engaged with science.”
- Promote new teaching, curricular, and research connections among faculty from five originally disparate departments.
- Achieve the highest level of energy efficiency and cost-savings possible for a STEM learning facility in New England.
- Speak about science, about Holy Cross's science tradition, about our commitment to being good stewards, giving attention to energy utilization and savings.

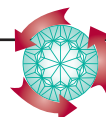
### Design Principles

Key elements in the design included:

- Supporting and enhancing how learning happens at CHC, with special attention to Discovery Chemistry (DC), a pedagogical approach developed some decades ago by CHC chemistry faculty. DC is a lab-based, guided inquiry learning experience, introducing students in the four-course introductory chemistry sequence to the scientific method.
- Putting science on display—not only to continue highlighting the College's rich legacy in the sciences, but also to attract new students into introductory courses, encouraging them to pursue further studies and—hopefully—further research in these fields.
- Making visible the learning and doing of science, with transparency and clear sightlines into laboratories and write-up spaces—a true showcasing of science to the CHC community, spaces enlivened by bountiful natural light.



- Building a community of learners, with spaces welcoming to students and faculty, spaces comfortable, inviting, safe, and supportive of our Discovery curricula, spaces for individual and group study scattered throughout, with particular attention to the relationship between departmental offices and clusters of community spaces.



## Discovery Chemistry in Practice

In the DC environment, students explore a guiding question, for example: “What is the relationship between the mass of the product of a precipitation reaction and the mass of the reagents?” From their exploration of that question, they then must predict the appearance of a graph that demonstrates that relationship. Their predictions often vary based on their growing level of chemical intuition. Students collaborate in collecting and pooling their data, which are then used to evaluate their predictions and introduce chemical concepts in the subsequent discussion-based lecture sections. This process makes the lab experience key to the learning process.

Our new and renovated spaces wonderfully complement this approach to learning. Classroom spaces attached to the labs—with flexible tables and large chalkboards for students to work problems and share data—are conducive to group work. Their adjacency to the lab allows easy movement between collecting data and discussing our progress. These open labs, which accommodate up to 32 students, have hoods along the walls, glass windows into the hallway that admit natural light, and open benches in the middle that allow the instructor to observe all student groups at one time.

As students advance beyond the general and organic chemistry curricula, the upper level courses are taught in a combined physical, analytical, and instrumental Super Lab Suite that can accommodate twenty students. As faculty teach labs in a round robin format, the open space and the size of the Super Lab Suite allow instructors to see all student groups, circulating to provide assistance as needed. Again, the adjacent classroom provides the critical space for students to integrate hypothesis generation with data collection and analysis.

“The layout of the Super Lab Suite allows for group discussion around each instrument without disturbing conversations at neighboring experiments,” according to Professor Sarah Petty. “In the adjacent open wet lab space, students at the bench can easily hear instruction from the professor, even when the lab is full and many instruments are running.”

Particular attention was given to sound quality. The intent was that all rooms (from offices, to research and teaching laboratories, to tiered classrooms) to be free of the background noise caused by air movement

and we wanted to be able to speak at normal volume in all spaces. To do so, it was insisted that acoustics were a central feature of the facility’s design and we dealt frequently with the architect’s acoustical specialists to select the materials for interior spaces and to purchase quiet fume hoods that allowed us to achieve this goal of extraordinary sound quality.

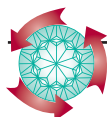
## What Difference Do These Spaces Make?

*Come and stay awhile.* Extensive use of interior and exterior glass makes science teaching, learning, and research evident to all, providing a bright unencumbered air to classrooms, laboratories and offices. Use of glass walls in labs enable good lines of sight and adds to the safety of undergraduate research across adjacent spaces. Carefully located areas of various sizes for individual, study, group work, and informal social interactions encourage student ownership of the space.

*Promote new connections.* Knowing that proximity can lead to new relationships among individuals, programs, and departments, the new building was strategically placed to physically connect biology, chemistry, mathematics/computer science, physics, and psychology. Within months of opening, new research and teaching collaborations were established among students and faculty across these departments, collaborations enabled by the opportunity to share equipment, labs, and classrooms.

*Make science visible.* With an energy monitor in the lobby, everyone can readily see the energy consumption of the buildings and assess the carbon footprint saved by the new technologies incorporated into the design. The monitor can alternate these energy displays with photos and descriptions of the College’s noted science graduates, recent publications, student and faculty accomplishments, community science outreach programs, etc. All complete the story that the sciences are a central part of the liberal arts and of the College of the Holy Cross.

**Architect:** EYP Architecture & Engineering  
**Photos courtesy of:** College of the Holy Cross and Malyszko Photography  
**Location:** Worcester, MA  
**Gross square footage:** 44,000 gsf New / 104,000 gsf Renovation  
**Cost (Construction):** \$41.6 M  
**Construction period:** 5/2007 – 3/2010  
**Date completed:** March 2010  
**Disciplines housed:** Chemistry, Physics, Mathematics with Biology, Psychology, Computer Science and the Science Library



# Stuart Hall and James Hall Dickinson College

## The Planning Process

The process of translating Dickinson's culture and history into new spaces for science was the process of getting the planning right. Its beginning as a frontier institution is still honored through the idea that the liberal arts and sciences are essential in preparing all Dickinson graduates for responsible citizenship into the future. This commitment is reflected in their academic programs and in the spaces in which those programs are housed. The planning and the architectural design of the new science complex was intended to assert the centrality of the sciences to the mission of the College.

Completion of the Rector Science Complex will not only reunite all members of the biology Department in one physical space, but it also will facilitate the exchange of ideas between faculty with similar and diverse interests. Often the ideas that generate the greatest progress originate from a different perspective that sparks a new way of thinking about a long-standing problem. I am looking forward to the exchange of ideas about my teaching and research among all of my colleagues in the Rector Science Complex.

—Michael Roberts, Associate Professor of Biology

The planning process was intentionally transparent. The strategy of making the planning process transparent to all required the right team—or, in Dickinson's case—the right set of planning teams. The core team involved faculty, facilities officers, and students. One important lesson learned from the involvement of students was to engage them early and often. When the planning process began, first-year students were invited to join the planning team so there could be consistent student participation over the months and years it takes with a major facilities initiative such as this.

The planning team aimed to create a social heart for the sciences, a home for a 21<sup>st</sup> century science program, reflecting Dickinson's vision of the future of science learning on this campus.

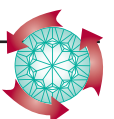
## Planning Goals

- To create a facility that asserts the centrality of the sciences within a liberal arts education and that serves as a home base for the community of science learners and practitioners.
- To continue Dickinson's tradition of being at the forefront of pedagogical change through "workshop" approaches, interactive labs, and fieldwork.
- To accommodate research-based pedagogical approaches that are learner-centered, team-based.
- To facilitate opportunities for students to engage in complex scientific research with faculty equally committed to teaching, mentoring, and to first-class research.
- To create spaces that signal the increasing interdisciplinary nature of science, that enable learning and research in cutting-edge scientific fields.



## Making Learning Visible & Connected

The immediate impression walking into the Rector Science Complex is how transparent everything is, how seamless everything is. Both transparency and seamlessness reflected the planning goals focusing on dissolving boundaries between disciplines, between formal and informal learning spaces, between learning in a classroom and learning in a lab.





The power of transparency is evident from stepping first into the spine, the social heart of the complex. It includes an atrium, smaller spaces for group study, and for the display of posters and other artifacts putting science on display. The spine opens up to the street directly across from the dining center. It thus becomes a welcoming place for all students, offering social spaces for informal collaborations and conversations that build communities of learners—with and beyond the fields of science.

Faculty chose to have their offices located in ways that integrated the disciplines physically just as the academic program integrated them intellectually. This was a pragmatic planning decision, not made arbitrarily or without reflection. Weaving the thread of transparency throughout the wings also influenced the design of office suites and teaching labs.

## Building on the Past

For more than 25 years, faculty at Dickinson have been pioneers of pedagogical change. The concept of workshop physics, developed on this campus by Priscilla Laws and widely adapted in other settings, was grounded in a conviction of the value of student-centered learning.



The time has come! We should help undergraduates move from being passive receivers of truths revealed in the canonical introductory texts, to being disciplined solvers of problems, and finally to becoming constructors of their own knowledge.  
—Priscilla Laws

The evolution of workshop physics had sparked a series of earlier renovations of the old Tome Building (built in 1883, one of the oldest continuously operating science buildings in the country).

Thus Dickinson faculty had decades-long, first-hand, onsite experience with reimagining spaces: knocking out walls to make learning in classrooms visible to those passing by, with arranging furniture and technologies to accommodate interactive learning and with students spilling out into corridor spaces to continue in-class discussions and collaborative projects.

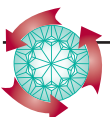
All of these experiences catalyzed ideas incorporated into the planning and designing of the Rector Complex.

## Assessment Findings

- % of science majors increased—from 15% in 2009 to 20% in 2012.
- % of students pursuing a minor in one of the science disciplines increased from 29% in 2009 to 34% in 2012.
- Surveys in 2013 of the Class of 2012 indicated that 82% regularly “apply information literacy and research skills” gained as undergraduates in their professional lives.

Information about the impact on students is gathered through surveys administered at the beginning of their first year and again at graduation, tracking goals/expectations and outcomes of various dimensions of their learning experience (academics, professional development) and with their overall experience at Dickinson.

**Architect:** ZGF Architects LLP  
**Photos Courtesy of:** Chuck Choi  
**Location:** Carlisle, Pennsylvania  
**Net/gross square footage:** 84,186 NSF / 90,000 GSF  
**Cost:** \$29,926,560  
**Construction Period:** July 2006 – August 2008  
**Date completed:** August 2008  
**Disciplines Housed:** Biology, Biochemistry, Molecular Biology, Chemistry, Neuroscience, and Psychology



# Link Teaching and Learning Center Duke University

“The classrooms are amazing! As a freshman, I absolutely loved my first day of Duke classes in the Link. The furniture, the architecture, and the technology all make me feel like a real student.”  
— Student

The planning and design of the Link Teaching and Learning Center (opened August 2008) was significantly influenced by the experience of recent renovated “prototype” spaces on our campus, as well as by larger trends in higher education emphasizing the impact of flexible spaces for collaborative learning. Our vision included technology-enhanced classrooms, group study spaces, informal learning spaces, and on-site support that would promote effective teaching and learning, including collaborative and problem-based learning activities.

## Planning Goals

- All learning spaces should be fundamentally excellent teaching environments with appropriate square footage/seat, good sightlines and acoustics, pleasant aesthetics, transparency, as well as lighting and control systems.
- Spaces should maximize flexibility with respect to furniture systems, teaching walls configuration, infrastructure for power, data, and information technology as well as audio visual systems.
- Spaces should support a range of learning and teaching styles and pedagogies.

The charge to planners was two-fold: to arrive at environments that could allow for experimentation with new pedagogies and technologies and to capture lessons learned to inform the evolution of other learning environments on campus.

Within this framework, an intensive planning, design, and construction process took place. Senior leadership led the effort in consultation with architects, faculty, students, information technology specialists, and instructional design specialists. Final decisions were guided by reflecting on the needs of a broad range of courses, including specific examples of technologically-intensive courses that could be uniquely supported in the Link.



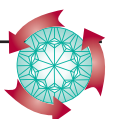
“The whiteboard walls, the technology available in the classrooms, and the location. You can go from class directly into studying.”  
— Student

The Link project—in its planning and its use—provided a significant opportunity for evaluation and assessment to inform future academic space planning at Duke.

This process is repeated regularly to identify key elements of success and highlight areas for improvement.

## Assessment Evidence

The project included a requirement to conduct ongoing assessment of the Link to confirm that the design principles work in practice. The initial assessment was completed in January 2009. Based on data gathered from multiple sources including student and faculty web surveys, systematic observations, analysis of service records, and staff and faculty discussions, several factors defined the success of this ambitious project.



# Link Teaching and Learning Center Duke University

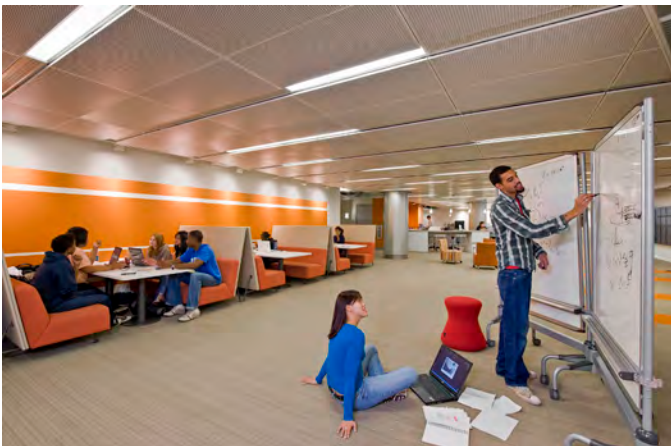
- *Architecture and design concept:* Students and faculty typically singled out these aspects when asked what they liked best about the space. The modern design and aesthetics were almost universally well-received.
- *Co-located formal and informal learning spaces and flexible classroom features:* The clustering of classrooms, group study and common study space has been viewed as a success by faculty and students. The permeable boundary between the classrooms and study spaces resulted in tangible benefits to teaching and learning experiences.
- *Convenient access to technology, services and support:* Classroom support was a significant advantage to faculty teaching in the space. Availability of equipment for checkout at the Service Desk was also praised by both faculty and students.
- *Location:* The convenient and central West Campus academic quad location as well as proximity to library resources and services were cited as key features by both students and faculty.

As a result of the ongoing assessment, successful elements led to adjustments in space planning throughout Trinity College of Arts of Sciences and Duke University. These included:

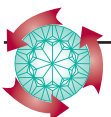
- The popularity of the Walltalker® floor to ceiling writing surfaces led to the installation in other teaching spaces, which immediately increased the level of satisfaction for users of those spaces at very low cost.
- The technology and flexibility of Link spaces served as a model for a space supporting the unique Wired! program in the Art, Art History and Visual Studies department.
- Recent renovation of a Language Lab suite converted a space with partitioned recording stations to a flexible “Link-like” space with lightweight furniture and technologies to support collaboration with non-Duke language instructors.

Perhaps most important is that Trinity College of Arts and Sciences now has a policy that requires creation of open collaboration spaces in proximity to a suite of classrooms. Like the Link, this mix of formal and informal spaces has proven to be extremely popular and promotes unexpected student/faculty interactions.

The Link’s success extends beyond the boundaries of the space and continues to serve as a place where experimentation in pedagogy and classroom design will continue to guide Duke’s effort to meet the needs of the 21<sup>st</sup> century learner.



**Architect:** Shepley Bulfinch  
**Photos courtesy of:** Duke University, Shepley Bulfinch, and Anton Grassl/Esto  
**Location:** Durham, North Carolina  
**Net/gross square footage:** 23,900 sf  
**Cost:** \$7.1M Construction and Equipment  
**Construction period:** 12 months  
**Date completed:** August 2008  
**Disciplines housed:** Multi-disciplinary (Humanities, Social Sciences, Natural Sciences, Environmental Sciences, Engineering, Public Policy)



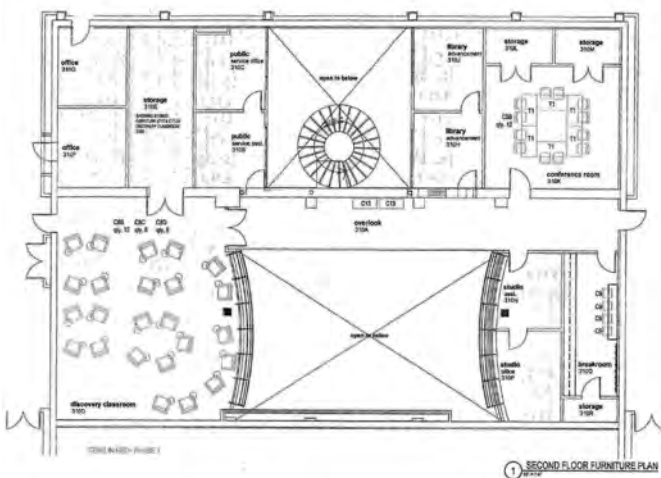


# The Noel Studio for Academic Creativity

## Eastern Kentucky University

### Background and Dream

After years of planning and discussion, Eastern Kentucky University (EKU) broke ground in 2009 on one of the most innovative construction projects in our history: the Noel Studio for Academic Creativity. The project absorbed the previous writing center within a new, creative, cutting-edge space at the heart of the Crabbe Library at the center of campus. Encouraged with a generous gift from by Ron and Sherrie Lou Noel, who wanted EKU students to have access to spaces and resources that would facilitate creative thinking, the Noel Studio opened its doors in 2010.



EKU students and faculty work side-by-side with Noel Studio staff members in the most innovative, technologically sophisticated spaces on campus, which include the Greenhouse (the large collaborative space that serves as its core), and the Discovery Classroom (the flexible classroom used as a teaching and learning space for Noel Studio pedagogy). It is the physical embodiment of the dream of two persistent visionaries (librarian and writing center director) who had nudged the EKU community for many years.

The space which the Noel Studio now occupies was a dark storage area holding books that were dusty and outdated, many untouched for years. Three long-forgotten skylights needing repair covered the ceilings. Although the space was physically central, it was underused and uninviting. Administrators and donors believed that such a central space should serve all members of the EKU community, and administrators began to set forth an image of a centralized, student-centered space that would change how “communication” teaching and learning happened on our campus.

### Creativity

For those responsible for planning, supporting, and using the Noel Studio, the creative process necessarily involves several elements:

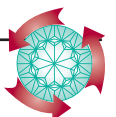
- *Perception shift*: looking at problems from multiple angles.
- *Re-learn/un-learn*: re-examining a normal approach to a problem.
- *Question*: examining a problem with persistence.
- *Plan*: experimenting with ideas in a safe environment.
- *Collaborate*: getting feedback on ideas and revising as necessary.

Even though concepts such as a ‘thesis statement’ are presented in the classroom, the Studio environment challenges students to see ideas presented again in a fresh atmosphere. Students like to be in the Discovery Classroom, because it is conducive to interaction and creativity in ways that are different from a formal classroom.

—Faculty member

The creative design of the Noel Studio allows students to:

- Practice and review oral and nonverbal communication using private rooms equipped with recording capabilities.
- Interact with composition and research using touch-screen monitors.
- Brainstorm and map ideas on wall-to-wall and mobile whiteboards.
- Collaborate with peers in both open and private settings.



# The Noel Studio for Academic Creativity Eastern Kentucky University

What works: data from student surveys

- 95% strongly agree or agree that they feel more comfortable identifying the thesis/purpose of their assignment while in the Studio.
- 92% strongly agree or agree that they are more able to consider their topic from multiple perspectives.
- 98% strongly or agree that they feel more confident using information from their Studio sessions in planning next steps for their class assignment.

## Program, Pedagogy, Place

At its core, the Noel Studio is a dynamic, integrated, and technologically-sophisticated environment that inspires individual and collaborative learning. Its design accommodates multiple learning styles, while open and fluid spaces provide the flexibility to let faculty and students maximize learning. As a program, the Noel Studio develops informed, critical, and creative thinkers who communicate effectively. As a place, the Noel Studio provides the EKU community with a unique, flexible space intended for communication design. It is designed to engage students and faculty from a variety of disciplines, all spatial affordances carefully designed to invite creative, convergent and divergent thinking.

## Lessons Learned in Planning

Reflecting on our many years of planning, some important lessons can be distilled:

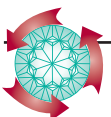
- Form integrative, sustained collaborations that align key stakeholders planning toward one jointly agreed upon mission and vision. Collaborators should come together regularly over time to discuss key issues and opportunities in the design of reinvented or new spaces.
- Develop and maintain an entrepreneurial spirit that guides day-to-day planning collaborations and events. Explore new, provisional models that can support the design process, space, and programming.

- Re-purpose existing spaces and concepts, intent on improving and energizing them. Take current concepts and give them a new, unexpected, or exciting perspective that encourages use, collaboration, or learning.
- Let pedagogy drive space design. Envision how visitors will navigate the space, what they will do when they arrive. The space should be designed to provide an experience—aesthetic, academic, or in many cases both, for students, faculty, and all visitors.



The Studio is an ideal venue for learners of all ages and there are active collaborations on a regular basis with area schools to integrate communication and creative-thinking initiatives into the community. Through a collaboration around a community literacy initiative with Madison County, 8th-grade students come to the Studio to use manipulatives to construct visual representations of characters and scenes from their favorite book.

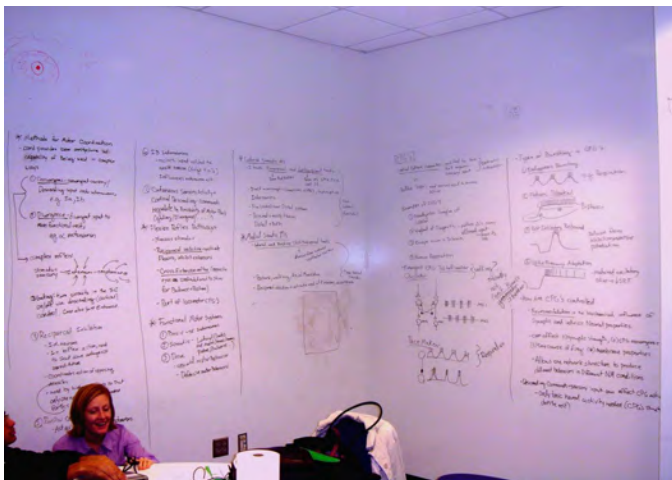
Planning and design by the institution  
Photos courtesy of: Cindi Trainor, EKU PR  
Net/gross square footage: 10,000  
Construction period: 2009-2010  
Date completed: September 2010  
Disciplines housed: Minor in Applied Creative Thinking but sees students from all colleges at EKU



# Problem-Driven Learning

## Georgia Institute of Technology

You are a first-year student at Georgia Tech, a declared major in biomedical engineering. In the first day of your first required course you go to class and walk into a room that is markedly different from any classroom you have seen before. A small group of your peers and one faculty member are also here. In introducing the course, the faculty member uses terms you may have never heard before: problem-driven learning, agentic learning, describing these as approaches to creating boundary-crossing agents, empowered self-directed learners, model-based reasoners.



This describes the experience of entering BME majors at Georgia Tech, an experience intentionally designed to socialize each student into the community of biomedical engineers, to prepare students to be able to “assume the persona of the practitioner.”

### Background

The Wallace H. Coulter Department of Biomedical Engineering was founded in 1997 as a joint department between the College of Engineering at Georgia Tech and the School of Medicine at Emory University, with initial and subsequent funding from the Whitaker Foundation.

The Coulter faculty, in collaboration with cognitive and learning scientists in the department, began by proposing to develop undergraduate and graduate programs that embraced a problem-driven learning (PDL) approach to education. Borrowed from medical education, PDL was designed as an apprenticeship model of learning in which small groups work closely with an expert facilitator in solving real-world, complex problems.

Planners recognized this approach was well-suited to the cognitive and learning challenges associated with the field of biomedical engineering, that such engineers must be able to:

- analyze biosystems using physical laws and properties.
- understand pathophysiologies of the human body.
- ultimately design healthcare solutions that address disease and disability.

Most significantly, as identified by the early faculty team, BME graduates need to become integrative thinkers and problem solvers, using the cognitive strategy of model-based reasoning to traverse the gap between the life sciences and engineering. They need to be systems thinkers and accomplished communicators who can work in teams, translating across disciplinary boundaries.

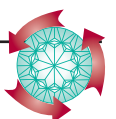
In a constantly changing field, graduates need to feel empowered to direct and evaluate their own learning.

With expertise in cognitive and learning sciences at the table, findings from research in these fields informed this early discussion. The planners explored the nature of distributed cognition, aware that for students to arrive at deep conceptual understanding they must be given multiple opportunities to engage with the same content, opportunities to become agents of their own learning.

Based on National Science Foundation-funded studies of learning in biomedical engineering research laboratories, the team determined that PDL was a more meaningful descriptor of their approach. These considerations both anchored and imbued the design of the building and the classrooms.

### Community of Learners

In early stages of planning the spaces, the concept of a “community of learners” began to emerge. This concept, a model of learning as changing forms of participation and membership in a community, had significant implications for the design of the research and educational space. It celebrates the idea that everyone inhabiting the building would be a learner, but at different scales. Undergraduates and graduates, lab directors, and faculty would all be exploring the frontiers of science.





The intent was to design a building that would support a vertical integration whereby learners at all levels could be made to feel at home, be visible and accessible to each other, mentoring and being mentored, thereby kindling a sense of community.

### PDL Classrooms

As the predominant reasoning strategy of engineers is to create diagrammatic and mathematical models, spaces were needed where engineers could articulate and represent their work in developing these models, so as to engage issues and problems from varied perspectives. The recognition that the work of biomedical engineering practitioners is teamwork also influenced the planning and designing of the PDL spaces.

Thus, a suite of five small PDL rooms with writable white walls to the ceiling became the educational anchor for the building. The surround white boards serve as an external memory, a site for articulating, hypothesizing, and negotiating. More technically, these adaptive walls support a distributed cognitive system, a collective of minds that is necessary to reach a solution to the complex problems given to the PDL classes.

These classrooms spill out onto the BME student lounge area looking out onto a tree-filled quad that invites students to rest, to refresh, to congregate, and to study. Commonly, the comfortable chairs are populated by student teams waiting to use the PDL rooms, study groups working out problems, or sleep deprived students grabbing catnaps from early morning until late at night. This space was meant as a gathering space for BME students, a place that in its very existence announced that they are members of the community. When not in use for classes, the PDL rooms are sought after meeting spaces for student groups, for solitary studying, and for design teams.

The whiteboard rooms give me an opportunity to work with others on a problem. It's very difficult to work out a problem with multiple people when you are limited to solving the problem on a piece of paper. However, with the whiteboards, I not only get a chance to work in a space that is visible to many people, but I get a chance to compare methods to problem-solving. Learning from another student is direct knowledge building, but teaching another student is a way to reinforce an important concept. As a TA, I'll run around helping each student when they reach a block, but it's very satisfying to sit back and watch students teach each other!  
—Student TA

### The PDL Design Studio

The design studio in the basement of the building is generally a mess because it is a studio in the true sense of the word. This is where students take their first steps as designing engineers, learning to draw, build paper prototypes, and navigate a design from start to finish. Cabinets are available for each team to store their materials and prototypes.

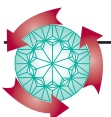
This space is truly reconfigurable and responsive to the changing needs of the student teams. As this is a space with a low ceiling renovated for the purpose of a design studio, a great deal of attention was given to acoustics, since as many as eighty student in teams could be working at the same time. Carpet, acoustic ceiling tiles, and pushpin fabric wallboards keep the sound at a very manageable level even when the design teams are busy communicating or building prototypes. The ambiance is relaxed and inviting, signaling to students that they are welcome whenever this space is not reserved.

### Other PDL Spaces

The other three levels of the building house the research laboratories and offices where significant numbers of BME undergraduate and graduate students mingle and work. Open lab spaces are the norm where resources are pooled and equipment is shared. Conference rooms are found on every floor where a faculty committee meeting might follow a student meeting. Anyone can reserve these rooms for gatherings, fostering a co-mingling of faculty and students on all floors.

Taken together, the PDL classrooms, the design studio, the research labs, the mechanics shop and the instructional labs have been designed to support and nurture a community of learners, where students are empowered to be agents of their own learning, fearless in the face of a complex problem.

**Planning and design by the institution**  
**Photos courtesy of:** Georgia Institute of Technology  
**Location:** Atlanta, GA  
**Construction period:** 2001 - 2004  
**Date completed:** July 2004  
**Disciplines housed:** Biomedical Engineering Faculty from various science and engineering disciplines



## A Scenario

At Grinnell, students in an introductory chemistry course hear about global warming and greenhouse gasses in the classroom. They then go to the lab and measure the temperature difference between two beakers with a sun lamp shining on them, one filled with air and one with another gas, like carbon dioxide or oxygen. They repeat this for about eight different gasses. Pooling class data in a spreadsheet, they then note variation in measurements, seeing some clear trends: Some are clearly greenhouse gasses; others are not or have ambiguous results.

Students, following rudimentary instructions on drawing Lewis electron structures, look for structural similarities in those that are greenhouse gasses and differences for those that are not. Next week they measure the infrared (IR) spectra of the gasses and note which ones absorb lots of IR light and which do not. Moving on, they simulate the IR spectra using computational software, looking at molecular motions that correspond to their actual absorbance measurements, linking this information to their temperature measurements. Students then develop a theory for what structural features correspond to gasses being greenhouse gasses.

In doing this, they learn key chemical concepts not because they are in chapter six or that they might need to know for a later class, but because they are interested in answering an important question and know they need to understand concepts and models to address the question of interest. The added advantage of this learning experience is that it goes beyond learning content. More importantly, in the process of doing science, they become aware that advances in science rarely progress in a linear fashion to a single right answer.

So, what does this have to do with facilities planning?

## Background

For over fifty years, Grinnell College has been recognized nationally as a pioneer in developing research-rich learning environments in the undergraduate setting. This culture was greatly enriched through a two-stage process of planning spaces for STEM learners that began in the mid-1990's.



Goals of the first stage were spaces that:

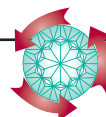
- Support the educational philosophy of the science departments, including provision for discovery-based learning in classrooms and for research by faculty and undergraduates, accommodating essential state-of-the-art technologies and instrumentation.
- Prompted and supported a sense of community among STEM learners and faculty and that could be a living room for the campus.

Those years (at Grinnell) were about pushing myself. The most important thing that happened at Grinnell is that I met three or four mentors at Grinnell who helped me to push the boundaries of what I had done prior.  
— Student

## Lessons Learned

Features of spaces that accomplish our goals included:

- Teaching labs designed more like research labs to promote research-type activities and provide summer research space.
- Classrooms designed to promote the engaged learning that is collaborative learning.
- Public spaces in corridors with tables and chairs for individual and group work and for poster sessions and other public community events.



- Tack boards scattered throughout for posting student research, making visible the process and results of the doing of science.
- Exterior glass to provide transparency into the building, spotlighting activity, together with windows within the building to bring natural light and energy into the interior spaces.

## Findings from Research

With the completion of the first facilities phase and support from an NSF AIRE award, in 1998, David Lopatto, a member of Grinnell's Psychology Department, undertook a study of what and how undergraduates learn when engaged with faculty in research labs and in course-based research-like experiences.

Findings from this work, undertaken in collaboration with colleagues at other institutions, provided powerful organizing principles and goals for moving into the second stage of planning STEM spaces at Grinnell.

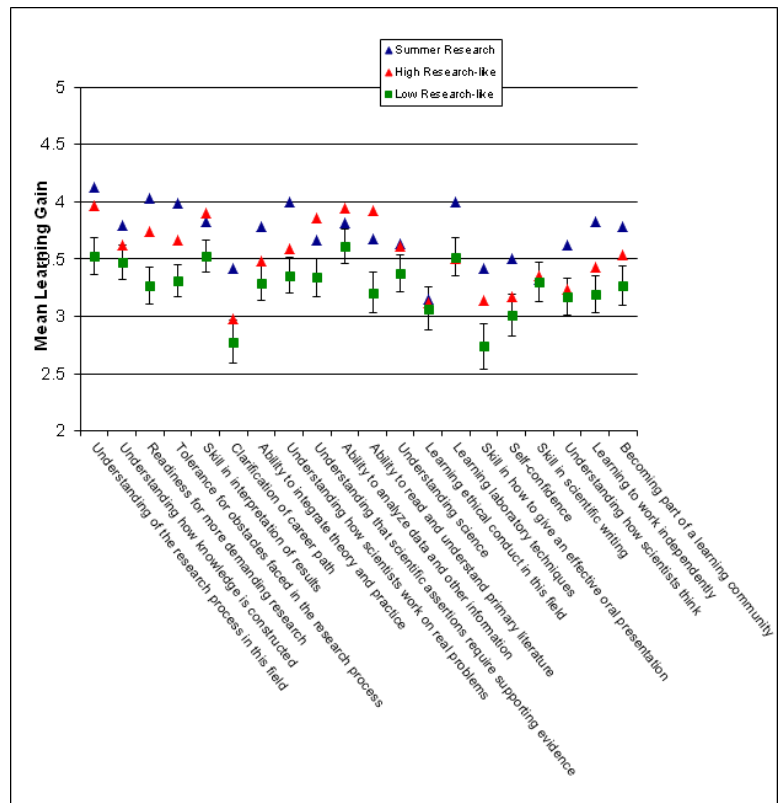
Major findings of their research included:

- Student-reported gains in disciplinary skills, research design, information or data collection and analysis, information literacy, communication, and a readiness for more demanding research.
- Student-reported gains in personal development, including the growth of self-confidence, independence of work and thought, and a sense of accomplishment.
- Undergraduate researchers were more tolerant of obstacles faced in the research process.
- The quality of mentoring is a strong influence on student experience as it allows the instructor to break down the distinction between classroom learning and research.

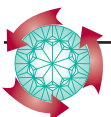
In the process of his research, Lopatto designed the CURE (Classroom Undergraduate Research Experience) survey, seeking to document the impact of working as an undergraduate researcher in teams or with peer mentors. Lopatto has compared student learning gains over three types of experiences: dedicated summer research, traditional science

courses, and courses incorporating research-like experiences. He finds that students in research-like courses report gains close to a dedicated research experience.

The STEM community of learners at Grinnell, informed by Lopatto's work and on their own experiences in classroom and lab, has a communal understanding that research experiences, both within courses and stand alone, can be significant maturation times for students, where they can both learn and discover themselves, choosing and refining their beliefs. In this sense, expertise is defined both by cognitive capacity and by the self-knowledge and beliefs to which one is committed.



**Architect:** Holabird & Root  
**Photos courtesy of:** Grinnell College  
**Location:** Grinnell, Iowa  
**Net/gross square footage:**  
 Phase one: 109,000 GSF / 62,000 NSF  
 Phase two: 155,000 GSF / 88,000 NSF  
**Cost:**  
 Phase one: \$22 Mil Proj / \$19 Mil Const  
 Phase two: \$45 Mil Proj / \$38 Mil Const  
**Date completed (projected):**  
 Phase one: August 1997  
 Phase two: August 2007  
**Disciplines housed:** Biology, Chemistry, Physics, Mathematics, Computer Science, Psychology





# Biomanufacturing Research Institute and Technology Enterprise (BRITE) North Carolina Central University

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## The Planning Process

The innovative idea behind the planning of BRITE was the dream of shared science facilities and a hands-on campus research environment that would connect STEM learning in the undergraduate setting to STEM research and real-world practice, developing a best-in-the-nation workforce for the region's fast-growing biotechnology, bio-manufacturing, and R&D employers.

The planning challenge (2006) was that there were no resident faculty to guide the process and few existing models to adapt spaces designed intentionally as a bridge between academe and industry, or different levels of learning—middle school through high school to undergraduate and graduate communities of learners. The final placing and presence of the BRITE facility signaled their intent to bridge communities and cultures, the present and the future.



However, the diversity of the planning team reflected the intent of NCCU leaders that the resulting spaces had to reflect attention to interdisciplinarity, sustainability, contemporary pedagogies and technologies, as well as to the biotech world beyond the campus. The team included representatives of the University's finance, administration, science faculty and the deans of the Law School, Arts and Science School, and the School of Business.

Working with the guidance of Dr. Li-An Yeh, (then newly hired as BRITE Director) and representatives of two design firms, they developed a planning agenda that began with meeting with representatives from biotechnology and biopharmaceutical companies that were expanding operations in North Carolina.

## Bridging to the Corporate Community

This agenda action was strategic at two levels: BRITE representatives set out to learn first-hand the specific skill sets, equipment knowledge, and workplace protocols these firms would like new employees to have. This reflected BRITE's goal of giving students a realistic hands-on career preparation. Bringing the private sector partners into the planning and decision-making helped to turn that vision into a workable design for both program and space.

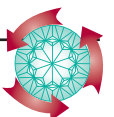
*If you are able to train students in realistic, career-focused research and quality assurance skills, we are happy to help show you how to do it and provide the equipment needed to make it work to everyone's benefit.  
—A Corporate Partner*

It was also strategic in drawing corporate support for building the curricular infrastructure, with many firms providing equipment so that learners at BRITE would be able to learn in conditions similar to their corporate laboratories.

## Key Lessons Learned

One key lesson learned in planning and building BRITE is that, through embracing the knowledge and real-world advice of corporate partners and refining the pedagogy of traditional academic curriculum in response, NCCU now has a stronger competitive position in this region.

The BRITE Center experience, together with North Carolina's statewide programs linked to BRITE, offers a creative model for university systems seeking to expand enrollments in STEM, create jobs, and strengthen alliances with private sector partners in their geographic region.



# Biomanufacturing Research Institute and Technology Enterprise (BRITE) North Carolina Central University



## Key Features of the Space

The BRITE laboratories and classrooms provide a dynamic and everyday connection to what students will experience as life science professionals, effectively blurring the lines between industry and academic facilities. Design features include:

- Laboratories that are easily adaptable, with a limit on fixed benches and heavy use of modular equipment and infrastructure. This also provides for easy upgrades and modifications as lab use and research needs change into the future.
- An entry porch that calls attention to the important place the Biotechnology program has on campus, providing a gateway to the science quad and the entire NCCU campus.
- A pattern of windows on the west elevation that replicates the geometry of an unfolded DNA strand, sending a powerful yet subtle affirmation of what happens inside the space.
- Integration with NCCU's adjacent Mary Townes Science Building, creating a 180,000 square foot, \$56 million science quad, with shared classrooms, lecture halls and auditorium space with science and technology degree programs in the Science Complex.

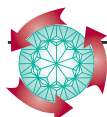
## The Learners

To benefits as many students as possible:

- Any NCCU student interested in life science careers can tap into STEM educational offerings at BRITE.
- Students from rural areas of North Carolina can take biotechnology and science courses at a community college and apply to BRITE for junior year and transfer credits towards a B.S. in Pharmaceutical Sciences.

BRITE also offers opportunities to economically disadvantaged students. NCCU is the nation's first state-supported liberal arts college for African Americans, and is one of ten HBCU's (Historically Black Colleges and Universities) in North Carolina. Successful career training for minority and economically disadvantaged students is a core mission at NCCU, and BRITE (with its partner STEM facilities) provides a comprehensive career ladder for these students, many of whom are the first in their families to attend college.

**Photos courtesy of:** The Freelon Group  
**Location:** Durham, NC  
**Net/gross square footage:** 59,929 SQ FT  
**Cost:** \$17,800,000  
**Construction period:** October 31, 2006 - April 3, 2008  
**Date completed:** April 3, 2008  
**Disciplines housed:** Medicinal Chemistry, Chemoinformatics, Mammalian Cell Genomic Sciences, Anatomy and Physiology, Bioethics, Microbiology, Biochemistry, Immunology and Virology, Biostatistics, Assay Design, Bioprocessing



# Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP)

*How do you keep a classroom of 100 or more undergraduates actively engaged as learners?*

*How do you enable students to practice communicating and working in teams in a large-enrollment class?*

*How do you boost the performance of students from groups currently under-represented in the study and practice of STEM fields?*

*How do you shape a learning environment that enables students to practice becoming a physicist, to begin to see what physics is, what physicists do?*

These are the kind of questions that catalyzed my reimagining of the introductory, large-enrollment physics class at North Carolina State University (NCSU) in the mid 1990's. Initially called Student-Centered Activities for Large Enrollment University Physics, the title (but not the acronym) changed as the concept was adapted to other settings and disciplines.

The pedagogical approach is based on education research documenting how collaborative, immersive learning leads to improved academic outcomes for students. I started not with reimagining the space, but with articulating specific answers to a further question:

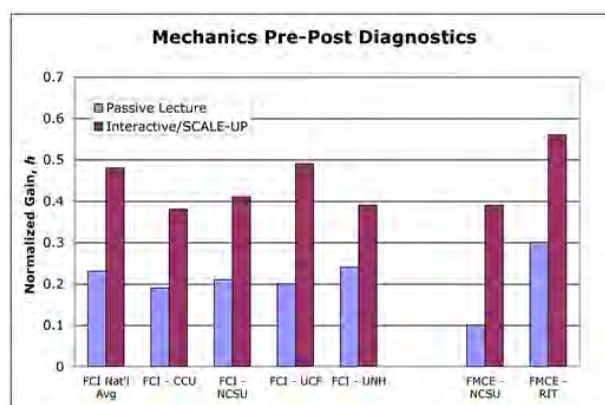
*What do I want my students to be able to do as a result of their engagement in my introductory physics course?*

From specific, detailed answers to that question I started with an iterative exercise: identifying assessment practices by which I could ascertain if students met my performance criteria, and then creating lessons and developing new kinds of instructional materials that reflected my desired learning outcomes and that could provide data for continuous assessment purposes.

Overall, a SCALE-UP environment is highly-interactive, collaborative, hands-on, and technology-rich. It works when there is co-development, implementation, and assessment of pedagogy, teaching, materials, and learning spaces. As far as I can tell, it works for all disciplines, within and beyond STEM fields. With the emergence of a national community of SCALE-UP adapters, significant evidence of efficacy has been documented.

## Assessment Evidence

Rigorous evaluations of learning have been conducted, either in parallel with curriculum development and classroom design work, or as a follow-up to such efforts. Many adopters have given conceptual learning assessments (using nationally-recognized instruments in a pretest/posttest protocol), and collected portfolios of student work. Several schools have conducted student interviews and collected information from focus groups, supplementing hundreds of hours of classroom video and audio recordings made at NCSU during the early development phases.



There is ample evidence from multiple adapting sites that students in SCALE-UP classes gain a better conceptual understanding than their peers in traditional lecture-based classes. As the figure indicates: for the first and second semesters of introductory physics, students performed better on a variety of conceptual surveys.

The pattern apparent in the figure below, where students in the top third of their class made the most progress toward perfect scores on the assessment tests, is an important counter-argument to those who complain that “reform courses only benefit the weaker students and we are ignoring the stars of tomorrow.” Clearly that is not the case.

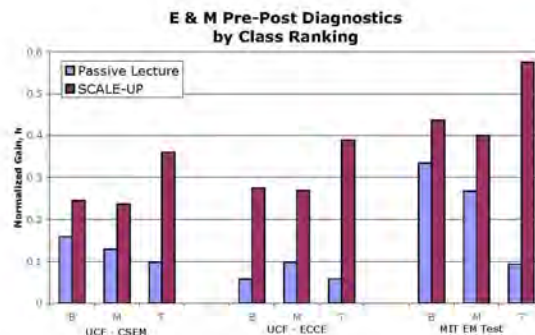


Fig. 6. Students in the top third of their classes gained the most from the SCALE-UP experience.



# Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP)

It is also important to note the affective outcomes of participation in a SCALE-UP learning environment. At institutions where they have the option, students almost always prefer SCALE-UP based classes compared to lecture courses. Although attitudes of SCALE-UP students are sometimes studied directly, they are more often revealed indirectly.

For example, when students select the SCALE-UP version for their second semester, they report that their friends directed them into SCALE-UP classes. (SCALE-UP sections fill before lecture sections). NCSU has a five-year average attendance rate of more than 90%, even though attendance is not required for SCALE-UP classes. At the very least, this implies that students value class time.

At best, it may also indicate they enjoy learning in this type of setting—and it is clear the faculty enjoy teaching in such spaces. As noted in the evaluation of the pilot SCALE-UP classrooms at the University of Minnesota:

*The instructors who were interviewed enjoyed teaching in the rooms so much that their only concern was a fear of not being able to continue to teach in these new learning spaces. Similarly, more than 85 percent of students overwhelmingly recommended the Active Learning Classrooms for other classes.*

## A View into a SCALE-UP Setting

Peeking into one of these rooms, you would note that the learning space looks more like a restaurant than a classroom, or perhaps more like a banquet hall, because there is much noise from the visibly engaged students.

[You] have a professor right in the middle and...a couple of guys spread out and you can flag them down...In the lecture, you are sitting...25 rows back. You really don't have anyone but the two people next to you and they don't know. You really don't have anyone with some knowledge to help you out.  
— Student

Our challenge in redesigning the space for introductory physics was to achieve an environment that would promote the kind of active learning we wanted for our large enrollment classes. What you would see is the realization of our idea that social interactions between students and with their teachers

is the “active” ingredient that works for us. You would see nine students at a 7 foot diameter round table—the size and shape of the tables are very important—working in groups of three or collectively as a table-group of nine.

A short faculty “lecture” would present an interesting scenario for students to explore and would be followed by the instructor roaming around the classroom, engaging students and teams in Socratic-like dialogues. Students spend time on “tangibles” and “ponderables,” which means they are dealing with hands-on activities, simulations, and complex problems.

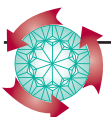


We have integrated instructional technologies into this learning space, and each table has at least three networked laptops (probably not like a banquet hall, but something approaching real eating spaces on college campuses!). These notebook computers give students immediate connections to the resources of the world wide web.

From our own experiences and from research on learning, we knew that as students collaborate on interesting tasks they become deeply and personally involved with what they are learning. The doors of the closets and the walls of the classroom are covered with whiteboards— public thinking spaces— to help them share their learning with each other and their instructor.

### Photos courtesy of:

North Carolina State University, Robert Beichner  
Penn State Behrend, Jonathan Hall  
MIT, John Belcher



# Griffin Hall Center for Informatics Northern Kentucky University

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From its initial cocktail napkin rendering onward, the Griffin Hall Center for Informatics has aimed to embody a complex and still largely unfamiliar term—informatics—with grace and power.

## Background

Around 2004, leaders at Northern Kentucky University (NKU) realized they needed to think differently about the way disciplines were being linked by information science and technology. We recognized that as the demand for graduates in the computing fields was beginning to increase after a downturn at the start of the decade, the growing importance of digital technologies and computational paradigms across many fields was leading to isolated and duplicated programs in the undergraduate setting. The span was great: from journalism to cybersecurity, from computer science to communication studies. Informatics was the name for this unity, but certainly in 2005, the concept was an odd one.

The Griffin Hall Center for Informatics was conceived as a physical explanation of this name. In response, the university created a College of Informatics in 2005, assembling a cadre of campus colleagues from all the disciplines and professional fields that were confronting (and needed to confront) the notion of “information” head on. Connecting to regional hi-tech firms was absolutely essential in our planning, providing real-world insights about what our graduates would need to be able to do as prospective employees in the their firms.

It is easy to imagine that the top 10 jobs in 2015 [will be ones that] do not exist today. That is why innovative companies and public enterprises are engaging the unique talents and capabilities of the College of Informatics.

—Frank Caccamo, Retired CIO  
Procter and Gamble; Reynolds and Reynolds

## Vision

Our vision of a physical explanation of the concept of informatics is expressed in the Griffin Hall Center for Informatics. We imagined a single eye-catching, mind-catching space that would enclose the entire College of Informatics. It would have faculty offices and an advising center, research laboratories and learning spaces for our undergraduate and master’s students. Since NKU is a metropolitan university primarily offering bachelor’s and master’s degrees, extensive faculty research labs were not a need. The focus was to be on spaces for learning.

A lot of people think computer programming is all about being logical, and that is one part of it. But you’ve got to come up with creative solutions to handle a complex problem, and I find that allows me to bring out the creative person in me.

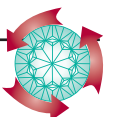
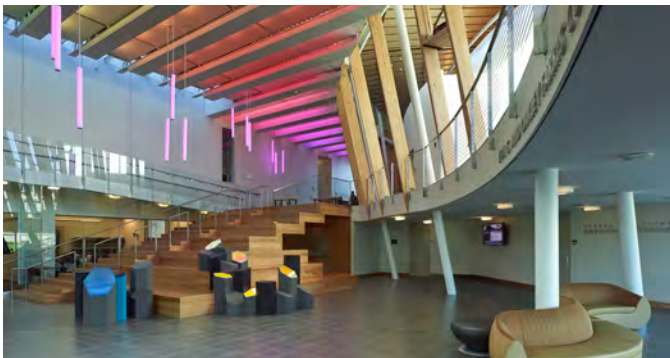
— Ben Bedinghaus, 2011 graduate

## Programmatic & Spatial Characteristics

Opening in October 2011, Griffin Hall highlights the three most salient characteristics of NKU’s College of Informatics:

- *It is silo-breaking*, expressing the view that informatics is a *transdiscipline*—a field transformed by, and transforming, disciplines it engages. Offices, labs, and classrooms are not segregated by department; prospective journalists work and learn side-by-side with prospective computer scientists.
- *It is cutting-edge*. This means that the building is outfitted with the newest technologies (RFID, Intelligent Building System, AVID digital media network), and that it offers a variety of spaces for new pedagogical approaches using those technologies.

A bestiary of decentered classrooms that encourage small group interactions, device-mediated and direct, is available for faculty experimentation. NKU’s Center for Innovation and Technology in Education, housed in the building, is resource for faculty assessing the efficacy of pedagogies employing these spaces.



# Griffin Hall Center for Informatics Northern Kentucky University

- *It is real-world.* A large part of the third floor of this five-story building is given over to the Center for Applied Informatics Mobile/Web Academy, where teams of students work on mobile app development projects for large businesses, small startups, government, and non-profit organizations.

## The Digitorium

One theme emerged as the college worked to encourage students to move from mere consumers of digital technology to becoming analysts and creators: the notion of building-as-playground.

The George and Ellen Rieveschl Digitorium, the heart of Griffin Center, is a two-story, 100-seat auditorium, dominated by a large rear-projection, high definition video wall. Banked theater-style seating (with arm rests and table-tops) retracts fully into the rear wall, bleacher-style, converting the large space into an infinitely reconfigurable, multi-purpose “playground.”

A Lutron/Strand LED lighting system with IP-addressable 20-bit color fixtures illuminates the large common area. (The pastel glow of the building through curved glass has become a signature image of the campus at night.) A programmable digital ticker flows around the two-story lobby, inviting students to express information in lights and flowing text.

The digitorium is infinitely reconfigurable and infinitely multi-purposed. Eight “opera boxes,” which can be isolated by glass doors, are adaptable for small classes, student team work, or seating during a performance ring the second level.

Given this flexibility, the digitorium has been used as a digital opera house, a global command center, a trading floor, theater, and auditorium, hosting individual speakers and collaborative group activities to digitally-mediated human performances to complex, real-time simulations.

As a learning space the digitorium shines. As one example, a novel survey of an informatics course, funded by a grant from the National Science Foundation CPATH program, introduces the notion of “informatics at multiple scales” (from electrons in logic gates to worldwide social networks). Its students are issued iPads and interact with the microtile wall through a variety of apps. A twitter feed is a parallel channel for commentary, and multiple windows display the results of group work.



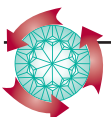
## Evidence of impact

- The cohesiveness of formerly-isolated NKU departments and programs around informatics, with students and faculty from across campus teaching and learning in Griffin Hall.
- Greater connections for students with regional business partners, enhancing the “real-world” goal of the COI.
- Student awards, internships, co-op experiences, career opportunities post-graduation.

In a university where nearly half of its enrolled students are first-generation, most of them commuting to campus, the building has become an inspiring confidence-builder, and a magnet.

It has been a focal point for NKU's efforts to engage broader groups of people with the informatics fields. There is a local and national shortage of graduates in the computing fields, and drawing in students who otherwise would be attracted to non-computing fields is a key goal.

**Architect:** Goody Clancy  
**Photos courtesy of:** Brad Feinknopf and Goody Clancy  
**Location:** Highland Heights, Kentucky  
**Net/gross square footage:** Net 76,044 SF / Gross 133,636 SF  
**Cost:** \$34.1 Million  
**Construction period:** December 2009 to April 2011  
**Date completed:** June 2011





# Discovery Learning Research Center (DLRC) Purdue University

## Background

The Discovery Learning Research Center (DLRC) is a unique active learning environment at Purdue, in that “learners” are faculty seeking deeper experiential knowledge about how students learn and about how particular pedagogical approaches and spatial affordances enhance student learning. In the context of this R1 campus, the DLRC provides an opportunity to bridge the cutting-edge research work done by STEM researchers at Purdue with the exploration of cutting-edge pedagogical approaches—in service of the University’s fundamental education mission. The DLRC has three goals, to:

- Catalyze large-scale, interdisciplinary research programs in teaching and learning, especially in STEM and STEM related fields.
- Promote articulation between the scholarship of teaching and learning and actual classroom practice—at all levels.
- Provide leadership across the University in influencing STEM public literacy and educational policy.

Our goal is to help to bridge the gap between what is known from research on education and what is actually taking place in the classroom. We would like to help Purdue transform educational practice in order to maximize student success, but also to explore educational trends that other universities would want to follow.

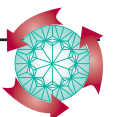
— Gabriela C. Weaver, DLRC Director

## About the DLRC

The DLRC is housed on the first two floors of the Hall for Discovery and Learning Research on the Purdue campus. The DLRC is conceived of as a sandbox space for faculty experimenting with pedagogical innovations, assessing the impact of a particular approach, and determining the influence of spatial variables on the learner. These are a carefully designed and monitored set of strategies that reflect the larger DLRC goals to improve learning within a particular classroom setting and to influence teaching and learning at Purdue campus wide.

The DLRC offers specialized facilities designed for educational research, for developing and experimenting with educational materials, methods, and instructional technologies. The DLRC also engages Purdue colleagues in interdisciplinary collaborations on scholarly projects related to learning. Each of the spaces for learning within the DLRC are reconfigurable as spaces for research on learning:

- The *project laboratory* (STEM) is a space for engineering and group design projects.
- The *science laboratory* is a sandbox space to explore a variety of STEM learning environments within the traditional lab setting.
- The *learning studios* have the flexibility provided by movable walls, furniture and tension grids.
- *Breakout spaces* extend the capabilities of the adjacent learning studios, promoting the interactions and articulation that are the essence of the DLRC.



## One DLRC Product: The Flipped Chemistry Classroom

Gabriela Weaver, DLRC director, doesn't lecture to her general chemistry students—at least not in class. She records short lecture snippets that students review online before the class period. While at “class,” students work problems introduced in those snippets while she wanders around the room, observing students as they are learning, seeking where they are having difficulty.



Her efforts are part of the growing evolution of classrooms that invert (or flip) the traditional sequence of lecture/homework, with professors providing lectures or other course-related materials via the Web and students actively engaged in the formal classroom setting. This approach is adapted from the work of Robert Beichner (featured elsewhere in this guide), originally designed for large enrollment introductory STEM courses.

The whole idea of flipping the classroom and putting most of the content delivery outside of class time is that it frees up the class time, challenging students with more complex, realistic problems, under the guidance of an expert and in collaboration with peers. They get more and deeper opportunities to practice becoming problem solvers.

— Robert Beichner

## Assessment

The DLRC is the ideal setting to experiment with, practice, and assess such approaches as flipping the classroom. In the first two iterations, Weaver used exams from the American Chemical Society to normalize student performance between the conventionally taught first semester course and the flipped second semester course. Student performance improved significantly from the first to the second semester. The assessment data from Purdue is similar to that from chemistry faculty at other institutions involved with flipping the learning experience of their students.

## Planning Principles

Conceptualization of the DLRC was driven by three design elements: flexibility, transparency, and access.

The element of flexibility was based on the concept of the “black box” theatre. Just as with theatrical black boxes, the programming needs of the DLRC required spaces that could adapt to a multitude of different settings. The flexible design allows DLRC researchers to reconfigure rooms into learning pods of various sizes, experiment with novel technologies, adjust breakout spaces, vary seating arrangements, etc. With the overhead tension grid, faculty can alter acoustics, lighting, and mechanical systems.

The element of transparency was important because the spaces had to make visible—intellectually and visually—the process of learning. Faculty curious about how learning happens and eager to explore which factors ensure effective learning and teaching experiment in DLRC spaces equipped to record video and sound interactions between learners, learners and faculty, and with the technologies and tools that help researchers review and analyze how students work and the dynamics by which they engage in the learning process.

**Architect:** BSA LifeStructures

**Photos courtesy of:** BSA LifeStructures and Purdue University

**Location:** West Lafayette, Indiana

**Net/gross square footage:**

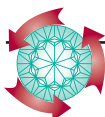
Net usable square footage: 81,795 NSF (assignable 56,400 SF, nonassignable 25,390 SF) Gross square footage: 91,860 GSF

**Cost:** \$19,500,00 (construction cost)

**Construction period:** 18 months

**Date completed:** November 2009

**Disciplines housed:** This facility is more research centers and groups than disciplines - the majority of the first two floors are home to the Discovery Learning Research Center.



# Sabine Hall Science Building Richland College

## Background

Richland College of the Dallas (TX) County Community College District has a rich legacy of innovation and quality in education, sustainability, and design. “Teaching, learning, and community building” is the mission of Richland College.

Completed in 2009, Richland’s Sabine Hall is a layered learning environment with multiple elevated terraces overlooking a large collaboration atrium/gallery with instructional science art. The Science Corner is a carefully planned student mentoring hub surrounded by transparent faculty offices, adjacent to a room which stores physical models for students to touch and disassemble—to advance understanding of biological structures. In addition to many informal learning spaces, the building includes a coffee shop, meeting rooms, a bookstore, and an outside terrace with a green roof and a green wall that keep students engaged and learning.

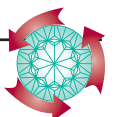
## Planning Goals

- Technology-rich, all-in-one-lab /lecture/ discussion spaces for Chemistry, Biology, Physics, and Geosciences.
- Universal design to recognize the very diverse student population.
- A powerful expression of the campus’s commitment to sustainability (LEED platinum).
- Seamless fit into the very distinctive twenty-five year-old architectural vocabulary of the campus.
- Visual transparency throughout for natural light and for building connections between students and faculty. (95% of spaces illuminated with natural daylight.)
- Thoughtful layers of learning spaces in a variety of scales to promote serendipitous interaction and allow learning to continue outside the formal learning spaces.
- A student “mentoring suite” (modeled after the existing science corner) to ensure the carefully choreographed interactions with faculty that enhance performance and improve student retention.

The Science Corner aims to remove the sense of hierarchical space between students and faculty. The space encourages students to learn from and with others, an important experience that fosters the traits of lifelong learning. Faculty members have ample opportunities to observe students’ commitment to learning. This collegial environment inspires both students and faculty to pursue learning with resilience.

## The Science Corner

The Science Corner places students in the center of a square with faculty offices on four sides. It is a carefully planned student mentoring hub surrounded by faculty offices. With office walls having transparent glass from 48 inches to the ceiling, unencumbered visual contact is provided between faculty members, the student study area, and the green roof terrace beyond. The space connects students and faculty in ways that multiply the impact of mentoring and peer-to-peer learning.





## Lessons Learned

Several core aspects of the Sabine Hall facility encourage student use of the space and promote productive use:

- *Adequate furnishings for the user needs:* A good table surface with room for three to four students, laptops, bulky books, calculators, and comfortable rolling tables and chairs enables learners to work effectively together.
- *Numerous collaboration spaces:* The open atrium, the Science Corner, and other informal student lounge/study area spaces distributed throughout the building are heavily utilized in Sabine Hall.

Since the college is non-residential, students often return to the building in the evening to study and join together because of the quality of the spaces and their furnishings. The coffee shop in the atrium and a nearby restaurant provide enough food and refreshments to keep the building populated late into the evening.

- *Open space:* Students experience walls and doors as barriers. If there are walls and doors around informal learning spaces, students perceive that the space belongs to someone else (professor, tutor, etc.) and not them.

The most important lessons learned that shaped the planning of the building—in particular the Science Corner—surfaced in a continuous review of the learning experience of our students, coming to a deeper understanding of how learning happens at Richland and why space matters as a part of the planning process.

We learned that the college-wide tutoring offered in another building was not utilized by science students. When tutoring was made available in the building where they attended classes and encountered science faculty, students quickly embraced the learning opportunities provided. When we designed the new science building, we knew that a Science Corner needed to be central to the learning environment.

We also learned our students often apologized for interrupting faculty when they visit their offices, but are open to learning when professors meet them in their “own” spaces. The intent of the space that became the Science Corner was to remove the sense of hierarchical space between the students and the faculty. In lieu of spending five “underutilized” hours each week in their offices waiting for students to walk through their doors, faculty can join students and tutors in this informal space, anticipating or following-up on discussions during a regular class/lab period.

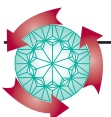
Finally, we learned that when students realize they can “own” the space, they move the furniture in ways that accommodate their needs at a particular time. This was a lesson that furnishings needed to be sturdy, mobile, flexible, and user-friendly.

## Assessment Evidence

|              | Tutoring      | No Tutoring   | % Diff        |
|--------------|---------------|---------------|---------------|
| SUBJECT      | A,B,C         | A,B,C         |               |
| BIOL         | 83.73%        | 69.39%        | 14.34%        |
| CHEM         | 76.95%        | 68.46%        | 8.49%         |
| PHYS         | 80.45%        | 74.53%        | 5.92%         |
| <b>TOTAL</b> | <b>80.11%</b> | <b>70.05%</b> | <b>10.06%</b> |

|                 | Tutoring      | No Tutoring   | % Diff        |
|-----------------|---------------|---------------|---------------|
| MALE/<br>FEMALE | A,B,C         | A,B,C         |               |
| Male            | 78.70%        | 68.83%        | 9.87%         |
| Female          | 81.30%        | 70.91%        | 10.39%        |
| <b>TOTAL</b>    | <b>80.11%</b> | <b>70.05%</b> | <b>10.06%</b> |

**Architect:** Perkins+Will  
**Photos courtesy of:** Perkins+Will  
**Location:** Dallas, Texas  
**Net/gross square footage:** 56,800 nsf / 113,636 gsf  
**Cost:** \$34 Million  
**Construction period:** Fall 2007-Spring 2009  
**Date completed:** April 2009  
**Disciplines housed:** Biology, Chemistry, Physics and Geosciences



# Chemistry Discovery Center University of Maryland Baltimore County

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Impressive large lecture halls economize teaching by “warehousing” students in orderly rows of expanding anonymity. The professor at the front of the room, who appears as a miniature to many, is forced by the design of the space to talk at the students rather than with them. The drifting attentions of students in the back are captured by their computers, smart phones, and other modern technologies, undermining the learner’s individual responsibility for learning, marginalizing the process of learning.

I cannot teach anybody anything; I can only make them think. —Socrates

Knowledge must be gained by ourselves.  
— Benjamin Disraeli

My epiphany as to the importance of room design in the economy of learning, in the teaching of responsibility for one’s learning surfaced in reflecting on these quotes while sitting in the back of the (then empty) large lecture hall in which our 1300 students in introductory chemistry were taught. I realized that the dimly lit, cavernous, steeply ramped lecture hall was the major impediment to efficient learning and teaching.

In common with other colleges and universities where introductory chemistry is taught in large lecture classes, historically UMBC had too many students who were unsuccessful in this course. Also in common with many of my colleagues, I must confess, I practiced the traditional model of teaching in these classes, relying primarily on lecturing—with minimal active participation by students. We looked in the mirror:

- The class average on tests and exams had been dropping slowly in recent years; higher numbers of students did not pass intro chem.
- The Tutorial Center (self-initiated assistance) was overwhelmingly utilized by A and B students.
- Anecdotal accounts of increased student frustration and failure: CHEM 101 is a “weed-out course.”

On my new journey to enlightenment, I discovered the literature solidly behind the theory that learning was enhanced through discussion, through the involvement of students.

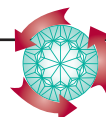
Moving forward, I acknowledged the need to practice my profession in a room designed to promote individual responsibility for learning.

[S]hallow learning...can become a way of life for students that imagine that this is what chemistry is all about. The interlinked, multidimensional learning, described as deep learning...requires commitment on the part of the student (and the teacher) to see this as a necessary and satisfying condition of learning. ...It is our responsibility...to enable and encourage students to learn how to learn.

— A.H. Johnstone

With a supportive administration and an entrepreneurial spirit, I repurposed an old game room in the University Center into an “active learning” classroom for the chemistry department. With limited funds, round tables—to promote discussion—were produced, minimal technology was provided—to exchange working documents and chemistry-based art—to soothe fatigued minds with images of disciplinary interest furnished our first version of the chemistry discovery center.

Perhaps the most important spatial affordance reflecting my epiphany about how learning happens was that there was no front of the room, thus reducing the tendency to lecture.



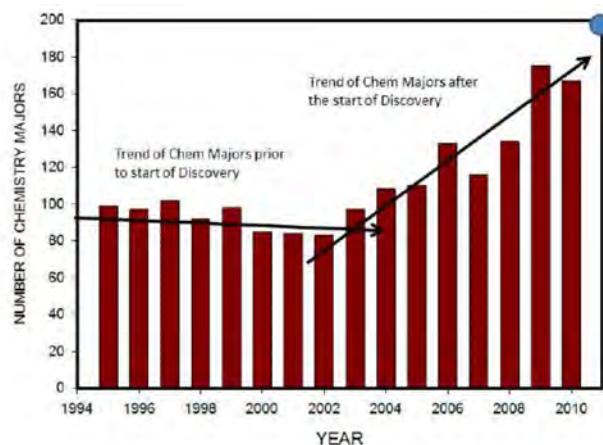
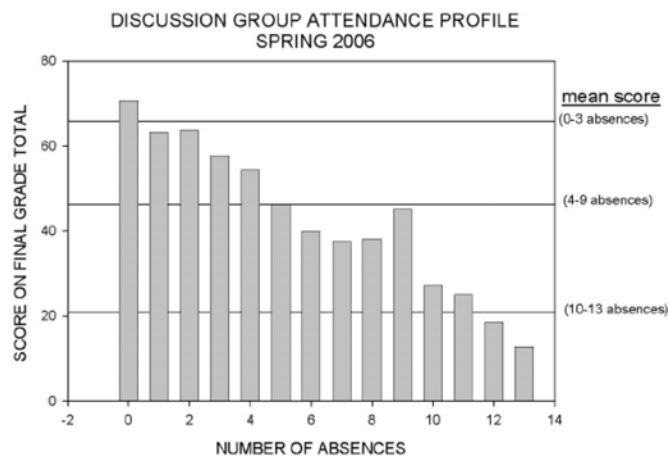
The redesign of the space and the redesign of the curriculum and schedule happened simultaneously. As departmental faculty we make a commitment to our students to:

- Increase student involvement in the learning process through fostering active learning.
- Promote “discovery learning” through knowledge construction and extension techniques.
- Promote problem-solving skills with positive competition and open debate.
- Promote increased independence and responsibility in the learning process by developing critical skills—teamwork, communication, management, self-assessment—an entrepreneurial skill set.
- Envelope the student in a multi-faceted learning environment—lecturing, discovering, and tutoring.
- Improve their experience with introductory chemistry courses.

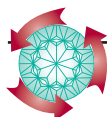
This involved integrating the freshman chemistry courses from concept (CHEM 101 and 102) to practice (CHEM 102L), and creating opportunities for crossing disciplinary boundaries between chemistry, physics, mathematics, and computer science, establishing a learning community among all entering science students.

The major curricular modification consisted of new, mandatory weekly two-hour “discovery learning” sessions for all students in place of the existing recitation session. Large lectures were gradually changed to a flipped mode, designed to guide the student on their journey into the world of chemistry.

## Assessment Evidence



**Planning and design by the institution**  
**Photos courtesy of:** William LaCourse, UMBC  
**Location:** Baltimore, MD  
**Net/gross square footage:** 2,087 net assignable square feet  
**Cost:** \$85,000 (total)  
**Construction period:** May 2007 - August 2007  
**Date completed:** August 2007  
**Disciplines housed:** Chemistry





# Michelle Smith Collaboratory for Visual Culture

## University of Maryland College Park

### Catalyst for Change: Challenge of Technology

The Michelle Smith Collaboratory for Visual Culture was created by the Department of Art History and Archaeology at the University of Maryland, College Park, to take advantage of the possibilities presented by new visual media for enhanced teaching and learning. The facility evolved from Department's Visual Resources Center, the provider of the thousands of slides used in the traditional art history classroom.

As the Department transitioned to digital media, the VRC became an informal "collaboratory," where people shared ideas and helped one another deal with the challenges, technological and otherwise, presented by teaching and research in this new environment. VRC staff recognized that this informal evolution was actually an important element of one of the positive and promising features of the digital revolution—increased communication and collaboration among individuals and organizations at many levels of the university and society.

### Process of Change, Step I: An Experimental, Informal "Collaboratory"

To explore the potential of this cultural transformation, VRC staff reconfigured workroom space to create an experimental, informal "collaboratory"—a place for people to come together to share ideas and solve problems encountered in teaching in the digital environment. Financial cost was minimal. Desks and computers were moved out of the room, creating an open area conducive to group interaction. Secretarial chairs and old typing tables, which all had wheels, remained to provide flexible furniture arrangements. A large (9' x 6') projection screen was installed on one wall, and a tall storage cabinet was adapted to house a digital projector and laptop across the room, creating an informal viewing area for digital presentations inside the VRC.

This newly configured area quickly became a learning space for presentations and group projects, such as the VRC's "Tech Talks"—a series of informal meetings held weekly to explore specific software or digital resources that might be used in teaching. In the informal atmosphere of the Collaboratory, faculty and graduate students began working together to solve pedagogical challenges and further research projects by adopting and adapting technological

concepts to develop new techniques for presenting their material. The collaborative nature of these meetings fostered innovation, collegiality, and excitement among the members of the departmental community.

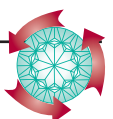
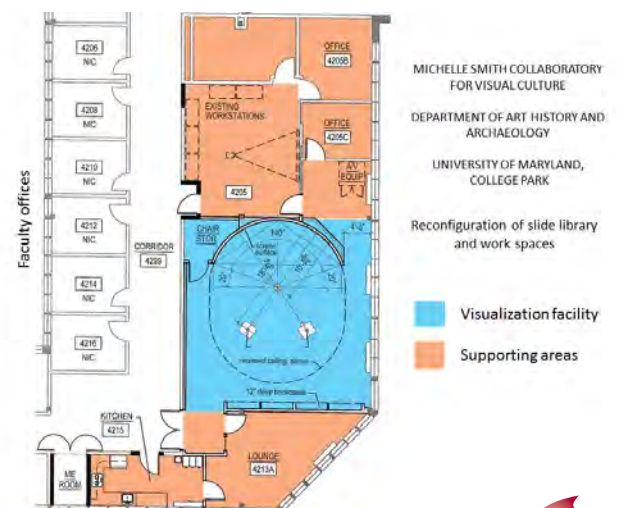
### Process of Change, Step II: The Michelle Smith Collaboratory for Visual Culture

In 2008, the experimental collaboratory became the prototype for a transformative facility made possible by the Robert H. Smith family. The Michelle Smith Collaboratory for Visual Culture replaced the Department's Visual Resources Center with a new facility designed to foster innovation in teaching and research by combining cutting-edge visual technology with an environment that encourages collaboration among faculty, students, and external scholars.

Planning goals included:

- An accessible venue with cutting-edge technology for visual disciplines.
- Flexible, adaptable spaces and furnishings, to accommodate groups of various sizes and multiple activities.
- Open comfortable space to encourage collaboration, exploration and experimentation.
- A space large enough for departmental gatherings, fostering a sense of community.

The old slide collection area, cleared of slides, furniture, and equipment, was reconfigured, renovated, and integrated with the existing workroom and a small faculty lounge to create a venue



# Michelle Smith Collaboratory for Visual Culture University of Maryland College Park

combining complementary flexible spaces for work and for meetings—spaces of varying sizes in which teachers and students can gather to work, share ideas, and find the resources necessary to explore intellectual interests, solve problems, and develop new materials and techniques for research and teaching.

## A Key Feature

The center of the Collaboratory, both conceptually and physically, is a visualization facility containing sophisticated and comprehensive technology customized to support ambitious projects to encourage and promote new understandings through visualization. One wall of the facility is dedicated to a large floor-to-ceiling curved projection surface, which is approximately 21 feet long with an arc of approximately 135 degrees. Three ceiling-mounted projectors, each directed toward a different portion of the screen, provide maximum flexibility for visual presentations of myriad types.

The projectors are controlled by a powerful multi-touch computer with an NVIDIA Quadroplex system to support a variety of visualization environments. The expanse of the projection surface, combined with multiple projectors and variable inputs, makes it possible to present visual materials of varying types simultaneously, revealing relationships among seemingly diverse subject matter.

## Visual Learning with Cutting-edge Digital Technologies

In the Collaboratory, faculty and students learn together, investigating and developing new resources in the digital humanities, which, in turn, foster new scholarship and knowledge. Early projects in the space included three-dimensional architectural models exploring the construction of sacred spaces or revealing spatial relationships among works of art as conceived by their creators. These initial projects have led to a new program in the department, known as The Digital Innovation Group, or “The DIG”: a group of graduate students and faculty working together to integrate new technology into the related disciplines of art history and archaeology.

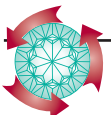
Small undergraduate classes meet in the Collaboratory, with excellent success. To cite just one example, in a course titled “Leonardo and the Science of Art,” science and engineering students, guided by an art history professor, explored the life

and works of Leonardo da Vinci as a multi-talented scientist, inventor, and artist. With access to an array of technological resources and a flexible space in which to move, these students built models, both physical and virtual, and created visual presentations of varying types. Their freedom to move about the space facilitated quick transitions from one activity to another.

The Collaboratory offers unique visualization opportunities not available elsewhere on the College Park campus. Increasingly, other departments and organizations across campus are interested in the potential of the space for experimenting with visual technology and interdisciplinary collaborations. University personnel with responsibilities for development and planning now recognize the Collaboratory as a “learning space.”

The present Collaboratory can be thought of as a one step in a longer process; as the outgrowth of a preliminary collaboratory prototype developed in the Department of Art History and Archaeology, The Michelle Smith Collaboratory for Visual Culture may serve as a prototype for something larger for the College and the University, as visualization becomes an increasingly important means of intellectual exploration and communication.

**Photos courtesy of:** University of Maryland College Park  
**Location:** College Park, Maryland  
**Square footage renovated:** 2,051 sq. ft.  
**Cost:** \$375,000  
**Construction period:** August through December 2009  
**Date completed:** December 2009  
**Disciplines housed:** Art History



# Integrated Science Building (ISB)

## University of Massachusetts Amherst

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### The ISB Design Process:

The Integrated Science Building was the first new academic building to be constructed at the University of Massachusetts Amherst in several decades. As such, it was emblematic of the future of science research and education on campus. From the start, the ISB concept was motivated by a shared belief among faculty leaders and a group of committed alumnae that the boundaries between disciplines must be broken down for the best research and teaching in the sciences. In particular, the agreed-upon vision for the ISB was to link teaching spaces for the chemical and life sciences, fostering interdisciplinary interaction, and to create research space that would house clusters of faculty with research thrusts that would benefit from proximity and the resulting collaboration and interaction across disciplines.

An additional goal of the ISB was to connect the different levels of undergraduate science teaching so that introductory students would rub shoulders with more advanced students, and more advanced students would witness activities in research labs and be attracted to join a research team. The challenge then became how to work with architects to convert these lofty goals and visions to an architectural implementation.

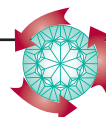
*The new building breaks the traditional format of individually housing each discipline in its own space. The bringing together of the teaching of the basic and advanced courses in life sciences and chemistry and the development of interdisciplinary but complementary research teams, closely reflects the evolving status of the chemical and life sciences as we embrace the new millennium.*

Design of the new science building was carried out in a highly interactive manner by working groups of faculty meeting with building architects: We went through a very inspiring pre-design with architects from Cambridge 7. This helped faculty gain insight into space requirements realizing their dreams for the ISB. We adhered to the mutually agreed upon guiding principles arrived at in pre-design:

- keeping proximity of classrooms and teaching laboratories to allow integration of the knowledge gathering (lectures and classroom exercises) and problem-solving activities (laboratory experiments).
- creating computer laboratories to foster self-guided learning.
- placing introductory and advanced laboratories near one another to promote interaction between lower and upper class students by having juxtaposing chemical and biological teaching laboratories to enhance interdisciplinary perspectives in students.
- catalyzing undergraduate research participation by the proximity of advanced teaching laboratories and faculty research space.
- fostering interaction among faculty and their research trainees in chemical and life sciences through research clusters.
- enhancing the health and development of interdisciplinary programs campus-wide by providing high quality common space for activities such as seminars, colloquia, and symposia.

The architectural firm of Payette Inc. was chosen for the design of the ISB. As in pre-design, faculty working groups met, brainstormed, grappled with translating dream to reality, confronting the increasingly detailed process of planning a building. A difficult decision was made because of fiscal and architectural constraints: dividing the building into a wet lab wing and an office/classroom wing. Wonderful design features were creatively integrated into the planning process by the Payette team, the pinnacle of which is the atrium with its beautiful and functional long stairway connecting all levels of the classroom/office wing. The faculty were stunned by the potential of spaces to enhance the impact of their educational efforts.

The proof is in the pudding, as they say: The ISB works! It is resplendent, it is lively, it inspires teachers, it is loved by students, it connects fields and fosters interaction... it is a dream come true! And as an indication that its impact goes beyond its walls: The next laboratory science buildings being built (coming on line in spring 2013) will house research clusters: groups of faculty with potential synergies across disciplines and without requirements for departmental ties.





# Integrated Science Building (ISB) University of Massachusetts Amherst

## Building Description

The integration of information gathering and problem-solving is fostered in the ISB at several levels: Lecture auditoria are equipped to facilitate student/instructor and student/student interaction in an active learning environment. Laboratories at both introductory and advanced levels are taught in open labs that also work well as discussion space, allowing small groups of students (12-15) to interact among themselves as well as with the instructor. The physical layout of the advanced labs resembles research and development space.

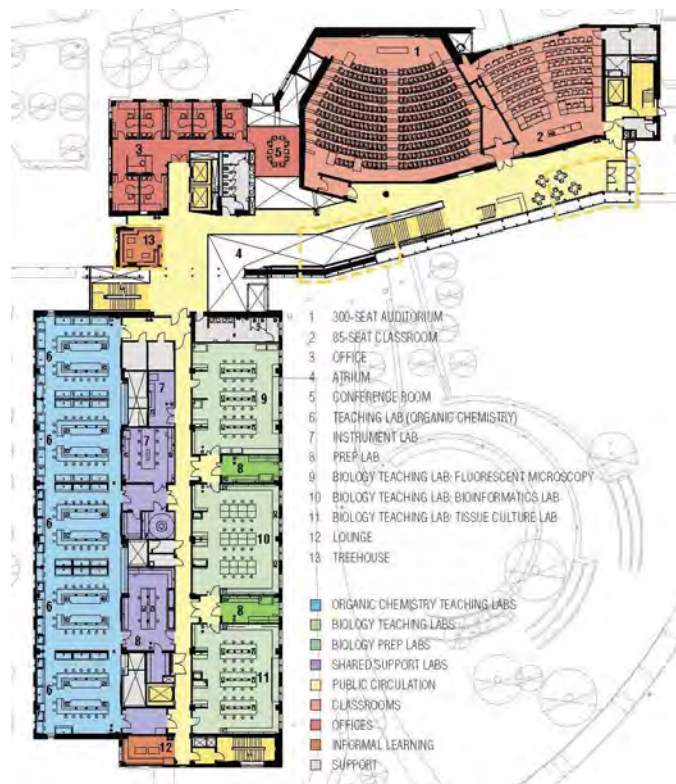
The first floor of the laboratory wing houses lower level laboratory classes including introductory chemistry labs and prep rooms. The second and third floors of the laboratory wing are devoted to more advanced undergraduate courses. They house the upperclass chemistry and life sciences teaching labs with shared instrumentation facilities. The fourth floor houses research laboratories where training of both undergraduate and graduate students takes place.

Laboratories are modular with well-planned shared spaces for equipment and instruments, in which our students learn first-hand how science is done using a state-of-the-art facility. Teaching laboratories for the chemical and life sciences are juxtaposed in the ISB. Intellectually, there is an increasing emphasis on chemical perspectives in biology teaching and on biological examples in chemistry teaching. Furthermore, instrumentation rooms are set up to be used in both chemistry and life sciences teaching laboratories. Shared instrument rooms demonstrate to the students that the same measurements are used in all these fields and will encourage interaction.

[A] range of approaches and instructional levels is accommodated in one space allowing for interactions across levels, as well as across disciplines.

In the nearby “dry” wing, there are large common spaces fluidly connected by a wide open stairway in front of a dramatic three-story window wall. This area is sprinkled with accessible breakout areas for informal student interaction and studying, as well as a range of classrooms including small classrooms equipped with computers, centralized computer resource centers for self-paced instruction and tutoring, medium sized lecture rooms (50 to 100 students) with state-of-the-art audiovisual equipment, offices for faculty who focus on instruction and

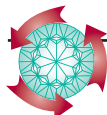
development of innovative curricula, two auditoria (one 125 person and one 300 person), and several conference rooms. Thus a range of approaches and instructional levels is accommodated in one space allowing for interactions across levels, as well as across disciplines.



The new building breaks the traditional format of individually housing each discipline in its own space. The bringing together of the teaching of the basic and advanced courses in life sciences and chemistry and the development of interdisciplinary but complementary research teams closely reflects the evolving status of the chemical and life sciences as we embrace the new millennium.

We now look back and realize that the process of designing the ISB has had almost as great an impact as the construction of the building itself! UMass Amherst will truly never be the same.

**Architect:** Payette Associates  
**Photos courtesy of:** Warren Jagger Photography  
**Gross square footage:** 173,000  
**Net square footage:** 81,630  
**Cost:** \$91M (GMP)  
**Cost/SF-** \$532  
**Construction period:** May 2011 - December 2012  
**Date completed:** December 2012  
**Construction manager:** Gilbane  
**Disciplines housed:** Teaching labs for Chemistry, Biology, and Biochemistry; and research labs for Veterinary and Animal Science



# Active Learning Classrooms

## University of Minnesota

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During each class period at the University of Minnesota today, our Active Learning Classrooms (ALCs) can accommodate 1179 students, who are learning subjects from biology to chemistry, environmental sciences and calculus, in team-based, technology-enriched learning environments. Within a year of opening our ALC-focused building (2010), half of all undergraduates at the University of Minnesota had taken at least one class in an ALC. A freshman entering the University today is likely to have multiple classes in these spaces.

ALCs are student-centered spaces that support innovative active learning strategies, allowing instructors and students to develop more effective teaching and learning strategies, including cooperative problem-solving, computer simulations, discussion, interactive drama, peer review, interactive lectures, and physical models. The ALCs are available for group and individual work before and after scheduled class time. Reflecting student preferences, the ALCs have quickly become one of the most sought after and heavily used student study spaces on campus, as well as for national conferences, workshops, and seminars.

How did these spaces evolve and emerge to become a significant mark of distinction of how learning happens at the University of Minnesota?

### Background: The ALC Pilot

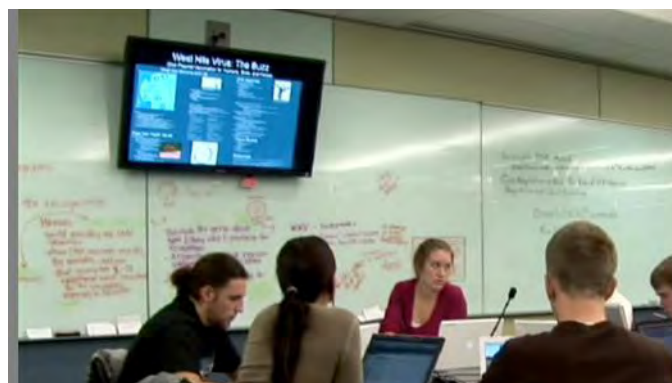
Our commitment to ALCs began in 2006 when the Office of Classroom Management explored ways to build flexible classrooms that would enable learner-centered teaching approaches. We were inspired by the impact of North Carolina's SCALE-UP program and MIT's Technology Enabled Active Learning (TEAL) classrooms on student learning.

Our plan was to test the viability of new construction technologies and with evidence of that viability to gain approval by university building code officials. Most importantly, we wanted to give faculty a place to experiment with teaching strategies that would be enabled in an active learning classroom.

We began with remodeling spaces in the basement of a classroom building into two pilot ALCs. By fall 2007, we had remodeled one 35-person fixed-bench classroom to produce a 45-person ALC (EE/CSci 2-260). We had also merged two existing general classrooms and a computer lab into a space that became a 117-person ALC (BioSci 64). Funding came

from combining funds from budgets for planned life cycle replacement, technology upgrading, and other funds. The ALC pilots were intended to stimulate interest in innovative classroom design, demonstrate flexible classroom construction techniques, and allow assessment of learning outcomes.

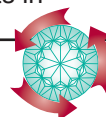
The ALCs feature large, round tables that seat nine students each in teams of three. Three switchable laptop connections at the table allow students to select which laptop displays on the adjacent 50-inch wall-mounted LCD. At the podium, the instructor can control any table display for projection on the room's large dual display screens. He or she can also select a specific display on the large projection and student screens from an instructor station.



These rooms feature a 360-degree glass marker board around the circumference of the classroom. Both ALCs are covered by the University of Minnesota's campus-wide wireless network.

These two pilot classrooms stimulated lively discussion on campus regarding student-centered learning versus lecture-style teaching. Some faculty members were strongly in favor of retaining large lecture halls and did not embrace the changes that ALCs represent. But initial research in the first two pilot ALCs indicated that most students and faculty members with experience in the rooms responded positively to them. These reactions included an overall enhancement of the student learning experience, a reduction in perceived psychological distance between instructor and students and among students, and praise for the role of the round tables in the ALCs.

The university responded in a way that underscored its commitment to changes in teaching and learning, by including the ALCs in the new Science Teaching & Student Services (STSS) building, which opened in fall 2010. The building can seat 1,639 students in



17 classrooms, including ten ALCs. These rooms, in combination with the pilot ALCs, mean that the University of Minnesota has made one of the largest investments in new learning spaces of any university in the country.

After the STSS building was opened, two controlled comparison studies were conducted in order to examine the contribution of ALCs to students' academic engagement and learning outcomes. In these studies, faculty members taught two sections of the same class, one in a traditional classroom and one in an ALC, using the same syllabus, materials, instructional methods, and assessment.

Findings from both studies indicated that, after controlling for all relevant demographic and aptitude-related variables, the ALCs improved students' engagement in the learning process; helped students to outperform final grade expectations, resulting in improved learning outcomes; and affected teaching-learning activities even when the instructor attempted to hold these activities constant.

A third comparison study investigated the question whether the type of pedagogy used in the ALCs matters to student learning. In this study, a faculty member taught the same course twice in an ALC, using the same syllabus, materials, and assessments. The first iteration of the class was largely expository and lecture-based, while in the second iteration the instructor took advantage of the room's layout and technology by incorporating more active learning techniques into the class. After controlling for numerous demographic variables, students in the second iteration of the course were found to have outperformed those in the first.

## Lessons Learned

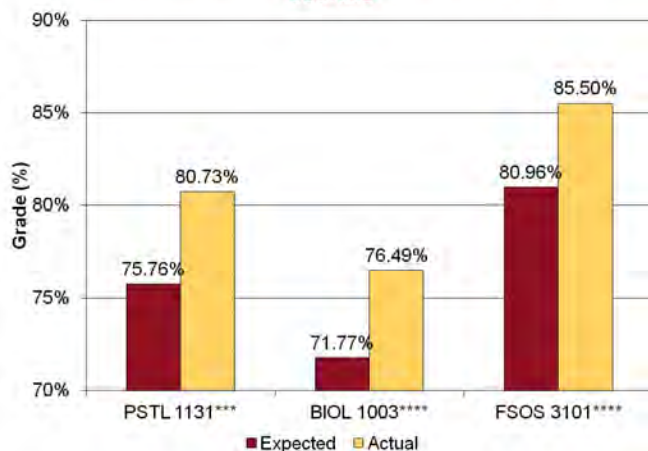
- Collaborating from the very beginning of the project is paramount.
- Integrating the voices of faculty and the voices of students into the process of planning and assessing is critical.
- Understanding the value of testing and prototyping, in sandbox spaces, of starting small and evaluating at every stage of the process of planning, and implementing different kinds of spaces.

## Looking Ahead

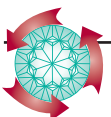
We are expanding support to faculty interested in transforming how they teach using the active learning format, and expanding use to other disciplinary fields across the campus.

We are also imagining what the next generation of ALC's will be.

**Expected versus Actual Grades in Three ALC Courses**



**Photos courtesy of:** Regents of the University of Minnesota  
**Executive architect; Structural/Civil/MEP; Engineering;**  
**Landscape architecture:** Hammel Green & Abrahamson  
**Design architect:** Kohn Pedersen Fox  
**Project manager:** Hines  
**Construction manager:** McGough Construction  
**Location:** Minneapolis, MN  
**Net/gross square footage:** 58,938ASF (Total assignable square footage) / 115,000GSF  
**Cost:** \$69 Million  
**Construction period:** January 2009 - August 2010  
**Date completed:** August 2010  
**Disciplines housed:** General purpose classrooms





# Jordan Hall of Science University of Notre Dame

A key consideration in designing Jordan Hall was to generate student enthusiasm for the sciences and create an environment where students will be more likely to spend time and collaborate. All of Notre Dame's undergraduates have at least one class in this building.

## Planning Goals

- To create a physical environment that would generate student enthusiasm for the sciences, promote discovery and collaboration, foster community, from the very first day.
- To provide spaces to accommodate research-based pedagogies in large-enrollment, introductory science courses.
- To put science on display, capitalizing on the University's significant holdings in scientific artifacts.
- To enable the consolidation and expansion of all undergraduate science learning activities at Notre Dame.
- To foster inquiry and facilitate inquiry at the cutting-edge of science.

## Planning Process

A transparent planning process involved intense collaboration between faculty across departments and disciplines to be housed in the new facility and the design team. This transparency enable planners to be creative and collaborative in imagining spaces, a process quite different from one of simply carving a big building into different spaces that would be owned by different departments.

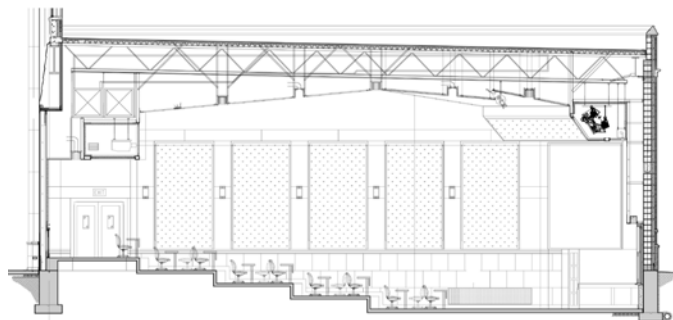
The challenge was to balance competitive interests, while allowing for departmental cohesiveness and for emerging interdisciplinary conversations and collaborations. The intent was to arrive at spaces that would benefit everyone: departments, faculty, and students in all disciplines, students at all stages of their undergraduate career. Key questions driving the planning were:

- What will the science of the future be like?
- How do students of today learn? What do we know about how our students learn?

In tackling the second question, planners took several steps, beginning with data about freshman motivation and persistence. They also reflected on their increasing personal experiences with collaborative learning approaches ("clickers" and other research-based pedagogies) and their growing awareness of the power of interactive, engaged learning. From surveying peers, they also came to recognize that even large enrollment STEM classrooms were becoming less like an "auditorium"—with fixed rows of seats facing the lecturer as a single point of contact.

## Team-based Lecture Halls

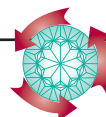
The design solution they realized is a concept of lecture halls for large enrollment introductory STEM courses, configured, equipped, and furnished to enable faculty to challenge students to think about and apply what they are learning, receive immediate feedback, and have opportunities to discuss, voice their conceptions, misconceptions, ideas.



The first floor of Jordan Hall features twin 250-seat tiered lecture halls. Five seating levels are designed so students can be engaged in different ways of learning during a class period.

Instead of sitting passively through lectures, students are able to interact with peers in answering questions to quizzes real-time via their laptops and wireless technology. A three-board sliding system provides a large expanse of writing surface.

As spaces for science learning, it was essential that demonstrations should be an integral part of a class period. The two lecture halls are well-equipped with full-glass fume hoods, an integrated system of cameras and projection screens that allow for different types of imaging and projection simultaneously— with three independent large screens at the front of the room, live demos, images from PowerPoint, and 2-D or 3-D objects can be projected through a document camera.



## Lessons Learned

- Faculty have greater flexibility in what and how they teach, and are able to customize their pedagogical approaches to the needs of a particular class or to a particular learning goal.
- Students comment that every seat in the lecture halls is a good seat. They like the location of the projection screens that allow them to view the instructor and the screens simultaneously, not one or the other.
- Faculty comment on how the layout of the seating tiers supports collaborative inquiry-based, integrative learning, keeping all students engaged and not “lost” in a typical auditorium-type space.

Together with the excellent labs and their adjacent data analysis rooms, these rich learning environments have provided engaging facilities for the undergraduate science programs. Within a couple years of Jordan Hall’s opening, enrollment in the science program exploded, necessitating the offering of evening courses to accommodate all the interested students.

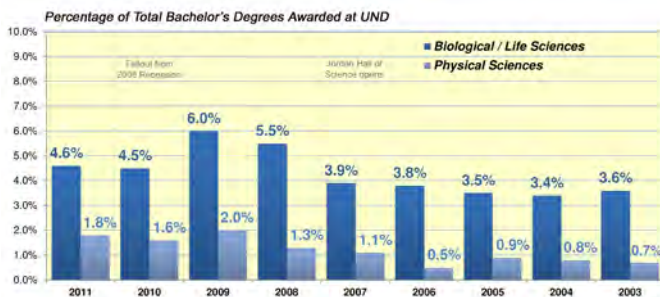


## Digital Visualization Theater

The first question, *what will the science of the future be like?*, was prompted as planners recognized that imagining was becoming important in all of the sciences, that new technologies were making it possible to imagine everything from individual atoms to galaxies.

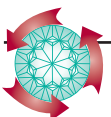
The concept of visualization gave faculty a metaphor for their planning, one that influenced how they designed and equipped classrooms (i.e., the large-enrollment lecture halls), hallways, laboratories, and especially the 136-seat room with a 360-degree domed ceiling.

...the reason we call it a Digital Visualization Theater rather than a planetarium is because it is intended to serve all the sciences and even Notre Dame students in fields outside of science. Students will be able to experience what it is like to be inside a cell, to see the transcription of DNA, or to experience what it would be like to visit King Tut’s tomb....  
—Dennis C. Jacobs, (then) Vice President and Associate Provost



The number of Science majors has expanded and non-major science enrollments have nearly doubled since the facility has been operational. An increase in medical student intents in the sciences has also occurred since 2007.

**Architect:** The S/L/A/M Collaborative  
**Photos courtesy of:** The S/L/A/M Collaborative  
**Location:** South Bend, IN  
**Net/gross square footage:** 202,000  
**Cost:** \$70,000,000  
**Construction period:** 28 Months  
**Date completed:** 2006  
**Disciplines housed:** Physics, Chemistry, Biochemistry, and Biological Sciences



# Weigle Information Commons and Education Commons University of Pennsylvania Libraries

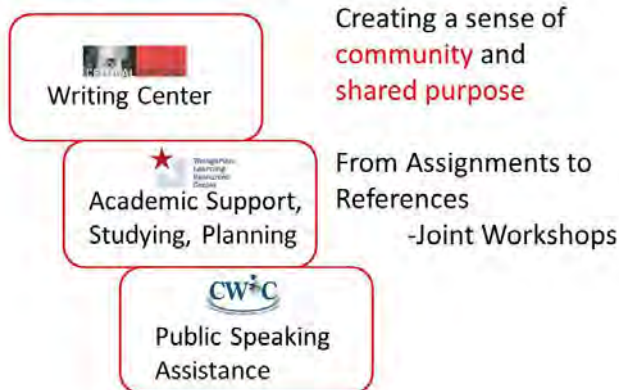
## Background

Noticing a growing emphasis on teamwork and collaborative problem-solving in academic curricula, administrators from the School of Arts and Sciences, the Office of the Provost and Penn Libraries began in 2001 to discuss the potential for a “collaboratory” where students would work in groups and access academic support services. Planning included regular meetings of groups of faculty and staff and continued for several years. Planners identified for renovation a large space on the first floor of the main library building, already a popular hub for undergraduate study.

## Planning Goals

- Embrace guidance from the university president to focus attention on the needs of undergraduate students.
- Create a technology-rich crossroads on campus to build connections across organizations and schools.
- Create a sense of community and shared purpose among staff across campus who support student services, in order to give students easy access to assistance.

## Program Partners



## Planning Process

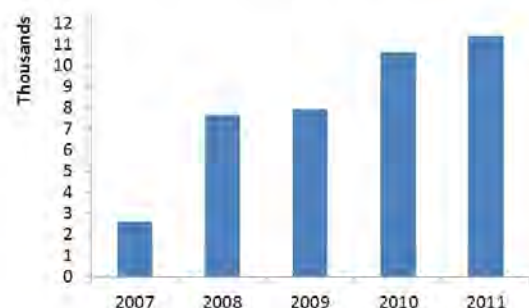
The planners began with an overall image of a self-service space with a variety of sub-spaces and robust technology infrastructure. The planning process, which included visits to campuses with similar facilities, nurtured new partnerships with academic centers around the campus. These partnerships, which have continued, are a critical factor in the ongoing success of the space. Supported by fundraising and a naming gift, the David B. Weigle Information Commons opened in 2006.

The Information Commons is a superb space for collaborative learning. The resources are phenomenal, and the staff is friendly, helpful, knowledgeable. [My students] found the booths ideal for hammering out script and casting differences.  
— Writing Center Director

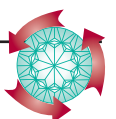
## Key Features

The twelve “data diner” booths are a key feature of the Weigle Information Commons (WIC), filled with student groups from early morning until the space closes at 2 a.m. They are popular with undergraduates who can reserve a booth and “make it their own”. Each booth has a monitor on an articulated arm, a PC laptop with webcam, and connections for personal use.

## Group Study Room and Data Diner Booth Reservations



\* Spring Semesters





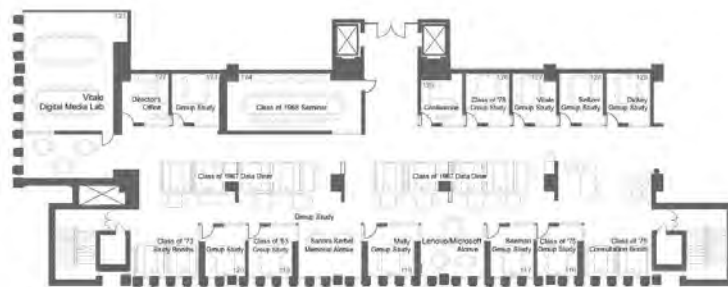
# Weigle Information Commons and Education Commons University of Pennsylvania Libraries

WIC has ten group study rooms with installed screens, adjustable monitors, PC and Mac computers, video-recording and video-conferencing. Several rooms support self-recording of presentations. A high-touch media lab supports creation of video, audio and animation content. Students borrow gadgets such as video-cameras, iPads, microphones and clickers.



For the staff, student ownership means letting go! Use of the space is dramatically high, filling to capacity on a daily basis. Students move furniture around the space, reconfiguring group spaces as they need. The space is noisy and bustling. Over 27,400 groups reserved the group study spaces during the 2011-12 fiscal year.

The WIC has established a strong brand on campus for providing direct assistance to undergraduates and supporting faculty exploration of new media technologies. Over 325 workshops attracted over 2,700 participants during the 2011-12 fiscal year. In the hands-on training sessions, freshmen, graduate students, faculty and staff share the common, often intimidating, journey of learning new software skills.



Plan of the Weigle Information Commons

## Impact Across Campus

Awareness of the popularity and effectiveness of the Weigle Information Commons led to a decision in 2010 by the university president to designate a second space for Penn Libraries to manage at the other end of campus.

The new space, the Education Commons, opened in March 2012. It has the unusual location of being situated in the arcade of Franklin Field, the University's stadium. Attractive to student athletes, its proximity to the campus science quad has helped to inform programming.

Technology is well integrated in both spaces. All computers include an extensive array of educational, media creation and productivity software. Both spaces support video-recording and video-conferencing. Both include self-service scanning, wireless printing, and moving whiteboards. Both include a variety of spaces in close proximity so a large class in a seminar room can break up into small group discussions in informal spaces without advance planning. Services are designed so that it is intuitive and inviting for students to ask for help.

Students comment that the Weigle Information Commons has a "daytime" feel with bright orange hues and sharp-edged booths and that the Education Commons has a "nighttime" feel with its blue décor and undulating banquettes. Both are clearly marked as spaces where students can be casual, relaxed with conversations and cell phone use, and generally feel in control of the space.

### Architect:

Weigle Information Commons (2006): Ann Beha  
Education Commons (2012): Joel Sanders

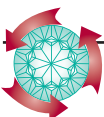
Photos courtesy of: David Toccafondi

Location: Philadelphia, PA

Net/gross square footage: 6,600 square feet

Construction period: 2005 to 2006 for Weigle Information Commons, 2011 to 2012 for Education Commons

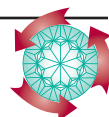
Date completed: 2006



A challenge for supporting informed participation is in providing a mechanism allowing various participants to integrate their perspectives in a meaningful way. To do so, it is important to support the process of reflection-in-action. As participants act upon a problem, breakdowns occur due to incomplete understanding of the underlying problem, conflicts among perspectives, or the absence of shared understanding.

People are motivated to participate if a problem affects them and if they see a benefit to participating. Supporting authentic problems in which people have a personal stake is an essential part of motivating a community. There must also be a reward for investing time and effort to becoming knowledgeable enough to act as designers. The nature of these rewards may range from a feeling of control over the problems, to being able to solve or contribute to the solution, a passion to master tools in greater depth, an ego-satisfying contribution to a group, or a sense of good citizenship in a community.

— Arias, Ernesto, Eden, Hal, Fischer, Gerhard, Gorman, Andrew, and Scharff, Eric. "Beyond Access: Informed Participation and Empowerment." University of Colorado, Boulder. 1999. <http://l3d.cs.colorado.edu/systems/edc/pdf/cscl99.pdf>



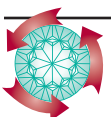
# Part III

## Endnotes and Resources



Planning is an unnatural process;  
it is much more fun to do something....  
The nicest thing about not planning is that failure  
comes as a complete surprise, rather than being  
preceded by period of worry and depression.

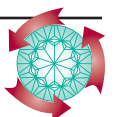
Sir John Harvey-Jones





# Endnotes (Part I)

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<http://www.pkallsc.org/>
- <sup>2</sup> Learning Spaces Collaboratory. *A Spotlight on National Reports*. <http://www.pkallsc.org/basic-page/spotlight-national-reports>
- National Research Council. *Discipline-Based Education Research: Understanding and Improving Learning in Undergraduate Science and Engineering*. Washington, DC: The National Academies Press, 2012. [http://www.nap.edu/catalog.php?record\\_id=13362](http://www.nap.edu/catalog.php?record_id=13362)
- National Research Council. *A New Biology for the 21<sup>st</sup> Century*. Washington, DC: The National Academies Press, 2009. [http://www.nap.edu/catalog.php?record\\_id=12764](http://www.nap.edu/catalog.php?record_id=12764)
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- President's Council of Advisors on Science and Technology. *Engage to Excel: Producing One Million Additional College Graduates with Degrees in Science, Technology, Engineering, and Mathematics*. February 2012. [http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final\\_2-13-12.pdf](http://www.whitehouse.gov/sites/default/files/microsites/ostp/pcast-executive-report-final_2-13-12.pdf)
- The Science Education Resource Center (SERC). *Pedagogy in Action*. <http://serc.carleton.edu/sp/index.html>
- <sup>3,12</sup> The Strategic Plan for the University of Maryland  
<http://www.sp07.umd.edu/PlanApril29.pdf>
- <sup>4</sup> Council on Competitiveness. *National Innovation Initiative Summit and Report: Thriving in a World of Challenge and Change*. 2005.
- <sup>5</sup> The Association of American Colleges and Universities (AAC&U). *Liberal Education and America's Promise (LEAP)*. <http://www.aacu.org/leap/vision.cfm>
- The Association of American Colleges and Universities (AAC&U). *Valid Assessment of Learning in Undergraduate Education (VALUE)*. <http://www.aacu.org/value/index.cfm>
- <sup>6</sup> National Research Council. *How People Learn: Brain, Mind, Experience, and School*. Washington, DC: The National Academies Press, 1999.
- Wieman, Carl. "Applying New Research to Improve Science Education." *Issues in Science and Technology*. Volume XXIX Number 1. Fall 2012. <http://www.issues.org/29.1/carl.html>
- <sup>7</sup> UMN Research & Evaluation Services  
<http://www.oit.umn.edu/research-evaluation/>
- University of Minnesota Office of Information Technology (OIT). *Learning Environments Research*. <http://www.oit.umn.edu/research-evaluation/selected-research/learning-environments/index.htm>
- <sup>8,10</sup> National Survey of Student Engagement (NSSE).  
<http://nsse.iub.edu/>
- <sup>9</sup> Environments & Spaces (SPIRES). *Supporting People Who Investigate Research*. <http://www.spirenetwork.org/>
- <sup>11</sup> Lippincott, Joan K. Assessing Learning Spaces. [Note: This paper was presented at the Association of Research Libraries Library Assessment Conference in Charlottesville, VA on September 26-7, 2006 in Charlottesville, VA.] <http://www.pkallsc.org/downloads/108>
- <sup>14</sup> Bennett, Scott. *Learning Spaces Research Project*. <http://www.libraryspaceplanning.com/projects.htm>
- <sup>15</sup> The Mazur Group.  
<http://mazur.harvard.edu/>
- <sup>16</sup> Brown, Malcolm B. "Learning Spaces." Diana G. Oblinger and James L. Oblinger, Editors. *Educating the Net Generation*. EDUCAUSE. 2005. <http://www.educause.edu/research-and-publications/books/educating-net-generation/learning-spaces>.



# Institutional Resources: Part II-A & II-B

## College of the Holy Cross—Integrated Science Complex:

Celebrating Science Website  
<http://academics.holycross.edu/celebratingscience>

About the ISC  
<http://academics.holycross.edu/celebratingscience/highlights/about>

Discovery Chemistry  
<http://academics.holycross.edu/chemistry/programs/discovery>

Science on Display: College of the Holy Cross, Integrated Science Complex  
<http://vimeo.com/album/2108450>

## Dickinson College—Stuart Hall & James Hall:

Shimmering Science  
<http://www.dickinson.edu/news-and-events/publications/extra-features/2008-09/Shimmering-Science/>

College's Science Complex Receives LEED Gold Rating  
<http://www.dickinson.edu/news-and-events/news/2008-09/College%E2%80%99s-Science-Complex-Receives-LEED-Gold-Rating/>

Redish, Edward F. "Chapter 10: Using the Physics Suite." *Teaching Physics with the Physics Suite*. John Wiley & Sons. 2003.  
<http://www2.physics.umd.edu/~redish/Book/10.pdf>

Science Programs Awarded More than \$500,000 in Grants  
[http://www.dickinson.edu/news-and-events/news/2007-08/Science-Programs-Awarded-More-than-\\$500,000-in-Grants/](http://www.dickinson.edu/news-and-events/news/2007-08/Science-Programs-Awarded-More-than-$500,000-in-Grants/)

Workshop Physics  
[http://physics.dickinson.edu/~wp\\_web/wp\\_homepage.html](http://physics.dickinson.edu/~wp_web/wp_homepage.html)  
<http://www.pkal.org/documents/Vol4WorkshopPhysicsPedagogies.cfm>

## Duke University—Link:

Link Website  
<http://link.duke.edu/>

Duke Link Photostream  
<http://www.flickr.com/photos/31061388@N04>

Educause Learning Initiative Presentation: The E-Learning Roadmap  
<http://www.educause.edu/eli/events/eli-annual-meeting/2011/e-learning-roadmap-making-strategic-decisions-complex-ecosystem-institutional-scope>

Evaluation of the Link  
<http://link.duke.edu/about/assessment>

## Eastern Kentucky University—Noel Studio

Noel Website  
<http://www.studio.eku.edu/>

Tour the Noel Studio  
<http://www.studio.eku.edu/tour-noel-studio>

Quality Enhancement at EKU  
<http://www.qep.eku.edu/>

Bemer, Amanda, Moeller, Ryan, and Ball, Cheryl. "Designing Collaborative Learning Spaces: Where Material Culture Meets Mobile Writing Processes." *Programmatic Perspectives*, 1(2), September 2009: 139–166. [http://www.cptsc.org/pp/vol1-2/bemer\\_moeller\\_ball1-2.pdf](http://www.cptsc.org/pp/vol1-2/bemer_moeller_ball1-2.pdf)

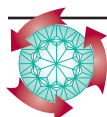
Carpenter, R., & Apostel, S. (2012). Communication center ethos: Remediating space, encouraging collaboration. In L. Y. Eunhyong & W. Atkins-Sayre (Eds.), *Communication centers and oral communication programs in higher education: Advantages, challenges, and new directions* (pp.163-174). Lanham, MD: Lexington Books.

Carpenter, R., Apostel, S., & Hyndman, J. Developing a model for ePortfolio design: A studio approach. *International Journal of ePortfolio*. 2(2): 163-172.

Carpenter, R., Valley, L., Napier, T., & Apostel, S. (2012). Studio pedagogy: A model for collaboration, innovation, and space design. In R. Carpenter (Ed.), *Cases on higher education spaces: Innovation, collaboration, and technology*. (pp. 313-329). Hershey, PA: IGI Global.

Ezarik, M. (2011, October 16). Collaboration station. *University Business*. Retrieved from <http://www.nxtbook.com/nxtbooks/pmg/ub0511/#/0>

Hadro, J. (2010, November 4). "EKU's Noel Studio Combines Research, Writing, and Communication." *Library Journal*. [http://www.libraryjournal.com/lj/communityacademiclibraries/887645-419/ekus\\_noel\\_studio\\_combines\\_research.html.csp](http://www.libraryjournal.com/lj/communityacademiclibraries/887645-419/ekus_noel_studio_combines_research.html.csp)



# Institutional Resources: Part II-A & II-B

## Georgia Institute of Technology—PDL Spaces:

About Problem Driven Learning website  
<http://PDL.bme.gatech.edu/about.php>

Eberlein, Thomas et al. "Pedagogies of engagement in science: A comparison of PDL, POGIL, and PLTL." *Biochem Mol Biol Educ.* 2008 July; 36(4): 262–273.  
<http://www.ncbi.nlm.nih.gov/pmc/articles/PMC2665262/>

Problem-Driven Learning at Georgia Tech: An Interview with Wendy Newstetter, Department of Biomedical Engineering, Georgia Tech. <http://www.pkallsc.org/sites/all/modules/ckeditor/ckfinder/userfiles/files/Problem-Driven%20Spaces%20at%20Georgia%20Tech%20-%20Newstetter%20Interview.pdf>

White, Hal. PBL Learning Spaces at the University of Delaware. [http://www.pkallsc.org/sites/all/modules/ckeditor/ckfinder/userfiles/files/PBL%20Learning%20Spaces%20at%20the%20University%20of%20Delaware\\_White.pdf](http://www.pkallsc.org/sites/all/modules/ckeditor/ckfinder/userfiles/files/PBL%20Learning%20Spaces%20at%20the%20University%20of%20Delaware_White.pdf)

## Grinnell College—Noyce Science Center

*Grinnell Science Project Awarded White House Honor*  
<http://www.grinnell.edu/academic/divisions/science/gsp/gsp-receives-white-house-honor>

Lopatto, David. "Undergraduate research as a catalyst for liberal learning." *Peer Review.* Winter 2006, Vol. 8, No. 1. <http://www.aacu.org/peerreview/pr-wi06/index.cfm>

Lopatto, David. "Undergraduate Research Experiences Support Science Career Decisions and Active Learning." *CBE Life Science Education.* 2007. vol. 6 no. 4 297-306. <http://www.lifescied.org/content/6/4/297.abstract#cited-by>

Lopatto, David. *Science in Solution: The Impact of Undergraduate Research on Student Learning.* Research Corporation for Science Advancement. 2009. [http://web.grinnell.edu/sureiii/Science\\_in\\_Solution\\_Lopatto.pdf](http://web.grinnell.edu/sureiii/Science_in_Solution_Lopatto.pdf)

Lopatto, David. "Undergraduate Research as a High-Impact Student Experience." *Peer Review.* Spring, Vol. 12, No. 2. 2010. [http://www.aacu.org/peerreview/pr-sp10/pr-sp10\\_Lopatto.cfm](http://www.aacu.org/peerreview/pr-sp10/pr-sp10_Lopatto.cfm)

Lopatto, David. "Undergraduate Research as a High-Impact Student Experience." *Peer Review.* Spring 2010, Vol. 12, No. 2. [http://www.aacu.org/peerreview/pr-sp10/pr-sp10\\_Lopatto.cfm](http://www.aacu.org/peerreview/pr-sp10/pr-sp10_Lopatto.cfm)

Assessment Instruments: <http://www.grinnell.edu/academic/csia/assessment/>

- CURE survey (Classroom Undergraduate Research Experience)
- RISC survey (Research on the Integrated Science Curriculum)
- ROLE survey (Research on Learning and Education)
- SEA CURE survey (Science Education Alliance Classroom Undergraduate Research Experience; a National Genomics Research Initiative)
- SURE III survey (Survey of Undergraduate Research Experiences)

## North Carolina Central University - BRITE:

BRITE Website  
<http://brite.nccu.edu/>

BRITE Futures Program  
<http://brite.nccu.edu/futures>

## Student-Centered Active Learning Environment with Upside-down Pedagogies (SCALE-UP):

SCALE-UP Website  
<http://scaleup.ncsu.edu/>

Project Impact and Details  
<http://www.ncsu.edu/PER/scaleup.html>

Conceptual Learning  
<http://www.ncsu.edu/PER/SCALEUP/ConceptualLearning.html>

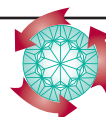
Problem Solving  
<http://www.ncsu.edu/PER/SCALEUP/ProblemSolving.html>

Attitudes  
<http://www.ncsu.edu/PER/SCALEUP/Attitudes.html>

Retention  
<http://www.ncsu.edu/PER/SCALEUP/FailureRates.html>

Beichner, Robert J. "Student-Centered Activities for Large Enrollment University Physics (SCALE-UP)." <ftp://ftp.ncsu.edu/pub/ncsu/beichner/RB/SigmaXi.pdf>

Beichner, Robert J. et al. "The Student-Centered Activities for Large Enrollment Undergraduate Programs (SCALE-UP) Project." [http://www.compadre.org/PER/per\\_reviews/media/volume1/SCALE-UP-2007.pdf](http://www.compadre.org/PER/per_reviews/media/volume1/SCALE-UP-2007.pdf)



# Institutional Resources: Part II-A & II-B

## Northern Kentucky University—Griffin Hall:

Griffin Hall Website

<http://informatics.nku.edu/griffin-hall.html>

Video Walkthrough of NKU Griffin Hall

<http://podcampcincinnati.com/first-video-walkthrough-of-nku-griffin-hall/>

## Purdue University—Discovery Learning Research Center

DLRC Website

<http://www.purdue.edu/discoverypark/learningcenter/>

Discovery Learning Research Center facilities movie

<http://www.purdue.edu/discoverypark/learningcenter/facilities/facilitiesMovie.php>

## Richland College—Sabine Hall Science Building:

Richland College's science building earns prestigious education architecture award

<http://www.rlc8.dcccd.edu/media/?p=3042>

## University of Maryland Baltimore County—Chemistry Discovery Center:

Transforming the Teaching of Science

<http://www.umbc.edu/window/chem101.html>

Chemistry Discovery Center Serves as Model for Physics, Math

[http://www.umbc.edu/window/discovery\\_center.html](http://www.umbc.edu/window/discovery_center.html)

An Elemental Education

[http://www.umbc.edu/magazine/fall10/feature\\_elemental.html](http://www.umbc.edu/magazine/fall10/feature_elemental.html)

Good chemistry: Creating more scientists in Maryland

<http://www.pbs.org/wnet/need-to-know/video/good-chemistry-creating-more-scientists-in-maryland/7321/>

LSC Webinar: The Chemistry Discovery Center at UMBC

<http://www.pkallsc.org/events/lsc-webinar-chemistry-discovery-center-umbc-0>

Process Oriented Guided Inquiry Learning

<http://www.pogil.org/>

Process-Oriented Guided Inquiry Learning

<http://serc.carleton.edu/sp/pkal/pogil/index.html>

## University of Maryland College Park—Michelle Smith Collaboratory for Visual Culture:

Collaboratory Website

<http://michellesmithcollaboratory.umd.edu/>

## University of Massachusetts Amherst—Integrated Science Building:

ISB Website

<http://www.cns.umass.edu/about/facilities/isb>

ISB Fact Sheet

<http://www.cns.umass.edu/about/facilities/isb/fact-sheet>

ISB Interactive Molecular Playground

<http://www.cns.umass.edu/about/facilities/isb/interactive-molecular-playground>

American Association for the Advancement of Science (AAAS) and National Science Foundation (NSF).

*Vision and Change in Undergraduate Biology Education: A View for the 21<sup>st</sup> Century.*

<http://visionandchange.org/>

National Research Council. *A New Biology for the 21<sup>st</sup> Century*. Washington, DC: The National Academies Press, 2009.

[http://www.nap.edu/catalog.php?record\\_id=12764](http://www.nap.edu/catalog.php?record_id=12764)

National Research Council. *Facilitating Interdisciplinary Research*. Washington, DC: The National Academies Press, 2004.

[http://www.nap.edu/catalog.php?record\\_id=11153](http://www.nap.edu/catalog.php?record_id=11153)

## University of Minnesota—Active Learning Classrooms:

ALC Website

<http://www1.umn.edu/ohr/teachlearn/alc/>

National Research Council. *BIO2010: Transforming Undergraduate Education for Future Research Biologists*. Washington, DC: The National Academies Press, 2003.

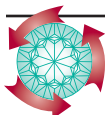
[http://books.nap.edu/catalog.php?record\\_id=10497](http://books.nap.edu/catalog.php?record_id=10497)

Office of Information Technology (OIT) Research Briefs

<http://www.oit.umn.edu/research-evaluation/research-briefs/index.htm>

UMN Research & Evaluation Services

<http://www.oit.umn.edu/research-evaluation/>





# Institutional Resources: Part II-A & II-B

LSC Webinar: The University of Minnesota Experience  
with Active Learning Classrooms  
<http://www.pkallsc.org/events/lsc-webinar-university-minnesota-experience-active-learning-classrooms-0>

## **Notre Dame University—Jordan Hall:**

Jordan Hall Website  
<http://science.nd.edu/about/facilities/jordan/>

On Campus at Notre Dame - Jordan Hall of Science  
Video  
<https://www.youtube.com/watch?v=njvVBuGHoVg>

An Interview with Dennis C. Jacobs, Former Vice  
President and Associate Provost, University of Notre  
Dame  
<http://www.pkallsc.org/sites/all/modules/ckeditor/ckfinder/userfiles/files/Notre%2520Dame%2520Interview.pdf>

## **University of Pennsylvania Libraries—Weigle Information Commons (WIC) & Education Commons (EC)**

WIC Website  
<http://wic.library.upenn.edu/>

WIC Facebook  
<http://www.facebook.com/pages/Weigle-Information-Commons/58055473584>

WIC Facilities  
<http://wic.library.upenn.edu/wicfacilities/>

WIC Music Video  
<http://www.youtube.com/watch?v=4z4Z717yD08&feature=plcp>

WIC Services Video  
[http://www.youtube.com/watch?v=muv4tOw29i0&feature=player\\_embedded](http://www.youtube.com/watch?v=muv4tOw29i0&feature=player_embedded)

EC Website  
<http://www.library.upenn.edu/ec/>

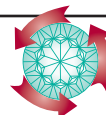
EC Facebook  
<http://www.facebook.com/PennEduCom>

EC Gallery  
<http://www.library.upenn.edu/ec/gallery.html>

**Note:** An archive of research papers and other resources relevant to planning for assessing learning spaces is on the LSC website (see Resources). Further contributions from the community are invited.

**Send to:** [jlmarum.lsc.ico@gmail.com](mailto:jlmarum.lsc.ico@gmail.com)

**Subject:** Resource: Planning for Assessing Learning Spaces



The greatest glory in the act of building is to have a good sense of what is appropriate. For to build is a matter of necessity, to build conveniently is the product of both necessity and utility, but to build something praised by the munificent, yet not rejected by the frugal, is the province of an artist of experience, wisdom, and thoughtful deliberation.

— Leon Battista Albert. *On the Art of Building*. 1486.

