# TRANSDISCIPLINARY COLLABORATIONS

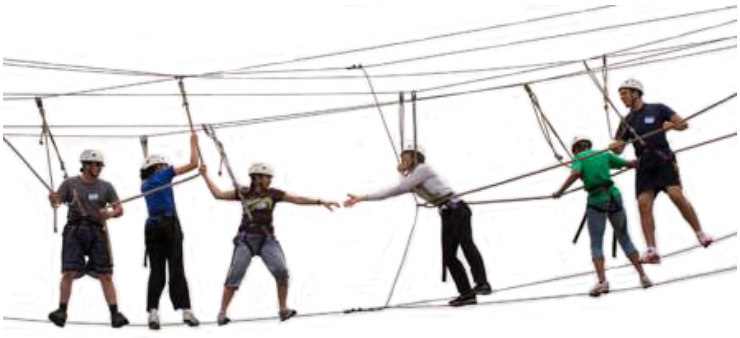
curated by Kim Alan Wheetley

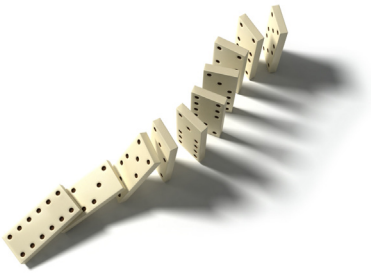
Southeast Center for EDUCATION IN THE ARTS

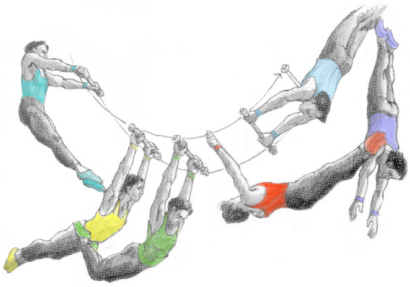
The University of Tennessee at Chattanooga

# CONTENTS

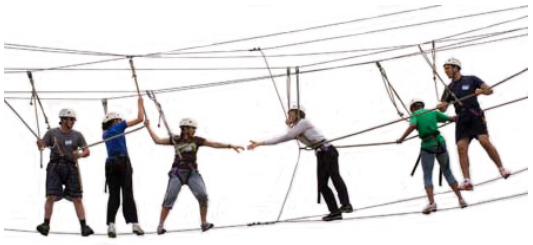


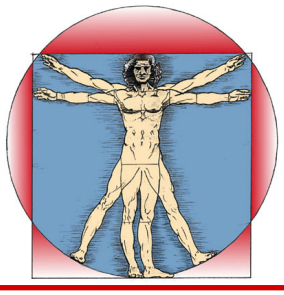


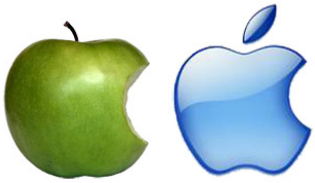




## TRANSDISCIPLINARY COLLABORATIONS





# TRANSDISCIPLINARY COLLABORATIONS

**transdisciplinarity**
is that which is at once between disciplines, across disciplines, and beyond disciplines

**transdisciplinary collaborations**
dissolve perceived and real boundaries between disciplines
reveal relationships among seemingly unrelated fields
synthesize diverse ideas, practices, and strategies

---

Our antiquated, static, and restrictive cells-and-bells education and business models with their siloed disciplines and specialties are failing. Students and workers are not being adequately prepared to function, communicate, or create in our complicated, globalized, media-saturated societies. They need to learn to embrace complexity, tolerate uncertainty, and manage tension. World-changing insights often come from combining disparate elements in new ways. We need to develop an interdisciplinary culture of inquiry that fosters integrative thinking, nurtures collaboration, accepts alternative perspectives, and melds various methodologies.

Many individuals and organizations across the country are doing just that – creating unique collaborative initiatives among arts, business, cultural, education, government, and philanthropic sectors that are thinking and working differently. They are bridging across perceived and real boundaries, honoring differences, sharing resources, fusing scientific and artistic practices, invigorating behaviors, and celebrating creativity. And the incubator for these innovations is integrative thinking.

Kim Alan Wheetley – Southeast Center for Education in the Arts

---

Study the science of art.
Study the art of science.
Realize that everything connects to everything else.

– Leonardo da Vinci

---

We build too many walls and not enough bridges.

– Isaac Newton

# INTERCONNECTEDNESS

In the new millennium, the world will be an increasingly interconnected place. We need to look at education holistically – as a total system with continuity through all levels. Right now, we are doing the opposite. We do not teach students to see the world as an interconnected place – to see the big view, to think integratively. We do not teach them to function in a complex world. The fundamental educational experience of our students now is that they learn in silos, right from kindergarten, a stale curriculum that does not connect to the society in which students actually live and function. We can't produce integrative thinkers with a nonintegrative machine. Why do we teach our children to think in silos and not integratively? There is some sense to it, but plenty of nonsense as well.

On the sense side, the world of knowledge is vast. We can't expect everyone to tackle it like a Renaissance scholar. So we pursue simplification and specialization to handle the complexity of the challenge of learning in a vast sea of knowledge. As such, a critical part of education involves breaking the interconnected world into chunks – simplification – that can be tackled and mastered one by one – specialization. This makes sense. Our students need to gain mastery, and mastery is achieved more quickly with simplification.

On the nonsense side, we have become so comfortable with the drive for mastery that we have forgotten in the educational world about the interconnectedness. We simplify and implicitly believe that multiple specializations in a wide assortment of simplified subjects will educate our students well. That is where the fallacy lies. Side-by-side learning of topics does not equate to integrative learning.

Creating an education system that can produce integration is no small task. Right now, as the world changes rapidly and our stale educational bureaucracy refuses to change, young people are ahead of us. They are connected to the Internet and already linked to a global bank of knowledge and people, which is starting to make their school experience seem less and less relevant. Many of them no longer bother with studying and extracurricular activities, but are participating in the real world by working after school and communicating globally over the Internet.

Roger Martin
*What Canada Could be for Education in the 21st Century*
John Wiley & Sons, Ltd., 2001

# WICKED PROBLEMS

It was the best of times, it was the worst of times,
it was the age of wisdom, it was the age of foolishness,
it was the epoch of belief, it was the epoch of incredulity,
it was the season of Light, it was the season of Darkness,
it was the spring of hope, it was the winter of despair,
we had everything before us, we had nothing before us,
we were all going direct to Heaven, we were all going direct the other way.

Charles Dickens, *A Tale of Two Cities*

A "tame problem" is one that may be complicated but can be resolved through the application of familiar ideas and approaches. A "wicked problem" has a level of complexity that goes beyond the limits of knowledge and previous methodologies that worked in the past. The requirement here is to be open to different ways of thinking, to use imagination to the full, and to be receptive to new ideas and new directions. And that brings the challenge of developing transdisciplinary modes of inquiry.

---

As the world grows more interconnected, today's challenges, geopolitical and otherwise, become more difficult to predict, understand, and handle. They are what design theorists Horst Rittel and Melvin Webber called "wicked problems" which are vexing because they have multiple, interrelated causes that can't be solved by traditional tools and methods. They are, by definition, unique and novel. They occur in a social context where stakeholders tend to disagree about the underlying causes thus hampering efforts to reach an effective solution. Wicked problems demand new ways of collaborating. Wicked problem-solvers must first seek to gain a common understanding with their counterparts. The new skills required include self-reflection, consensus building, and mobilizing others. Wicked problems call us to harness all the creativity and knowledge at our disposal. Solving wicked problems is the defining challenge of our age.

Steve Finikiotis
*Touch Points*, March 2011

---

Wicked problems have many causes involving multiple interests. Resolving a wicked problem calls for collective decisions. If you have multiple interests, each has its own knowledge construction. Individual knowledge is based on personal, lived experience. Local knowledge is based on shared community events. Experts contribute from a particular box that they are trained in. Strategic knowledge is the organizational agenda. Holistic knowledge gives focus and vision. These knowledges tend to reject each other. One of the troubles in working to bring them together is that there is a grain of truth in each. Individual knowledge can be biased. Local knowledge can be merely anecdote. Specialized knowledge can speak in jargon. Strategic knowledge is by definition often self-serving. And holistic knowledge is often dismissed as airy-fairy. The relationships between these knowledges are many and varied, but for constructive decision-making, we're going to need them all.

Valerie Brown, John Harris, Jacqueline, Russell
*Tackling Wicked Problems: Through the Transdisciplinary Imagination*, 2010

# ASSOCIATIVE BARRIERS

Creative successes and chances to innovate best occur at the *intersection* – a place where wildly different ideas bump into each other and build upon each other. Not only do we have a greater chance of finding remarkable idea combinations there, we also find many more of them. Breaking down associative barriers is fundamental to reaching the intersection.

*Associative barriers* are the limits we cluster around a concept in order to categorize and structure the stimuli in our environment. Building such barriers is the mind's way of creating order in a chaotic world. Researchers suspect that these barriers are responsible for inhibiting creativity. People with low associative barriers can make unusual connections that may eventually lead to successful creativity. These include individuals who have been exposed to various cultures, that are self-taught, and/or that have less traditional backgrounds. Such people are less wedded to one way of doing things and are therefore more likely to arrive at unique intersections.

Frans Johansson
The Medici Effect: Breakthrough Insights at the Intersection of Ideas, Concepts, and Cultures
Harvard Business School Press, 2004

# DISCIPLINE SILOS

In schools, subjects tend to be hermetically sealed off from each other – you do science on a Thursday morning, you do math in the afternoons. And this is really a feature of education, because outside of education people know naturally that all these things flow in and out of each other. Disciplines affect each other. There appears to be an increasing desire and need to break down the traditional “discipline silos” in favor of a more integrated study and understanding of complex systems.

Sir Ken Robinson
*Out of our Minds: Learning to be Creative*, Capstone, 2001

---

By and large, both in public and independent school education, there is still a tendency to focus on the disciplines separately, and, frankly, there's a lot of value in that. There's great value in going deeply into a subject and learning the tools and the approaches that are used by specialists in those areas. But in practice, there's almost no profession in the world of work where there aren't integrated perspectives. In the past, there was this polarization. It was “Should we integrate the curriculum?" versus “Should we have separate disciplines?” Now we're taking a much more sensible approach. For example, you now see courses on environmental science that deal with science but also with law and legal issues. Some states are going out of their way to formally build in more interdisciplinary linkages. It's not the debate it used to be.

But there is significant work ahead. Many high schools have siloed departments. Even people in middle schools designed in teams don't always use them effectively. And yet, a teacher working within a conventional program can do plenty to bring a degree of interdisciplinary richness to the classroom. When a teacher can shift the focus of a course around significant and important ideas or concepts, you'll find that tends to breed more interdisciplinary thinking, And thinking is what it's all about.

Heidi Hayes J*acobs*
*Active Literacy Across the Curriculum*, Eye on Education, 2006

---

Discipline-based content standards (language arts, math, music, science, social studies, theatre, etc.) puts us further into silos, sending each content area off to work with that discipline content away from everyone else. This is not best practice. It is exactly what we have to avoid in order to develop 21st century skills. As professors and scholars within higher education, we often find ourselves functioning within our own disciplinary and even sub-disciplinary silos. We do not get the benefit of exposure to pedagogical practices and principles that have their origins in other disciplines. As a result, it becomes easy to lose sight of the broader educational goals that inform our disciplinary (and interdisciplinary) practices. In this way, our disciplines often come to fix the boundaries of our approaches to pedagogy.

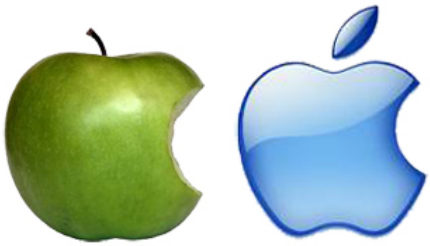
Michael Mascolo, Christina Hardway, & Deborah Margolis
"Editorial: On Pedagogy and the Human Sciences"
*Pedagogy and the Human Sciences*, 1, No. 1, 2009

# COGNITIVE SCIENCE

Teaching should be aligned with the way people think rather than with the subjects that have always been taught. There are 12 cognitive processes that must be mastered by all students no matter what careers they choose.

| Conceptual Processes | Analytic Processes | Social Processes |
|---|---|---|
| Prediction | Diagnosis | Influence |
| Modeling | Planning | Teamwork |
| Experimentation | Causation | Negotiation |
| Evaluation | Judgment | Describing |

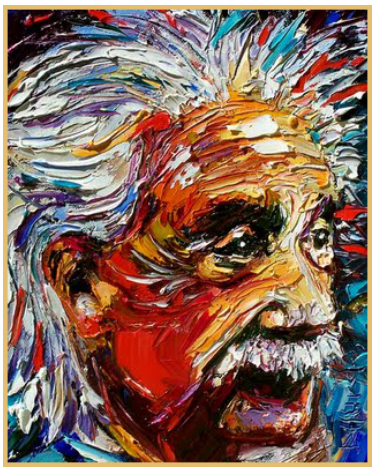
Proficiency at all the cognitive processes depends on discovery and being able to extrapolate from one's experience about what has been discovered. These processes depend strongly on prior cases, and prior cases are best learned slowly in childhood. They also depend on an analysis of those cases, which is best done with help from a teacher. Discussion, reflection, and analysis of prior cases make one better able to deal with new cases. New cases must be compared with old ones in a way that helps one reason better from them.



Knowledge is experience, but it is experience that has been analyzed so that it can be retrieved again just in time as needed. This happens only if we have thought about what we have experienced. A teacher's job, therefore, is to provide the experiences and to help the student reflect upon the significance of those experiences. Good parents do this naturally. Good teachers would do it naturally as well, if they were allowed to do so.

Roger Schank
*Teaching Minds: How Cognitive Science Can Save Our Schools*
Teachers College, Columbia University, 2011

# Observations by
# ALBERT EINSTEIN



The value of an education in a liberal arts college is not the learning of many facts, but the training of the mind to think of something that cannot be learned from textbooks.

Combinatory play seems to be the essential feature in productive thought.

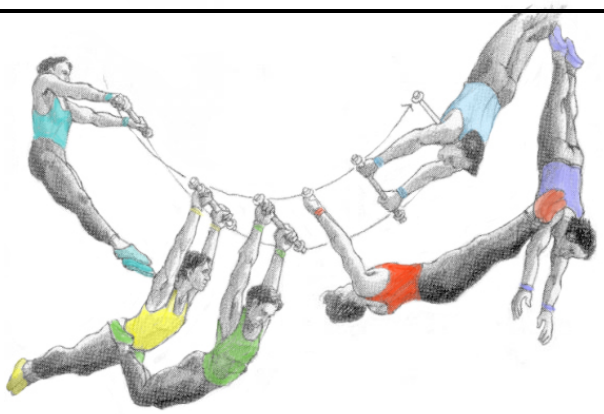
A great thought begins by seeing something differently, with a shift of the mind's eye.

I am enough of an artist to draw freely upon my imagination.

Imagination is more important than knowledge.
Knowledge is limited.
Imagination encircles the world.

After a certain high level of technical skill is achieved science and art tend to coalesce in esthetics, plasticity, and form. The greatest scientists are artists as well.

# INTERDISCIPLINARY LESSONS FROM DEWEY



An interdisciplinary approach generally aims (1) to bridge between academic disciplines, subdisciplines or schools of thought; (2) to recruit a wide range of teachers, students, researchers, professionals and even technologies in order to gain a more complete perspective; (3) to assemble tools or approaches from multiple disciplines in order to resolve an especially challenging problem; and (4) to cross traditional academic boundaries for the purpose of improved research or teaching.

In *Democracy and Education*, John Dewey argues for interdisciplinary instruction: "Education should aim not at keeping science as a study of nature apart from literature as a record of human interests, but at cross-fertilizing both the natural sciences and the various human disciplines such as history, literature, economics, and politics."

So, what are some lessons that Dewey might teach us about interdisciplinarity today? First, interdisciplinary inquiries represent opportunities for educators to become innovators, even revolutionaries, to bring many disciplinary tools to bear on crucial problems (for example, homelessness, corruption, environmental degradation, alternative energy), some that have confounded previous generations working in their own divided (and sub-divided) disciplines.

Second, interdisciplinary collaborations foster greater collegiality by cultivating more appreciation and understanding of the scholarly methods, nomenclature and literature mastered by our colleagues in different disciplines.

Third, interdisciplinary inquiries and collaborations can positively impact teaching. Student disinterest in academic subject matter could be blamed on an American culture steeped in anti-intellectualism. Still, interdisciplinary education has the potential to liberate students from this attitude of disinterest, helping them see connections between their studies in different classes and disciplines – in a sense, enlivening academic pursuits. Rather than being overly scholastic and dead to students' interests, the methods and literature they are exposed to can become relevant and fascinating.

Fourth and last, interdisciplinary collaborations might help us to define "research" in more generic terms, in language not so narrowly tailored to any one discipline, but that invites as many scholars in as many disciplines as possible "to the table" – in other words, a definition that makes interdisciplinary teaching and research highly inclusive and collaborative endeavors.

Shane Ralston
*Interdisciplinarity: Some Lessons from John Dewey*
*American Dialectic, Vol. 1, No. 2, 2011*

# CROSS-CULTURAL COMMUNICATION

Interdisciplinarity is a way to combine the objects and methods of different disciplines to solve a particular problem or tell a particular story. A discipline is defined by its object of study or subject matter. Literary critics study literature; psychologists study cognition, emotion, volition or will; sociologists study society and social institutions, status and roles within them; and so forth. Crucially, disciplines are also defined by what counts in them as evidence. Humanities scholars often interpret texts; social scientists employ statistical data; the physical sciences are historically empirical and experimental. In saying that disciplines are defined by their methods, we mean that specialists also learn to think like their disciplines.

– Literary critics think in terms of forms of expression: linguistic, rhetorical, generic, or syntactic structures. They notice the forms of expression as much as their content. Their methods are intertextual. They employ citation, argument, and the distinction between text and document.

– An historian, alternatively, uses documents as evidence, not as verbal constructs.

– Anthropologists think in terms of the social and kinship structures, practices, cultures and objects of everyday life.

– Economists provide for the needs and desires of the people, and therefore think in terms of less and more, maximization, risk, scarcity, and exchange. But even beyond content and method, disciplines are also social practices, embedded in institutions and activities.

– Mathematicians do not give papers at conferences, but produce theorems and formulae. Typically, they present the math without discussion; their peers go away to work it up on their own computers; and only later, after they have had time to play with the formulae, do they reconvene for discussion.

– Literary scholars often read papers, for the language itself is important to them. They like their papers to be well formed with beginning, middle, and end (like the narratives or poems they are used to interpreting).

– Scientists almost always use powerpoints, for they need to present evidence that is often best presented visually, such as diagrams, flow charts, tables and graphs.

This means that disciplines are “distinct cultures” and that interdisciplinarity must also entail “efforts in cross-cultural communication.” There is an anthropology of interdisciplinarity including different levels of civility, different degrees of democratic decision-making, different styles of presentation, and different styles of leadership. Yet despite the formidable fact that the different areas of knowledge production that we call disciplines actually constitute different cultures, some problems are just too complex to be solved by one discipline, some stories are too complex to be told without help from other disciplines. Most of the problems of the modern world are just this complex, as are most stories having anything to do with humans.

Regenia Gaginer, University of Exeter
*Why Interdisciplinarity?*
Compass Interdisciplinary Virtual Conference, 2009

# TRANSDISCIPLINARITY

Transdisciplinary studies are an area of research and education that addresses contemporary issues that cannot be solved by one or even a few points-of-view. They bring together academic experts, field practitioners, community members, research scientists, political leaders, and business owners among others to solve some of the pressing problems facing the world, from the local to the global.

What sets transdisciplinary studies apart from multidisciplinary, interdisciplinary, and integrative studies is a particular emphasis on engagement, investigation, and participation in addressing present-day issues and problems in a manner that explicitly destabilizes disciplinary boundaries while respecting disciplinary expertise. They are built around three key concepts: transformative praxis, constructive problem solving, and real-world engagement. The advocates of transdisciplinary studies argue that they come from the nature of the 21st century world, with its loss of a unifying narrative of knowledge, the continuing destabilization of disciplinary boundaries, and the transgressive character of the times. Our world, they claim, requires a contextualizing of knowledge in order to address complex worldwide issues (such as global warming and ethnic cleansing) and collaboration across academic disciplines that includes non-academics in solving problems and addressing global issues.

J. Thompson Klein, W. Grossenbacher-Mansuy, R. Häberl
*Transdisciplinarity: Joint Problem Solving Among Science, Technology, and Society An Effective Way for Managing Complexity*, 2004

Our educational institutions not only bear little resemblance to organic systems, but are the starting point in the creation of many other separated ideas, mindsets, and practices. The isolation of ideas and tools into separate disciplines is the result of a mechanical view of life, birthed in the heart of industrialization, obsession with quantifiable data, and the rise of the scientific management. However, life in general doesn't operate mechanistically, but is porous, complex, and organic. Therefore, not only is life meant to be connected across concepts and practices, but the separation of ideas and disciplines naturally results in wicked problems. When we attempt to solve these problems within the silos where they were created, the problems become more confusing and the wicket gets stickier.

Transdisciplinarity is the meshing or integrating of multiple disciplinary theories, practices, and tools in order to create new solutions to the problems erected through the separation of professions into silos of concepts and information. When these separated systems intersect, the space across or in-between them can result in something more than the sum of the parts. These new ideas have a greater potential to answer the grand challenges of our times.

Fra*nk Spencer*
*Transdisciplinary Design: How We Solved Our Wicked Problems,* 2011

The world is facing a polycrisis, a situation where there is no one, single big problem – only a series of overlapping, interconnected problems. These interconnected, complex problems cannot be solved by using independent, fragmented, disciplinary-focused knowledge. These siloed solutions cannot ignore a diversity of voices or merged perspectives.

Moving toward transdisciplinarity does not mean abolishing disciplines; indeed, their varying perspectives are needed to solve complex problems. However, disciplines need to be taught and research conducted in the *context of their dynamic relationships with each other* and with societal problems. They cannot be perceived as protected silos of specialized knowledge anymore. Only fluency across disciplinary boundaries will provide clear views of the world and what needs to be done to ameliorate humanity's pressing problems. This fluency emerges through well thought out opportunities for cross-collaborative work. Transdisciplinary work entails a fused way of looking at social problems leading to an *amalgamation of disciplinary concepts* rather than an amalgamation of disciplinary units.

Inherent in transdisciplinary work is being able to communicate with each other. The issue of finding a common language so people can talk to each other entails more than finding the right words. It requires empathy, the ability to see the world though the lens of others and then act from those insights.

With transdisciplinary work, people have to anticipate that there will be a variety of outcomes rather than one right outcome. Each outcome will resonate more or less with different actors involved in the process (academics, students, community members, corporations). People must be prepared to accept that their perspective may have to be overshadowed in order to solve this particular social problem.

Arizona State University uses the term *working at the seams* when referring to inter-departmental /interdisciplinary partnerships and joint problem solving. It purposely developed new research centers and institutions and positioned them as *the place* where translational research occurs (they do not use the word transdisciplinary). Industry and community stakeholders meet up with academics at these centers, which serve as the incubators for innovation and new knowledge generation. The resultant translational research is readily applicable to the stakeholders involved in the research (faculty members, communities or industry). ASU referred to this as *use-inspired* research, evolving at the seams. Their concept actually mirrors the quantum physics concept of working in the vacuum between entities. The vacuum is not empty but full of possibilities.

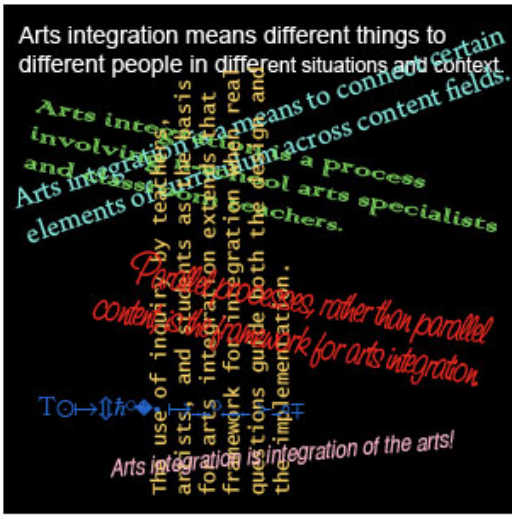
Sue L. T. McGregor and Russ Volckmann
*Transdisciplinarity in Higher Education*, Integral Leadership Review, 2011

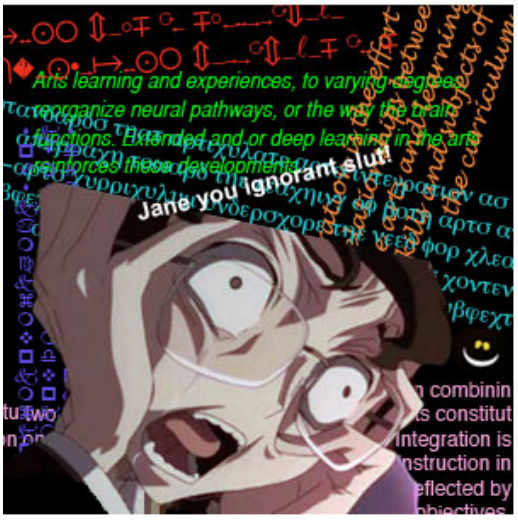
Can someone help me?

I'm confused by all the different definitions of
"integration"
"disciplinarity"
"multidisciplinarity"
"interdisciplinarity"
"transdisciplinarity"

Current interest and practice has not yet produced a consensus on these theories or their practices, much less on universal definitions.

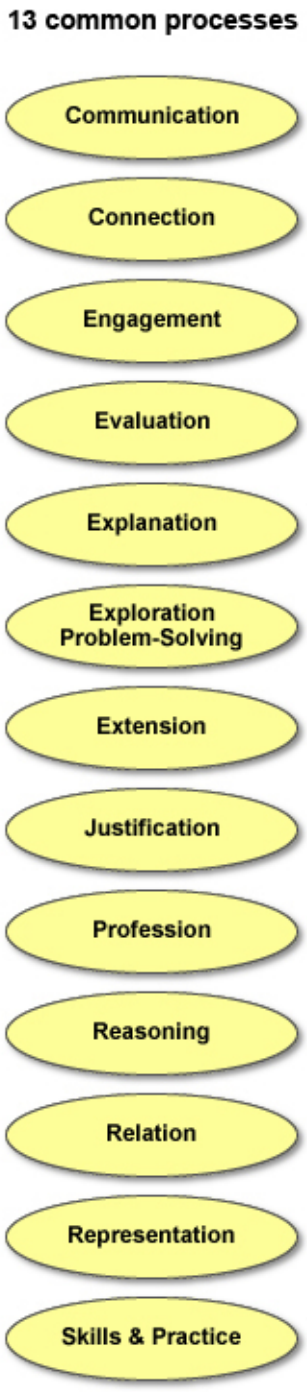
Well, why don't we just all get together for an hour or two and agree on some simple definitions?




Sometimes it's best to just agree to disagree.

# UNIFYING LEARNING PROCESSES




Our qualitative research study was designed to examine whether a set of cross-curricular learning processes could be found in the respective US national standards for math, language arts, foreign language, science, social studies, fine arts, and technology. We found that all K-12 subject matter standards could be analyzed and synthesized into 13 common learning processes.

This superset of 13 learning processes may argue for the increased need for instruction, which integrates various content areas. Recognizing that learning of most subject matter is more similar than different, it becomes more difficult to argue that all subject matter instruction and learning should be experienced disjointedly. In the future, if the superset of 13 learning processes became the basis of the national standards, curriculum could be reconceptualized so that teachers taught processes rather than content areas.

**Standards developers**

Those who develop standards have a great deal of influence on future directions in education. If these individuals were to shift their focus to the processes involved in learning, modifications could be made to content standards in social studies, language arts, and fine arts, to provide greater influence of the processes involved, as is currently done in the science and math standards. The existence of a broad cross-curricular set of learning process standards would allow for all national K-12 standards to be mapped onto the same set of learning processes. Such a mapping would enable teachers and other developers of curriculum to observe the interrelatedness of seemingly non-related content, according to the shared learning processes. At some point, national standards should be written either entirely as learning process standards, or mapped as process standards in coordination with content standards so that teachers can more easily observe the relationships between content and process.

**Curriculum developers**

As they translate standards into lesson plans and units, curriculum developers without a strong sense of the learning processes underlying the content will have difficulty constructing curriculum that meets the level of rigor demanded by the standards. If a set of K-12 national process standards existed, however, the desired rigor could be retained due to the fact that the language of the learning processes would be stated explicitly in the standards, rather than implicitly hidden beneath the content.

**Teachers**
Educators should familiarize themselves with the thirteen learning process standards to determine how the processes can be used to relate seemingly unrelated content. Curriculum delivery should include all of the thirteen learning processes ranging from the more teacher-led *(skills & practice)* to the more student-led (*exploration / problem-solving)* providing teachers with multiple pathways for increasing student understanding of content.

**Teacher educators**
Teacher educators must also be familiar with the learning processes that underlie curriculum as they instruct pre-service and in-service teachers in the development of curricular materials and instruction. If standards were based primarily on learning processes, rather than content standards, a greater focus would be brought to the pedagogy of teaching and would perhaps minimize the occurrence of tedious lectures based only on content coverage with little regard to instructional method.

**Assessment**
In an era of high stakes standardized testing, discussions regarding assessment practices could be founded upon student learning rather than countless facts associated with subject matter. 21st Century learners must continually learn how to continually learn. Based on national standards on learning processes, educators working in unison across all disciplines may be able to use these learning standards to evaluate a student‘s subject matter mastery, ability to learn, and progress as a life-long learner. These latter two dimensions may better speak to the goals of education than the temporary learning of facts that may or may not be employed in the future.

Education today is fractured by segregation according to subject matter. By utilizing the superset of learning processes, educational discussions, investigations, planning, and development can be unified giving educators and curriculum developers a new platform from which to write integrated, multi-dimensional 21st Century curriculum.

Michael J. Bossé, Elizabeth A. Fogarty
"Unifying K-12 Learning Processes: Integrating Curricula Through Learning"
*Current Issues in Education*, Mary Lou Fulton Teachers College, Arizaon State University, 2011

# THINKING TOOLS

Robert and Michele Root-Bernstein studied reports by eminent thinkers on how they think in many disciplines. From those reports, they identified a set of thirteen mental operations they call "thinking tools". These operations are used consistently across the divergent fields of science, mathematics, history, philosophy, theatre, painting, writing, and music.

*Observing* – patient, detailed, sustained perception

*Imaging* – forming mental representations of the world when we do not actively perceive it

*Abstracting* – paring down complicated things to simple principles

*Recognizing patterns* – discovery of repeated structures in nature, mathematics, rhythm, music, movement, language

*Forming patterns* – combining and repeating structural elements or operations

*Analogizing* – identifying shared properties in two or more different things

*Body thinking* – drawing preverbal and preconceptual intuitions from our bodily sensations and responses

*Empathizing* – sensing the lived experience of another person or organism or thing

*Dimensional thinking* – imagining an object in another domain, from two to three spatial dimensions, or from present to future time

*Modeling* – creating a virtual, mental, imaginary, or physical representation of a concept, idea, object, or set of conditions

*Playing* – irreverent and imaginative reordering of conventions and rules

*Transforming* – serial or simultaneous use of multiple mental operations

*Synthesizing* – bringing together many of these operations in understanding the world

These are the cognitive processes we employ as we make sense of our experience. They are operations of deeply immersed and engaged thinking.

Root-Bernstein, Robert, & Root-Bernstein, Michele
*Sparks of Genius: The 13 Thinking Tools of the World's Most Creative People*
Mariner Books, 2001

# SYNERGY

Perhaps the most ambitious form of synthesis occurs in interdisciplinary work, which should not be invoked lightly. We would not consider an individual to be bilingual unless he or she had mastered more than one language. By the same token, it is inappropriate to characterize work as genuinely interdisciplinary unless it entails the proper combination of at least two disciplines. Moreover, the two disciplines should not merely be juxtaposed; they should be genuinely integrated. Such integration should yield understandings that could not have been achieved solely within either of the parent disciplines.

The dangers of inadequate synthesis are perhaps most manifest in interdisciplinary work. Much activity in the early years of schooling is misleadingly labeled as “interdisciplinary.” Children may well benefit from carrying out evocative classroom projects or from pursuing a unit on generative topics like “patterns” or “water” or the “cradle of civilization.” But these endeavors do not involve disciplines in any legitimate sense of that term. In making a diorama or a dance, in thinking of water or cities in a variety of ways, students are drawing on common sense, common experiences, or common terminology and examples. If no single discipline is being applied, then clearly interdisciplinary thinking cannot be at work.

Even when students have begun to master the disciplines singularly, there is no guarantee that a combination of disciplines will be appropriately or productively linked. Courses may well and appropriately involve both history and the arts. One can read about the battles of the Spanish Civil War in a history text and one can also look at Picasso’s painting Guernica, or read the novels of Ernest Hemingway, without making any particular effort to link or compare these sources. We might term this approach “disciplinary juxtaposition” – a failure to realize the illumination that may accrue when different perspectives are synergistically joined.

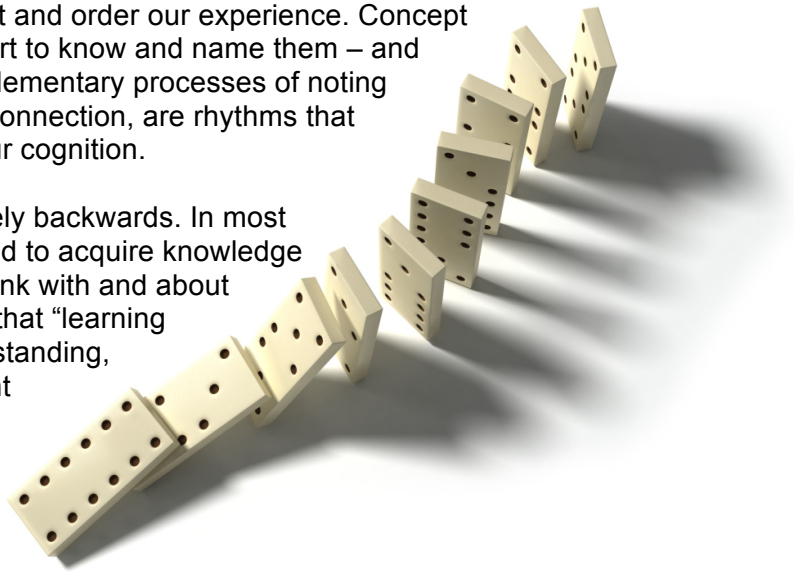
Interdisciplinary investigation is very important, and the best synergistic work is at a distinct premium in our era.

Howard Gardner
*Five Minds for the Future*
Harvard Business Press, 2008

# THOUGHT, TRANSLATED INTO ART, PROVIDES EXPERIENCE

The word *integration* comes from the Latin word *integrare*, which means to make something whole. When we speak of arts integration, we are speaking of a process of curriculum development and instruction that enriches relationships among students, teachers, and parents, as well as relationships within each of these groups. Arts integration is an approach to teaching and learning that lives in lessons and curriculum. When a teaching community embraces arts integration, and children meet it in different classes and experience it with various teachers over time, arts integration is a process that profoundly changes schools embracing its approaches to instruction, and assessment, to individualization and differentiation, to values, community relations, and ultimately, to spirit.

Contemporary cognitive theory is persuaded that learning involves developing webs of concepts and categories we need to interpret and order our experience. Concept formation requires analysis – pulling things apart to know and name them – and synthesis – bringing things together. The complementary processes of noting differences and similarities, of separation and connection, are rhythms that pulse through our identities, our politics, and our cognition.



The conventional patterns of school are precisely backwards. In most schools, most of the time, students are expected to acquire knowledge – from texts or teacher's lectures – and then think with and about that knowledge. But David Perkins reminds us that "learning is a consequence of thinking. Retention, understanding, and the active use of knowledge can be brought about only by learning experiences in which learners think about and think with what they are learning." For Perkins, thinking comes first, and knowledge is its consequence.

When the arts are integrated with other subjects, students make things that express their understanding of the phenomenon being studied. Even when students perform a dramatic text word for word, they are not performing the text; they are performing their understanding and interpretation of it. We know that when we want to test students' understanding of instruction, we often ask them to describe the content they are learning in their own words. That work of translation, from one code to another, anchors their understanding.

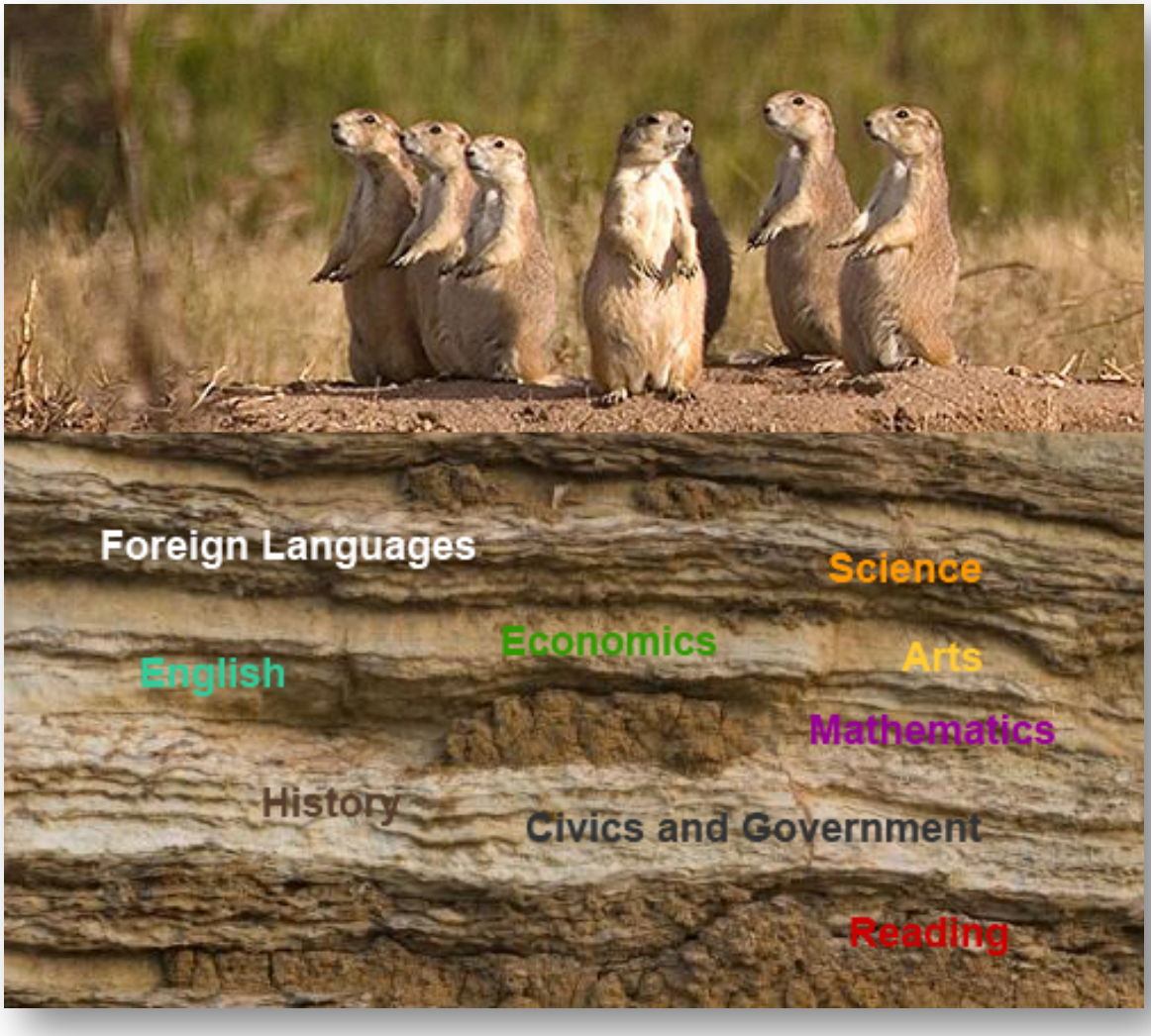

When students have the opportunity to encode their understandings in something they make – a play, a mural, a sculpture, a dance – they bring their thoughts and feelings together in a cultural object that they and their classmates can think about, for thought, translated into art, provides experience. Arts integration enables students to experience each other's ideas

Madeleine Grumet
*Putting the Arts in the Picture: Reframing Education in the 21st Century*
Columbia College Chicago, 2004

# CONCEPT-BASED INTEGRATION

A conceptual lens forces thinking to the integration level. Students see patterns and connections at a conceptual level as they relate the topic to the broader study framed by the lens. Concepts are abstract stimulating higher level thinking by causing students to rise above the fact base to gain understanding, timeless remaining constant even though the fact base that supports the concepts may change over time, universal, and can be applied across the fields of knowledge. Concepts integrate thinking and allow for the transfer of knowledge, provide a relevant focus for content study, facilitate the transfer of knowledge, and create a brain schema for processing new information.

H. Lynn Erickson
*Concept Based Curriculum and Instruction: Teaching Beyond the Facts*
Corwin Press, 2002




On a clear day you can see common concepts that span stratified disciplines.

We are moving from an economy and a society built on the logical, linear, computer-like capabilities of the Information Age to an economy and a society built on the inventive, empathetic, big-picture capabilities of what's rising in its place, the Conceptual Age.

Daniel Pink
*A Whole New Mind: Why Right-Brainers Will Rule the Future*
Riverhead Books, 2006

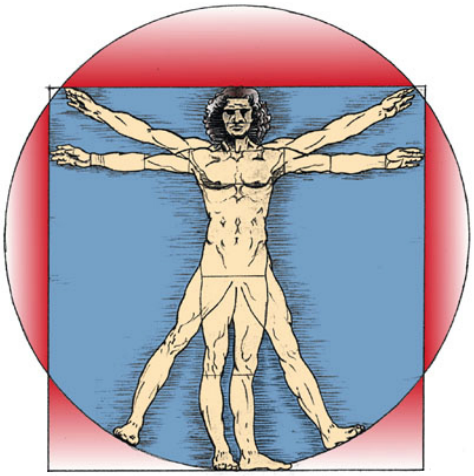
---

The arts are a medium and model for learning. All art forms share fundamental concepts with other thinking and symbol systems. Language, math, music, dance, theatre, and visual art all employ systems of symbolic representation. By drawing students' attention to the underlying structures that they share the study of the systems becomes mutually reinforcing, so students develop a deep and rich understanding of each system and the connections among them.

Dan Weissman
*Putting the Arts in the Picture: Reframing Education in the 21st Century*
Columbia College Chicago, 2004

---

# Reflections by
# LEONARDO DA VINCI



The average human
looks without seeing,
listens without hearing,
touches without feeling,
eats without tasting,
moves without physical awareness,
inhales without awareness of odour or fragrance,
and talks without thinking.

The artist sees what others only catch a glimpse of.

All sciences are vain and full of errors that are not born of experience
– the mother of all knowledge.

Painting is poetry that is seen rather than felt
And poetry is painting that is felt rather than seen.

Study the science of art.
Study the art of science.
Realize that everything connects to everything else.

# THE ART OF TEACHING

Five characteristics of art and artists can be applied to teaching.

Artists are fully engaged and committed to purpose. In the case of teachers, the engagement and commitment are to learning. ”To facilitate student learning artistically you must be a student yourself, fully engaged and committed to learning, actively seeking new ways to understand your discipline and how your students learn, gaining insights and nuances from the material, from the students’ interpretations, and from connecting students and material.”

Artfulness embodies art and science. For teachers this means drawing on the intrinsic link between art and science to enhance learning outcomes. Painters’, sculptors’, and printmakers’ success depends on a full understanding of the chemical properties of the materials they use. Teaching becomes artistic when we understand in a detailed and scientific way how it affects learning.

Art requires creativity. Artful teaching is not craft; it is more than the skillful application of teaching techniques. The artful teacher is always trying new materials and approaches to fit the needs and interests of the specific learner, never feeling that the ’perfect material’ or the ’perfect approach’ has been found. The teacher’s world is dynamic, filled with uncertainty and challenge, and teaching strategies are guided by a compass, not a road map. Artful teachers have the ability to be spontaneous and to improvise: to seize the moment and make it into something more compelling.

Artists grow and stay inspired through play, experimentation, and practice. When unexpected things occur they are embraced as valuable opportunities to learn, the specks of irritant or dust that lead to pearls. Likewise, teachers must draw on their ability to always remain learners. In serious and intense academic environments, it’s hard to be "playful," but the notion of having fun is a way of taking ourselves less seriously, and from that perspective we often see and understand things more clearly. This orientation can give us the space we need to experiment and to fail.

Finally, there is between artists and their material a special relationship. With teachers, the materials are our students and the special relationship is the need we have to create communities of learners. We can develop these strong relationships with and between students in the content materials through which we seek to engage them. We can nurture it by setting and keeping a reasonable pace. We can further promote it by setting the tone, which involves everything from the configuration of the classroom space to the way people are included in the unfolding action.

As its core, artful teaching focuses on learning – learning for teachers and learning for our students. It means being involved in a dance in which we may lead in the beginning, but then we let our partners provide movement and energy and direction. Artful teaching is helping self and students become artful learners, and there are as many paths to do this as there are teachers who are trying. Artful teaching lies in liberating the gifts that students and teachers bring to the classroom.

Maryellen Weimer
*Teaching As Art*
The Teaching Professor, Vol. 12, No.3, March 1998

# ARTIST HABITS OF MIND

Project Zero researchers at Harvard University studied how teaching artists work both in and out of the classroom. They discerned eight habits of mind as essential to what they call the "Studio Thinking Framework." The artist habits of mind can help teachers consider ways to model expert practice in their disciplines, individualize instruction and use more formative assessment and stimulate reflection and self-assessment.

The artist habits of mind resonate with the research carried out by Arthur Costa and Bena Kallick who write: "A habit of mind is knowing how to behave intelligently when you don't know the answer. A habit of mind means having a disposition toward behaving intelligently when confronted with problems, the answers to which are not immediately known: dichotomies, dilemmas, enigmas and uncertainties."

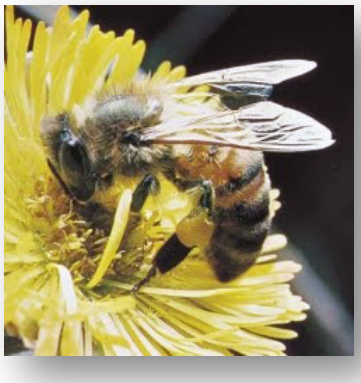
| Artist Habits of Mind | |
|---|---|
| **Develop Craft** | • Learning to use tools and materials<br>• Learning the practices of an art form |
| **Engage & Persist** | • Learning to take up subjects of personal interest and importance within the art world<br>• Learning to develop focus and other ways of thinking helpful to working and persevering at art tasks |
| **Envision** | • Learning to picture mentally what cannot be directly observed, heard or written and to imagine possible next steps in making a piece |
| **Express** | • Learning to create works that convey an idea, feeling or personal meaning |
| **Observe** | • Learning to attend to visual, audible and written contexts more closely than ordinary "looking" requires<br>• Learning to notice things that otherwise might not be noticed |
| **Reflect** | • Learning to think and talk with others about one's work and the process of making it<br>• Learning to judge one's own and others' work and processes in relation to the standards of the field |
| **Stretch & Explore** | • Learning to reach beyond one's supposed limitations, to explore playfully without a preconceived plan and to embrace the opportunity to learn from mistakes and accidents |
| **Understand Art World** | • Learning about the history and practice of the art form<br>• Interacting with other artists and the broader arts community |

Students are frequently asked to reflect on the quality of their work in the arts when they have had little prior experience doing so. When this is the case, their comments often refer more to personal taste. How can we support them to make more thoughtful reflections, ones that consider the standards or qualities in their work? How can we get them to examine the more thoughtful dimensions of their working process? One way to scaffold students' attempts at meaningful self-evaluation and reflection is to teach the artist's habits of mind. Making the ways that an artist thinks and works more apparent can nudge students toward applying them as criteria in their reflections.

*Studio Thinking (Eight Studio Habits of Mind)*

# CROSS-POLLINATED STUDIOS

**Classroom Designs Inspired by Creative Minds**



In the coming years, no educational paradigm shift will be more forcefully felt than the enrichment of disciplines through cross-pollination. Context and connection are fundamentally changing the way teachers teach and students learn. Not only are we hurtling at breakneck speed into an era in which traditional hard lines between the arts and the sciences are blurring, but we are also doing so with one eye firmly fixed on the way design can help the left and right brain work in harmony. How should the old-style classroom model evolve? Consider two illustrious thinkers who shaped the ideas of their times: Leonardo da Vinci and Albert Einstein. Destroying the traditional learning environment and creating something entirely new was a major challenge for these maestros, but here's what they came up with.

**The da Vinci Studio: Action Through Synthesis of Knowledge**

In Leonardo da Vinci's world, the lines between the disciplines, pervasive in today's schools, were absent; the works he did as a scientist, mathematician, and artist all informed the other efforts. No wonder one can look at his scientific drawings and wonder whether they were meant to be works of art and at his artwork and marvel at its scientific rigor. This kind of free-flowing interchange was accomplished in a workplace that was part artist's studio, part science lab, and part model-building shop.

So, what would a modern-day da Vinci studio look like as a classroom? Imagine a place with lots of daylight and directed artificial light, connection to an outdoor deck through wide or rolling doors, access to water, power supplied from a floor or ceiling grid, a wireless computer network, lots of storage, a floor finish that is hard to damage, high ceilings, places to display finished projects, reasonable acoustic separation, and transparency to the inside and outside with the potential for good views and vistas.

To take full advantage of today's da Vinci studio, teachers would need to collaborate more, offer students the opportunity to work on real projects, and encourage cross-disciplinary thinking in a way rarely seen within the four walls of traditional, unrevised schools.

**The Einstein Studio: Creative Reflection and Inspired Collaboration**

Albert Einstein's workplace was more study than studio. Preferring solitude and connections to nature, Einstein gave himself lots of time to stay in his own head. Because so much of what he did was cerebral, his inspiration could have come during quiet walks and in places other than his primary workplace. His official workplace may simply have let him develop ideas he had generated elsewhere. And so, when we talk about the Einstein studio today, we do so more in a metaphorical sense than as a way to actually duplicate Einstein's workplace in the modern school.

We can imagine that today's Einstein studio might include a place that encourages creative reflection, an inspiring setting not sealed off from the world outside or from those real problems and issues that must always have some place in abstract theorizing. To imagine an Einsteinian classroom, conjure the various ways the main lobby of a five-star hotel is furnished: It welcomes people alone or in small groups, it offers comfortable furnishings, it may nurture aspiration and inspiration with high ceilings, lots of glass, and easy connection to natural elements and water features, and it creates zones of privacy that remain firmly connected to the activity throughout the larger space. The Einstein studio can also be a movable feast, a portable state of mind to be re-created around a shade tree in the spring or on a class nature walk.

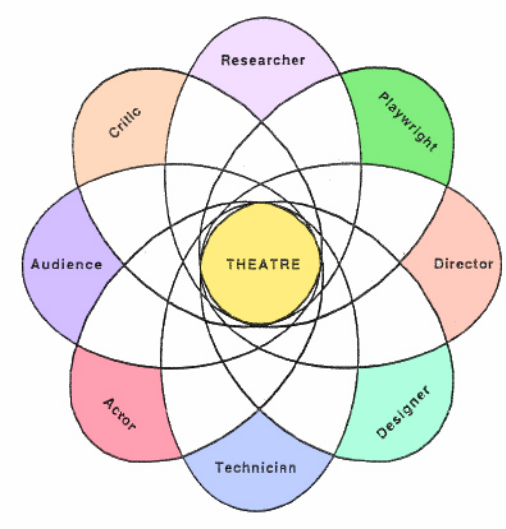
Think about connecting or even cross-pollinating the Einstein and da Vinci studios – creating a venue for both inspiration and inspired action.

Randall Fielding, Jeffery Lackney, Prakash Nair
*Master Classroom: Designs Inspired by Creative Minds*

# INTERDISCIPLINARY WORLD OF THEATRE

Integration inherently occurs in nature, daily life, and society – certainly in our interrelated, symbiotic 21st century world. So why then do our schools separate instruction into siloed disciplines? Our educational systems must be reinvented to meet the needs of our increasingly complex, diverse, globalized, media-saturated society. People have to be able to function, create, and communicate personally, socially, economically, and politically in local, national, and global venues. Schools must develop an interdisciplinary culture of inquiry where students work both independently and collaboratively, employing critical thinking and multiple intelligences for imaginative problem solving. How is this possible?

For an exemplifier of 21st century learning consider theatre which is, by its very nature, an interdisciplinary art form drawing on multiple aspects of human experience, knowledge, and skills. Theatre is a collaborative art that fosters social awareness and responsibility and requires group cooperation to achieve ensemble. Group members continually make choices, selecting and rejecting ideas, negotiating meaning, and evaluating the effectiveness of their communication.




There are eight roles associated with the creation, performance, and criticism of theatre: researcher, playwright, director, designer, technician, actor, audience, and critic. Discipline-based theatre education provides opportunities for students to engage in activities that enable them see and explore the totality of theatre from the perspectives of all these roles.

The concepts, processes, and values inherent in theatre are studied and explored through four methods of inquiry: production, history, aesthetics, and criticism. Each of these interrelated approaches provides a different perspective for experiencing, understanding, reflecting upon, and valuing the art of theatre. All four methods of inquiry are employed in varying degrees by researchers, playwrights, directors, designers, technicians, actors, audience members, and critics.

**Theatre Is a Way of Knowing**

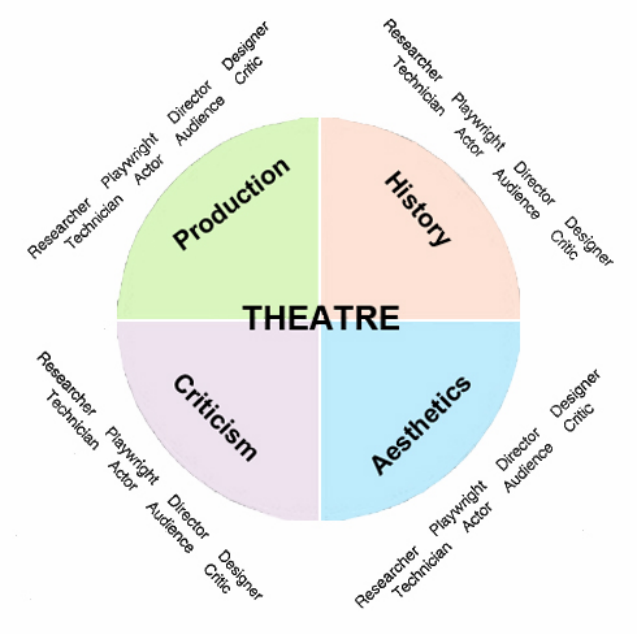
Dramatic play and informal theatre are integral aspects of the human experience prevalent in every culture throughout the ages. Shakespeare observed that all the world is a stage and all the men and women players, each in time playing many parts.

From birth, children instinctively use pretend play as a means of making sense of the world. They observe and respond to their environment. They imitate words and actions. They are entertained by nursery rhymes, stories, television and movies, and soon progress to play-acting, recreating favorite tales and role-playing characters in situations of their own devising. They interact with peers and arrange space and objects to create environments for their stories. They direct one another to bring order to their dramatic play. And they respond to one another's dramas. As they mature, they learn to change roles to meet the expectations of different audiences. They fantasize, envisioning roles in future events. They improvise, reacting to realities in the daily drama of life. And when not "on-stage," they become an audience observing

the actualities of the human drama as well as recreations enacted on television, in films, and upon the stage.

This world full of theatre comes in the doors of schools with the children who have learned language and behavior through the natural developmental process of drama. They arrive with rudimentary skills as playwrights, actors, designers, directors, and audience members. They possess powerful instinctive learning techniques, which all too often are curtailed through regimentation and rote teaching.

Outside the classroom children are typically active, self-directed learners. Educational theatre fosters these qualities in school situations, helping students to maintain and refine techniques and skills for exploring a wide range of interests. By responding to other people's cues and receiving response in return, children begin to establish their own identities. They learn to take risks as they explore new possibilities through conversation and role-play. They learn about life through the stories of others and their own storying in dramatic play. In creative dramatizations of literature and improvisational explorations of playscripts, students actively engage in situations that make sense to them in terms of their experiences and their present levels of understanding.



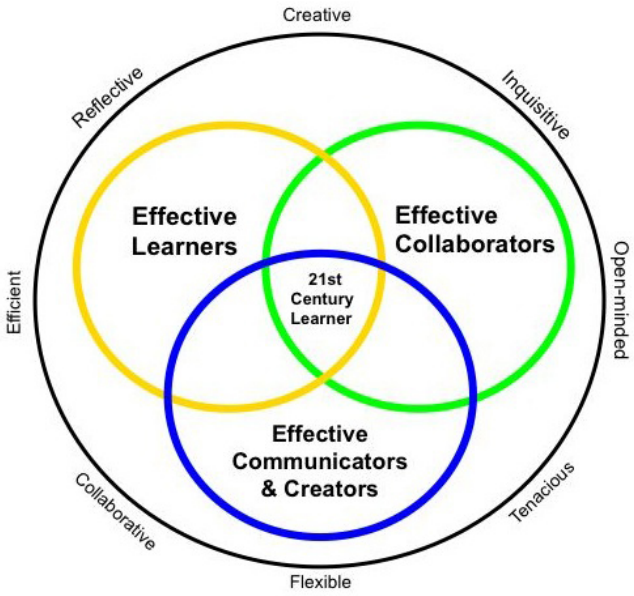

As individuals role-play, things happen and words are spoken that affect and modify the actions and behaviors of others. The introduction of ideas and issues challenge students to consider the implications of their decisions and to take responsibility for the consequences of their actions. To take on a role is to detach oneself from what is implicitly known and understood. It invites analysis, evaluation, modification, and synthesis of concepts already held.

Education in general is the process of helping individuals find essential meanings in life. These meanings accrue as people live and draw inferences from actual and symbolic experiences. Through theatre, students are engaged in make-believe situations, yet the real world continues to exist. The learning that occurs stems from the interaction of actual and symbolic meanings. Time can be altered and ideas juxtaposed. What is important is not so much the literal enactment of a plot but the process of exploring the meanings of the story – the themes, concepts, and issues. And ultimately the significance of the dramatic experience depends not so much on the event itself but on the analysis and reflection that occurs during and afterwards.

Kim Wheetley
*Discipline-Based Theatre Education Conceptual Framework*
Southeast Center for Education in the Arts, 1996

# ARTS AND 21st CENTURY SKILLS

The Partnership for 21st Century Skills brings together the business community, education leaders, and policymakers to define a powerful vision for 21st century education and to ensure that students emerge from our schools with the skills needed to be effective citizens, workers, and leaders. The arts are included as core subjects within the Partnership's *Framework for 21st Century Learning* as well as in the "No Child Left Behind" Federal law.




Dance, music, theatre, and visual art each have their own unique set of knowledge, skills, and processes, but they share common characteristics that make arts education powerful preparation for college and career and help to produce globally responsible citizens who are prepared for future success. Many of the 21st Century Learning Skills are taught compellingly and effectively through the arts, as illustrated below.

| * 21st Century Skills | ** Students engaged in the arts learn to: |
|---|---|
| Critical Thinking<br>Problem Solving | – use various types of reasoning to think and reflect critically and solve problems in both conventional and innovative ways. |
| Communication | – communicate in a variety of contexts through various artistic media and technologies to convey their own ideas and interpret the ideas of others. |
| Collaboration | – work together effectively and respectfully to flexibly share responsibility, compromise on diverse ideas, and accomplish common goals. |
| Creativity | – draw on a variety of sources to generate, evaluate, and select creative ideas to turn into personally meaningful products. |
| Innovation | – investigate new processes, implement creative ideas, and revisit traditional ideas to create new and reinterpret existing works of visual and performing arts. |
| Information Literacy | – access and evaluate information from a variety of sources accurately and creatively with an understanding of ethical and legal issues. |
| Media Literacy | – analyze and use media to understand how and why messages are creat and interpreted and how media influences culture, beliefs and behaviors |
| Information<br>Communication<br>Technology Literacy | – use technology effectively to research, access, create, and communicate creative ideas and information with an understanding of ethical and legal issues. |
| Flexibility<br>Adaptability | – be flexible and adapt to change in a variety of artistic contexts. |
| Initiative<br>Self-Direction | – be self-motivated, self-directed, and reflective learners who independently mange their goals and time to continuously improve as artists. |
| Social Skills<br>Cross-Cultural | – work respectfully and effectively with socially and culturally diverse teams or content to increase innovation and quality in their work. |
| Productivity<br>Accountability | – set goals, accept responsibility, and refine the quality of their work toward high standards of excellence and accountability. |
| Leadership<br>Responsibility | – use the arts to inspire others, optimizing the skills of team members<br>– through their interpersonal awareness, integrity, and ethical leadership to solve problems that benefit the larger community. |

* Partnership for 21st Century Skills

** Southeast Center for Education in the Arts

Partnership for 21st Century Skills

# SYMBIOTIC ART AND SCIENCE

A conference on the intersection of life sciences and arts: *Symbiotic Art and Science*, was convened by the National Endowment for the Arts and the National Science Foundation in March, 2011. Bringing together scientists and artists (and some who wear both hats), the conference looked at innovative collaborations that have taken place between the arts and sciences, and asked important questions, like What motivated you to cross disciplines and how did you do it? Or, What do artists gain from working with scientists, and what do scientists gain from working with artists? Three participants were asked to blog about their experiences.

---

*Choreographer and dancer Liz Lerman, artistic director of the Liz Lerman Dance Exchange:*

Introductions at the meeting took an interesting turn as one person after another acknowledged their split personality or hybrid research tactics. I found myself remembering my own mantra as a young choreographer moving from a residency at Children's Hospital in Washington, DC, to a rehearsal of the company, to teaching at a local university, and saying to myself, "I am not fragmented. It is just that the world is so compartmentalized that in order for me to be whole, I have to cross many borders." I have continued that journey and now describe those borders as membranes. For example, we can respect the creative act of making distinctions knowing at the same time that there are real differences between art and science even as we seek and discover with delight their common properties.

Everyone at the conference seemed to be immersed in a variety of projects that bring together very curious forms of experimentation in which the arc of observation-research-testing-sharing-questioning cycles around and around. Many of the participants have been at this for years. We could have taken just one of the projects put forward and spent a week coming to terms with its implications. For myself, listening to the project introductions, I was moved by the passion and caring that seems to be motivating so much of the exploration.

National Endowment for the Arts Blog
*Symbiotic Art & Science, Part I*

---

*Dr. Bevil Conway, Assistant Professor of Neuroscience, Wellesley College:*

I am both an artist and a scientist. My artistic endeavors have included printmaking, painting, and sculpture, while my primary scientific interests have centered on mechanisms of visual perception, primarily color. I have never considered my engagement in science as distinct from my activity as an artist. Although art and science differ in their modes of production, their expert communities, and often their quantifiable utility, both avenues of investigation have provided me with a mechanism to appreciate (and hopefully uncover!) the mysteries of perception. Both are fun.

From what I've witnessed amongst those of my colleagues who also make art and practice original scientific research, it seems that the spark that motivates both pursuits is essentially the same: a desire to make, and satisfaction in having made, something original, whether a piece of art or an experiment. As neurophysiologist David Hubel pointed out when I summarized the conference to him: the sciences and the arts are more closely aligned with each other than either is to the humanities. The arts and sciences have as their goal the creation of something entirely original. The humanities, on the other hand, are essentially engaged in criticism, although the best criticism is also original.

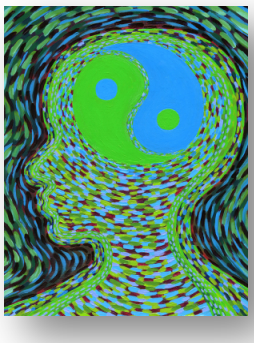
How do I approach a scientific experiment or an art project? In both cases, the "process" appears to me to be similar. I struggle to quiet the internal mental critic. I play. I make accidents and observations. I work every day, obsessively, and often have a difficult time sleeping. I worry about craft, and enjoy getting a feel for the materials and how they react under different conditions. And sometimes while working in my studio or laboratory, something happens that strikes me as worth following up. In this sense, the process is much like that of evolution itself, which first requires a diversity of phenotypes from which natural selection picks winners.

National Endowment for the Arts Blog
*Symbiotic Art & Science, Part 2*

---

*Dr. Robert Root-Bernstein, Professor of Physiology, Michigan State University:*

If we wish to promote the melding of arts and sciences, then there is an issue that was not formally raised at our conference that needs to be addressed: can artists make scientific discoveries? There are, in fact, a large number of cases in which such contributions have been forthcoming. Artists and musicians addressing scientific and technological problems invented the stethoscope, laryngoscope, the first pill-making machine, camouflage, and the first artificial intelligence program. Artists have invented several classes of novel geometrical objects and structures that have been appropriated by scientists in both life and physical sciences including Buckminster Fuller's geodesic domes. The invention of pointillism by Seurat led directly to modern pixelization as well as to the color blindness tests. The "chip" – our modern integrated circuit – is made using mainly artistic techniques: the logic is embedded into the design by drawing, it is then printed using silk screen methods, miniaturized using photolithography, and the patterns are then etched into the chip. In other words, the modern world would not be possible without the insights and inventions of artists. We lose sight of this fact at our peril.



The mirror-image argument can also be made. Scientists and engineers addressing artistic problems have been similarly productive, inventing electronic music, kinetic sculpture, color theory, elucidating how we hear and perceive sound, devising optical and aural illusions to explore cognitive functions, unveiling the mathematical principles behind origami, tiling, packing, fractal forms, and much more. Unveiling this rich cultural heritage of cross-fertilization between scientists and artists might itself be a worthwhile endeavor. My point is to demonstrate that arts and sciences are similar enough that the methods of one can usefully be employed to make breakthroughs in the other.

National Endowment for the Arts Blog
*Symbiotic Art & Science, Part 3*

**BRIDGING STEM TO STEAM**

# BRIDGING STEM TO STEAM

The acronym STEM – shorthand for science, technology, engineering, and mathematics – has quickly taken hold in education policy circles, but some experts in the arts community and beyond suggest it may be missing another initial to make the combination still more powerful. The idea? Move from STEM to STEAM, with an A for the arts.

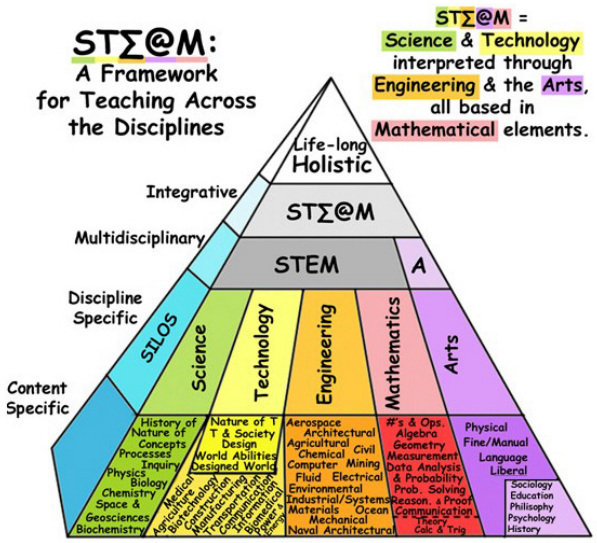
Although it seems a stretch to imagine STEM will be replaced in education parlance, momentum appears to be mounting to explore ways that the intersection of the arts with the STEM fields can enhance student engagement and learning, and even help unlock creative thinking and innovation. In fact, federal agencies, including the U.S. Department of Education and the National Science Foundation, are helping to fuel work in those areas. The NSF has provided research grants and underwritten a number of conferences and workshops around the nation this year, including a forum hosted by the prestigious Rhode Island School of Design, titled “Bridging STEM to STEAM: Developing New Frameworks for Art-Science-Design Pedagogy.”

One advocate of the STEM to STEAM push is Harvey Seifter, the director of the Art of Science Learning, a project financed by an NSF grant that organized three conferences last spring in Washington, Chicago, and San Diego that brought together scientists, artists, and researchers, as well as educators, business leaders, and policymakers to explore how the arts can be engaged to strengthen STEM learning and skills and produce a more creative American workforce. “For me, it is about connecting – or reconnecting – the arts and sciences in ways that learning can happen at the intersection of the two,” said Mr. Seifter. “We believe there is a powerful opportunity here to use the arts and arts-based learning to spark transformational change in science education.”

One core idea is that the arts hold great potential to foster creativity and new ways of thinking that can help unleash STEM innovation. “There is creativity in STEM itself, super genius in it, ... but in arts education, it really is the raison d’etre to be out of the box, to accept the chaos,” said John Maeda, the president of the Rhode Island School of Design, in Providence. Artists and designers, he said, are “risk takers, they can think around corners.”

The idea of integrating the arts with learning in other fields, including the STEM disciplines, is not new. In fact, some observers have noted an increase of late in activity more broadly to promote arts integration across the curriculum, at a time when the arts struggle to keep a foothold in classrooms amid school budget cuts and the pressure for academic gains in core subjects like reading and math. But some experts perceive a special connection between the arts and the STEM fields.

A 2008 study led by Robert Root-Bernstein of Michigan State University found that Nobel laureates in the sciences were 22 times more likely than scientists in general to be involved in the performing arts. Others note that Albert Einstein was an accomplished violinist. And then there's the Renaissance figure who some view as the personification of STEAM: Leonardo da Vinci, the Italian painter and sculptor who also made a name for himself as a scientist, engineer, and inventor.




Leaving the research question aside, however, some experts stop short of embracing a change from STEM to STEAM. Alan J. Friedman, a former head of the New York Hall of Science, said it's crucial for students not to lose sight of the differences, for example, between art and science. "One crucial point at which they part ways is the act of deciding, 'Is it good art? Is it good science?' Science and art have a lot to learn from each other, a lot of inspiration to share, a lot of commonality. They also have some very essential differences that are at the core of what they are, which is why I have trouble with STEAM." Susan R. Singer, a biology professor at Carleton College in Northfield, MN, echoes the point. "Not to devalue the symmetry, but they are very different ways of knowing the world. I would stop short of STEAM, but celebrate the ways that they work together."

Erik W. Robele
*"STEAM: Experts Make Case for Adding Arts to STEM"*
Education Week, December 2011

# INTERNATIONAL BACCALAUREATE

The International Baccalaureate offers three programmes of international education. The Primary Years Programme for ages 3 to 12 focuses on the development of the whole child.in the classroom and in the world outside. The Middle Years Programme for ages 11 to 16 provides a framework of academic challenge and life skills through embracing and transcending traditional school subjects. The Diploma Programme for ages 16 to 19 is a demanding two-year curriculum that meets the needs of highly motivated students, and leads to a qualification that is recognized by leading universities around the world.

The International Baccalaureate chooses to define "international education" according to the following criteria:

- Developing citizens of the world in relation to culture, language and learning to live together
- Building and reinforcing students' sense of identity and cultural awareness
- Fostering students' recognition and development of universal human values
- Stimulating curiosity and inquiry in order to foster a spirit of discovery and enjoyment of learning
- Equipping students with the skills to learn and acquire knowledge, individually or collaboratively, and to apply these skills and knowledge accordingly across a broad range of areas
- Providing international content while responding to local requirements and interests
- Encouraging diversity and flexibility in teaching methods
- Providing appropriate forms of assessment and international benchmarking.

The three programmes form a coherent sequence of education by promoting the education of the whole person through an emphasis on intellectual, personal, emotional and social growth. In all three programmes, the education of the whole person is manifested through all domains of knowledge, involving the major traditions of learning in languages, humanities, sciences, mathematics and the arts.

Furthermore, all three programmes:

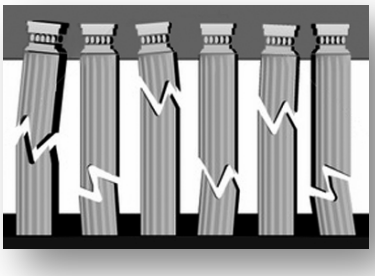
- require study across a broad range of subjects drawing on content from educational cultures across .the world
- give special emphasis to language acquisition and development
- encourage learning across disciplines
- focus on developing the skills of learning
- include, to a varying extent, the study of individual subjects and of transdisciplinary areas
- provide students with opportunities for individual and collaborative planning and research
- include a community service component requiring action and reflection.


International Baccalaureate

# UNIVERSITY DEGREES IN INTEGRATIVE STUDIES

Developing the ability to make, recognize, and evaluate connections among disparate concepts, fields, or contexts is what integrative learning is all about. Breadth and depth of learning remain hallmarks of a quality liberal education. Yet, today, there's a growing consensus that breadth and depth are not enough. Educators are taking seriously the fragmentation of knowledge, not just in their courses, but through the knowledge explosion in the world around us.

Many of the most interesting educational innovations clearly are intended to teach students what we might call the new liberal art of integration. Not only do these innovations invite students to integrate learning from different sources, but they also provide models, frameworks, and practice in actually doing so. The most promising initiatives for integrative learning are about finding strategic points of connection, threading attention to integrative learning throughout (and between) an institution's various programs, and encouraging and scaffolding students' own efforts to connect the parts.



With all six regional and four major specialized accreditors undergraduate calling for some form of integrative learning as an outcome of college, what has long been an aspiration for education is now a common expectation. Campuses are discussing not whether integrative learning will be part of undergraduate learning, but rather how it will be defined, fostered, supported, and assessed.

Mary Taylor Huber, Pat Hutchings, Richard Gale, Ross Miller, Molly Breen
*Leading Initiatives for Integrative Learning*
Liberal Education, Spring 2007

---

Integrative studies programs are growing in popularity throughout the United States and around the world. Below are some of the degree programs currently offered.

**Degrees in Integrated / Integrative Studies**

Appalachian State University, NC
Brown University, RI
Case Western Reserve University, OH
Clayton State University, GA
Ferris State University, MI
Franklin Pierce University, NH
George Mason University, VA
Kennesaw State University, GA
Miami University, OH
Murray State University, KY
Northern Kentucky University
Oakland University, MI
Pittsburgh State University, KS
University of Arkansas–Little Rock
University of Illinois-Springfield
University of Massachusetts-Amherst
University of Nebraska-Lincoln
University of North Florida
Weber State University, UT

## Degrees in Interdisciplinary / Multidisciplinary Studies

Abilene Christian University, TX
American University, Washington, DC
Arizona State University
Cameron University, OK
Carnegie Mellon University, PA
East Carolina University, NC
Emporia State University, KS
Marylhurst Universty, OR
North Carolina State University
Stony Brook University, NY
University of Alaska
University of Central Florida
University of Calgary, Alberta, Canada
University of Hawaii-Manoa
University of Idaho
University of Maine
University of Oklahoma
University of Texas at Dallas
University of Texas at El Paso
Webster University, MO
West Virginia University

Schiller International University – Heidelberg, Paris, Madrid
Université Paris Diderot, Paris, France

## Degrees in Transdisciplinary Studies

Claremont Graduate University, CA
Parsons New School for Design, NY
University of California-Santa Barbara
University of Dayton, OH
University of North Carolina-Chapel Hill

Athabasca University, Canada
International Center for Transdisciplinary Studies, Jacobs University, Bremen, Germany

School of Inter-Disciplinary and Trans-Disciplinary Studies
at IGNOU The Peoples University, New Delhi, India

# COLLABORATION

artwork by Emilo Gomariz