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Igniting and Nurturing the Next Generation of STEM Talent, Innovation and Leadership, by Design

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Our future will belong to a "new breed" of STEM talent— *decidedly different* STEM minds that understand interdependence; discern, analyze and connect illusive patterns within vast amounts of unstructured data; deftly change course when hypotheses and prototypes fail; systemically unravel complexity; creatively generate new ideas, questions, technologies and inventions; embrace ambiguity and uncertainty; and globally collaborate to wisely advance the human condition. In this age of escalating global challenges, accelerating technologies and design and human-centered innovation, the nature and quality of how our children think and what they think about is the new "currency" for breakthrough thinking, research and problem-solving, pioneering collaboration, groundbreaking life-enhancing innovation, and transformative global change.

Habits of mind, mental models and patterns of thinking and behavior are shaped through immersion, experience and practice. When children engage in disciplinary and interdisciplinary research, investigation, and experimentation, they learn to inquire, explore, and discover; when they identify, frame and offer solutions to vexing global problems, they learn to ethically resolve complexity, and when they collaboratively wrestle with moral and ethical dilemmas, they learn to wisely grapple with issues of social, economic, political and environmental justice. They become more agile, autonomous, risk and novelty-seeking, failure-resilient, improvisational, and in control of their own minds and behavior, assuming responsibility for shaping the nature and quality of their thinking and manifesting it in action.

By design, we can inspire, ignite and nurture our children's inventive genius and enable it to flourish. We know what it takes to develop talent and expertise, and support and sustain the creative imagination. Yet, there is a growing chasm between the collaborative, exploratory, future-oriented and applications-focused ethos and environment essential for nurturing STEM talent and innovation, and the constrained, prescriptive and risk-averse culture and conditions of schooling.

Innovation happens at the edges and intersections of disciplines. It happens when irreverent questions are asked, conventional wisdom is challenged, disruptive hypotheses are explored, and possibilities of "what if" or "how might we" capture the imagination. Innovation also happens when it's safe to risk, tinker and venture into unexplored and unconventional territory. It is a messy, dynamic, unpredictable, and nonlinear process; and it requires a generative and integrative learning habitat within a vibrant innovation ecosystem that invites experimentation and discovery, rewards invention, and encourages intuitive forays and the passionate pursuit of often absurd questions and solutions wherever they may lead.

Our students live and learn in a digital world of global connections, intelligent machines and networks, immersive technologies, multi-user virtual environments and social networks. In this world, learning is experiential, purposeful, self-directed and on-demand; expertise is multi-generational and distributed; thinking is shared; problem-solving is collaborative; knowledge is co-constructed; boundaries are intentionally blurred; and learning, social relationships and play seamlessly converge.

To develop the STEM innovators our nation and world require, we must design conditions that engage students' minds and hearts and nurture their sense of wonder, infinite possibility and extraordinary contribution. Regrettably, most American students experience STEM learning as an exclusive, individual, theoretical and "formulaic" enterprise. By decoupling STEM education from the human experience, we have distorted the essential nature of the scientific enterprise and advanced instrumentalist and utilitarian rationales for pursuing STEM careers—global economic superiority and technological competition.

In a world of unprecedented connectivity and undisputed global interdependence, this "narrative" does not inspire talented students to devote their lives to science, nor does it ignite their commitment, boundless energy and altruism to use their knowledge and passion to make a transformative difference in areas of compelling human need. The generative learning environment(s) we design must stimulate students to develop those competencies needed for knowledge creation and application, ethical and entrepreneurial leadership, radical technological innovation and invention, imaginative human-centered design, and sustainable whole systems change.

Next Generation STEM Learning Design

Our nation must transform our system of STEM education and create an inclusive and robust learning and innovation ecosystem that ignites and nurtures a more "hybrid" and blended generation of STEM talent, innovation and entrepreneurial leadership. This "new breed" of integral and wise STEM innovators—future-oriented and applications-focused—fluidly integrates and navigates within and between a broad spectrum of STEM disciplines, seeds and cross-pollinates ideas, and represents a synthesis and an integration of multiple STEM domains: creative scientists *and* researchers, innovative engineers *and* inventors, designers *and* technology creators, and social entrepreneurs *and* policy strategists.

To develop this next generation, the program of studies and curriculum are reconceived within the context of four differentiated, yet dynamically integrated core learning and teaching "complexes." These unique learning habitats are designed to immerse and engage students in the real work and modes of inquiry, problem-solving, knowledge creation and application, that distinguish four fundamental STEM learning cultures and communities, each designed to develop high levels of understanding and knowledge application.

These four habitats and the nature of thinking and problem-solving emphasized are: (1) Inquiry and Research Laboratories and Interdisciplinary Learning Centers—*develop disciplinary, interdisciplinary, and inquiry-based thinking*; (2) Innovation Incubators and Design Studios—*ignite innovation and design-based thinking*; (3) Global Leadership and Social Entrepreneurship Institutes—*nurture change leadership and systems-based thinking*; and (4) **L**eadership, **Inn**ovation and **K**nowledge (LINNK) Commons—an integrative hub and "transformation exchange" that *connects the expertise, creative and leadership resources, and networks of the global STEM commons to identify and solve complex questions and problems that advance both the new STEM frontier and the human future*.

This design moves far beyond the traditional conception and boundaries of STEM learning and schooling, and enables learning to be situated in schools and diverse locations: museums, universities, NGOs, research laboratories, design schools, innovation hubs, engineering, design and production studios, and on-line pavilions. The learning calendar is yearlong and learning time and experiences are adaptive, driven by the nature and complexity of the student's work and their personal learning goals. Extended mentorships, internships and apprenticeships engage students in authentic problem-solving, research and innovative knowledge production. Learning is assessed through multiple means—internationally bench-marked standards, and multiple individual and team research and inquiry, design, and leadership projects; age and grade level distinctions are blurred. Practitioners, scientists, researchers, designers, inventors and social entrepreneurs are teachers and co-learners; faculty hold joint appointments in multiple learning cores; and all forms of advanced information and digital technologies are embedded into learning and teaching.

The core curriculum is guided by the knowledge, questions and problems that define each domain's work. Engaging students in the real work of research and inquiry, innovation and design, and ethical change leadership, enables them to experience what is required to be successful in each domain. Simulating a medical school residency model, students initially spend dedicated time in each core. When ready, they focus on expanding and deepening their knowledge and practice within their preferred domain. What is essential is that their purposeful engagement in each learning core enables them to experience, integrate and "try out" a range of options for future study, work and contributions in STEM and discover what they love.

Every STEM learning, leadership and innovation program would be part of a dynamic national and regional network—a robust innovation ecosystem designed to support and sustain the transformation of STEM teaching and learning and the continued nurturance of talent, innovation and leadership.

We shape the world from the inside out. The nature and quality of our thinking shapes who we become, and who we become shapes the world. The future well-being, prosperity and sustainability of our nation, the global community and our planet resides in igniting and nurturing, *decidedly different* STEM minds that will commit to using the transformative power of science, technology, engineering and mathematics to advance the human condition.

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