The National Academies of
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Integration of Education in the Sciences, Engineering, and Medicine with the Arts and Humanities at the Undergraduate and Graduate Levels

First Regional Information Gathering Workshop

Program Book

Le Laboratoire Cambridge
650 East Kendall Street
Cambridge, MA
October 13th-October 14th, 2016

1. Agenda

INTEGRATION OF EDUCATION IN THE SCIENCES, ENGINEERING, AND MEDICINE WITH THE ARTS AND HUMANITIES AT THE UNDERGRADUATE AND GRADUATE LEVELS

Agenda for the First Regional Information Gathering Workshop

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October 13th-October 14th, 2016

Thursday October 13th

12:00 p.m.-1:00 p.m. Informal boxed lunch

1:00 p.m.-2:00 p.m. Panel I: Models, Practices, Opportunities, and Challenges for Mutual Integration of the Arts, Humanities, and Engineering (The Honeycomb room)

- Amy Banzaert, Lecturer in Engineering at Wellesley College
- Rick Vaz, Director, Center for Project-Based Learning, Worcester Polytechnic Institute
- Emma Smith Zbarsky, Associate Professor, Department of Applied Mathematics, Wentworth Institute of Technology

2:00 p.m.-3:00 p.m. Presentation by Kevin Hamilton, Professor and Senior Associate Dean in the College of Fine and Applied Arts at the University of Illinois, Urbana-Champaign, on concepts of integration in higher education (The Honeycomb room)

3:00 p.m.-3:30 p.m. Informal committee discussion with Howard Gardner, John H. and Elisabeth A. Hobbs Professor of Cognition and Education at the Harvard Graduate School of Education (Howard Brenner Studio)

3:30 p.m.-5:30 p.m. Committee closed session (Howard Brenner Studio)

5:30-6:30 p.m. Committee closed reception (CaféArt Science)

6:30 p.m.-8:30 p.m. Committee closed working dinner (Howard Brenner Studio)

Friday October 14th

8:00 a.m. -8:30 a.m. Continental breakfast

8:30 a.m.-9:30 a.m. Presentation by Matthew Mayhew, William Ray and Marie Adamson Flesher Professor of Educational Administration at The Ohio State University, on integrative teaching and learning in the scholarly literature

9:30 a.m.-10:30 a.m. Panel II: Models, Practices, Opportunities, and Challenges for Mutual Integration of the Arts, Humanities, and Technology

- Ben Schmidt, Assistant Professor of History, Northeastern University
- Rosalind Williams, Bern Dibner Professor of the History of Science and Technology, MIT
- Bret Eynon, Historian and Associate Provost at LaGuardia Community College (CUNY)

10:30 a.m.-10:45 a.m. Coffee Break

10:45 a.m.-12:00 p.m. Panel III: Models, Practices, Opportunities, and Challenges for Mutual Integration of the Arts, Humanities, and Science (The Honeycomb room)

- Dan Brabander, Professor of Geosciences, Wellesley College
- Vandana Singh, Professor of Physics, STIRS Scholar, Framingham State University
- Catherine Pride, STIRS Fellow, Associate Professor of Psychology, Middlesex Community College
- Loren B. Byrne, Associate Professor of Biology and Environmental Science Coordinator, STIRS Scholar, Roger Williams University

12:00 a.m.-12:15 p.m. Welcome remarks by David Edwards, Professor of the Practice of Idea Translation in the School of Engineering and Applied Sciences at Harvard University and Founder of Le Laboratiore followed by a musical performance of excerpts from Bach Goldberg Variations by Justin Lo, violin (HMS '17); Michael Wu, cello (HMS '18); and committee member Lisa Wong, viola.

12:15 p.m.-1 p.m. Lunch

1:00 p.m.-2:00 p.m. Discussion of Institutional Barriers and Opportunities for Mutual Integration of the Arts, Humanities, Science, Technology, Engineering, Math, and Medicine

- Bob Pura, President of Greenfield Community College
- Lee Pelton, President of Emerson College
- Helen Drinan, President of Simmons College
- Pam Eddinger, President of Bunker Hill Community College

2:00 p.m.-3:15 p.m. Panel V: Models, Practices, Opportunities, and Challenges for Mutual Integration of the Arts, Humanities, and Medicine

- Joel Katz, Director, Internal Medicine Residency Program, Harvard Medical School
- Michelle Morse, Deputy Chief Medical Officer, Partners In Health, Founding Co-Director, EqualHealth , Assistant Program Director, Brigham and Women's Internal Medicine Residency
- Rita Charon, Director of the Program in Narrative Medicine at the Columbia University
- Ed Hundert, Dean for Medical Education, Harvard Medical School

3:15 p.m.-5:00 p.m. Closed committee discussion (Howard Brenner Studio)

5:00 p.m. Adjourn

2. Speakers Information

Speaker Biographies

Amy Banzaert is the Director of Engineering Studies and Lecturer in Engineering at Wellesley College, an elite all-women's liberal arts college located in a suburb of Boston, MA. She is the founder of the Wellesley Engineering Laboratory, or We-Lab, at the College. Banzaert received her Ph.D., as well as her Bachelor and Masters degrees, in mechanical engineering from the Massachusetts Institute of Technology.

Banzaert's Ph.D. research involved study of emissions associated with cooking fuels, including a novel charcoal made from agricultural waste that can be used as cooking fuel in regions where poverty and deforestation are severe. Her current work is focused on educational approaches and research centered on engineering projects that can create positive change for under-served communities.

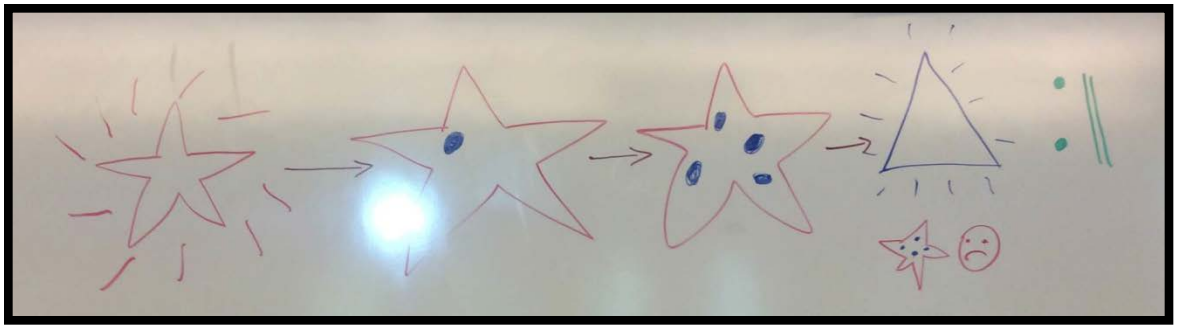
At Wellesley College, Banzaert teaches introductory courses in engineering, primarily within mechanical and electrical disciplines, with an emphasis on household-level technologies for local and international development. Pedagogies Banzaert incorporates into her classes include hands-on, project-based, active learning; service learning; and integrated lecture-lab.

Dan Brabander, Professor Geosciences/Environmental Studies, Wellesley College

"We must rid ourselves of the notion that careful study of a problem based on a narrow range of issues is the only kind of work to be taken seriously, while integrative thinking is relegated to cocktail party conversations." (Gell-Mann, 2010).

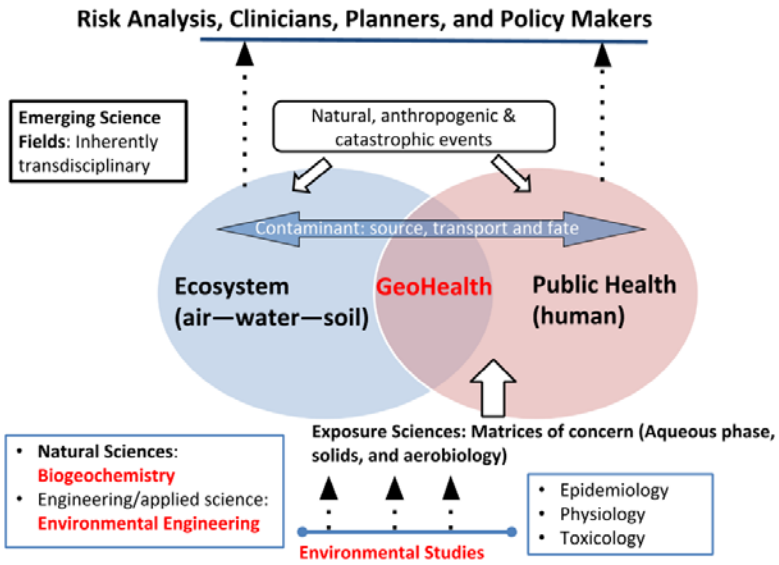
Fostering integration as a way of thinking. Brabander offers "Big Idea" courses that introduce systems thinking in applied and messy problem spaces. Course goals are centered on taking a crude look at the whole to determine a path of inquiry. Approach focuses on transdisciplinary theories (e.g., see open syllabus project: paradigms) while fostering intrinsic motivation though project based collaborative learning. Deliverables are aimed at de novo authorship of scientific narratives. Three recent courses have been designed with these goals as a framework: (1) SUST220(Wellesley) AHSE2199A/SCI2099A (Olin) Paradigms, Predictions, and Joules: A Historical and Scientific Approach to Energy and the Environment (2) GEOS/ES 201 (Wellesley) Environmental, Health, and Sustainability Sciences (3) ASTR/GEOS 120 (Wellesley) Planetary Habitability: Past, Present, and Future.

These applied alternative on-ramps into STEM have attracted a higher percentage of both URM and first generation students. In 2010, Brabander was awarded the Wellesley College's Pinanski Prize for Excellence in Teaching



Paradigm theory as collaboratively illustrated by Earth Processes and Environment students at Wellesley College.

Integration leading to new disciplines. Informed by research experiences at both Parsons Lab at MIT and Harvard School of Public Health, Brabander's current research is at the intersection of environmental health and medical geosciences and has helped shape and define an emergent new discipline: "geohealth."



Geohealth: An emerging discipline linking engineers, natural scientists, health professionals with clinician and urban planners in the built environment (Brabander and Fitzstevens. 2014).

Professor Brabander's research team comprises undergraduates learning science by doing science, citizen scientists, and not for profit organizations. Projects have been featured in numerous media outlets including NPR, ABC news, the Boston Globe, and Time Magazine. His current research focus is environmental geochemistry, health, and sustainable urban agriculture.

Loren Byrne is an urban and soil ecologist and environmental educator at Roger Williams University in Bristol, RI where he is an associate professor of biology and environmental science. His position there started in 2007 after a one-year visiting professor position at the College of Wooster in Wooster, OH. He earned his Ph.D. in ecology from Penn State University in 2006 by completing research about the effects of urban landscape management (lawns and gardens) on soil processes and biodiversity.

At Penn State, he also completed several visual art courses in which he created works (painting, drawing, installation sculpture) that explored environmental issues, including soil organisms. This pursuit of thinking about relationships between art and science continued the studies he completed for an individualized major in Ecological Artistry earned (as a BA degree) from Hiram College in Hiram, OH in 2000. In addition to studying photography and painting, he also practiced scientific illustration and was hired by a paleontologist to create illustrations of fossils, some of which were published in the journal Nature. At Penn State and Roger Williams, Loren has taught scientific illustration courses to help students discover the joy of creating art in a scientific context.

At Roger Williams, Loren also teaches a diversity of ecology and environmental science courses along with interdisciplinary courses in sustainability studies. He was the founding coordinator of the Sustainability Studies program at Roger Williams after helping create and implement the University's sustainability studies minor with colleagues from a diversity of disciplinary backgrounds. His strong interests in teaching interdisciplinary issues about human-environment relationships led him to pursue a book project about innovative classroom pedagogies; he edited the volume Learner-Centered Teaching Activities for Environmental and Sustainability Studies which was published by Springer in 2016. He is currently serving as the education programs coordinator for the Global Soil Biodiversity Initiative.

Rita Charon is Professor of Clinical Medicine and Director of the Program in Narrative Medicine at the Columbia University College of Physicians and Surgeons. A general internist with a primary care practice in Presbyterian Hospital, Dr. Charon took a Ph.D. in English when she realized how central is telling and listening to stories to the work of doctors and patients. She directs the Narrative Medicine curriculum for Columbia's medical school and teaches literature, narrative ethics, and life-telling, both in the medical center and Columbia's Department of English. Her literary scholarship focuses on the novels and tales of Henry James. Her research projects center on the outcomes of training health care professionals in narrative competence and the development of narrative clinical routines to increase the capacity for clinical recognition in medical practice. She is currently Principal Investigator on an NIH project to enhance the teaching of social science and behavioral science in medical schools. Her work in narrative medicine has been recognized by the Association of American Medical Colleges, the American College of Physicians, the Society for Health and Human Values, the American Academy on Healthcare Communication, and the Society of General Internal Medicine. She is the recipient of a Rockefeller Foundation Bellagio Residence and a John Simon Guggenheim Fellowship. She has published and lectured extensively on the ways in which narrative training helps to increase empathy and reflection in health professionals and students. She is author of Narrative Medicine: Honoring the Stories of Illness

and co-editor of Psychoanalysis and Narrative Medicine and Stories Matter: The Role of Narrative in Medical Ethics.

Helen G. Drinan has served as President of Simmons College in Boston since 2008. Under her leadership, the College has completed the largest fundraising campaign in its history ($100 million), welcomed the two largest freshman classes in its history, reconfigured its undergraduate curriculum around leadership development, launched 12 world-class online graduate degree programs, and has cemented its status as a premier institution for women scholars. Founded in 1899, Ms. Drinan is Simmons's eighth president. The twin hallmarks of Ms. Drinan's tenure are fiscal stability and growth, and the unwavering institutional focus on its mission to develop career skills of Simmons students. Prior to being named President, Ms. Drinan served as the Chair of the College's Board of Trustees.

In leading the institution forward, Ms. Drinan has established herself as a national expert on women's education as a pathway to developing successful leaders, with her comments and writings appearing in numerous media outlets including National Public Radio, The Huffington Post, The New York Times, The Boston Globe, and The Boston Business Journal. The most recent recognitions for her work on behalf of women's and girls' education and leadership include the MissionSAFE "Be the Change" Award (2015); Women's Lunch Place Honoree (2014); Strong Women Strong Girls "Phenomenal Woman" (2014); Girl Scouts of Eastern Massachusetts Leading Woman (2013); Woman LEAD "Woman Who Leads in Academia and Inspires Others" (2013), and the Greater Boston Chamber of Commerce Pinnacle Award for Excellence in Arts & Education (2012).

Ms. Drinan is a member of several organizations dedicated to empowering women including the Advisory Council of the Women in Public Service Project; 2020 Women on Boards; and the Massachusetts Women's Forum.

Her experience as a Peace Corps volunteer in the Philippines in the early '70s with her husband and two small children provided her with formative multicultural experiences that have influenced her leadership style and sensitivity. President Drinan was one of five prominent Bostonians highlighted in the Boston Globe's 50th Anniversary Peace Corps feature article.

Another seminal moment for Ms. Drinan was when she was diagnosed with breast cancer in 2014. She chose to make her battle public, using blogs, emails, and media interviews to help reduce the lingering stigma around cancer, and to encourage women and men to stay vigilant about their health. She is keenly interested in the relationship between carcinogens in consumer products and their impact on the incidents of cancer. An undergraduate alumna of Mount Holyoke College, Ms. Drinan also holds degrees from the Simmons School of Management and the Simmons School of Library and Information Science.

Pam Eddinger assumed the presidency of Bunker Hill Community College on July 1, 2013. From 2002 to 2005, she served as an administrator at MassBay Community College first as vice president of academic affairs and dean of the faculty (2002-2004), then as executive vice president (2004-2005). At MassBay, she successfully led the college's 10-year accreditation self-study, chaired the college's strategic planning committee, and secured a $2 million legislative earmark for capital improvement. She reorganized the college's three academic institutes, raised enrollment in the division of continuing education by 13 percent, increased revenue by $2 million, and expanded the automotive technology center with partners GM Motors, Daimler Chrysler, Toyota and BMW.

In 2005, she began her tenure at Moorpark College, a 15,000-student, comprehensive community college, serving as executive vice president from 2005 to 2008, before being tapped to serve as college president. Eddinger proved to be a leader in institutional effectiveness and long-term planning and strategy. At Moorpark, she led the college's development of the 2009-2019 educational master plan as well as other planning initiatives. She spearheaded the identification of core academic curricula, launched a web-based student planning and development initiative, guided expansion of distance learning, and committed sustainable resources for the creation of a student success center.

Eddinger immigrated to the United States from Hong Kong at the age of 11 and grew up in Miami, Florida. She received her bachelor's degree in English from Barnard College in New York City, and earned both her master's degree and doctorate in Modern Japanese Literature at Columbia University.

David Edwards is Professor of the Practice of Idea Translation in the School of Engineering and Applied Sciences at Harvard University and founding faculty of the Wyss Institute of Biologically Inspired Engineering. Founder of Le Laboratoire, a cultural center in Paris and Cambridge, where artists and designers perform experiments at frontiers of science, David works with contemporary artists, designers, chefs, perfumers, and other creators to pioneer research around ambiguous questions in human health, society and the environment. Beyond his experimental art and design work at Le Laboratoire, David has invented ways of packaging foods with edible skins, called WikiFoods, which sell today in New England food stores under the Incredible brand (Perfectly Free, NuFruit), and digitizing scent (oNotes), a communications platform with ramifications to health diagnostics (www.davidideas.com). His invention of porous particles for inhaled drug and vaccine delivery helped pioneer the development and commercialization of inhaled insulin and inhaled drugs and vaccines for tuberculosis (AIR, Civitis, Medicine in Need). Many of David's sensorial inventions appear in his future-of-food restaurant Cafe ArtScience in Cambridge's Kendall Square. He is a member of the US and French National Academies of Engineering and the US National Academy of Inventors as well as a Chevalier des Arts et des Lettres of the French Ministry of Culture.

Bret Eynon is a historian and Associate Provost at LaGuardia Community College (CUNY), where he guides collegewide educational change initiatives related to learning, teaching, curriculum, advisement, technology, and assessment. The founder of LaGuardia's Center for Teaching and Learning and its internationally-known ePortfolio project, Eynon's many articles and books include *Freedom's Unfinished Revolution: An Inquiry Into the Civil War and Reconstruction;* and *1968: An International Student Generation in Revolt;* as well as *Who Built America*? an award-winning series of textbooks, films, and CD-ROMs. A senior national faculty member with the Association of American Colleges and Universities, Eynon's most recent book, with Randy Bass, is *Open and Integrative: Designing Liberal Education for the New Digital Ecosystem.* Supported by grants from the NEH, FIPSE, the Mellon Foundation and the USDOE's First in the World initiative, Eynon's work has been honored for by the American Association for Higher Education, the American Council on Education, the Community College Futures Association, and the Carnegie Foundation for the Advancement of Teaching. The national Community College Humanities Association has recognized him as a Distinguished Humanities Educator.

Howard Gardner is the John H. and Elisabeth A. Hobbs Professor of Cognition and Education at the Harvard Graduate School of Education. He is also an adjunct professor of psychology at Harvard University and senior director of Harvard Project Zero. Among numerous honors, Gardner received a MacArthur Prize Fellowship and a Fellowship from the John S. Guggenheim Memorial Foundation in 1981 and 2000, respectively. In 1990, he was the first American to receive the University of Louisville's Grawemeyer Award in Education. In recognition of his contributions to both academic theory and public policy, he has received honorary degrees from thirty-one colleges and universities, including institutions in Bulgaria, Canada, Chile, Greece, Ireland, Israel, Italy, South Korea, and Spain. He has twice been selected by Foreign Policy and Prospect magazines as one of 100 most influential public intellectuals in the world. In 2011, Gardner received the Prince of Asturias Award for Social Sciences, and in 2015, he was chosen as the recipient of the Brock International Prize in Education. He has been elected a member of the American Academy of Arts and Sciences, the American Philosophical Society, the National Academy of Education, and the London-based Royal Society for the Encouragement of Arts, Manufactures, and Commerce. He serves on a number of boards, including New York's Museum of Modern Art and the American Philosophical Society.

The author of thirty books translated into thirty-two languages, and several hundred articles, Gardner is best known in educational circles for his theory of multiple intelligences, a critique of the notion that there exists but a single human intelligence that can be assessed by standard psychometric instruments (please see multipleintelligencesoasis.org). Since the middle 1990s, Gardner has directed The Good Project, a group of initiatives, founded in collaboration with psychologists Mihaly Csikszentmihalyi and William Damon, that promotes excellence, engagement, and ethics in education, preparing students to become good workers and good citizens who contribute to the overall well-being of society. Through research-based concepts, frameworks, and resources, the Project seeks to help students reflect upon the ethical dilemmas that arise in everyday life and give them the tools to make thoughtful decisions.

His newest research undertaking is a large-scale national study documenting how different groups think about the goals of college and the value of a course of study emphasizing liberal arts and sciences. The study seeks to understand how the chief constituencies of campuses incoming students, graduating students, faculty, senior administrators, parents, alumni/ae, trustees and job recruiters think about these changes and how they may impact the college experience in our time. Ultimately, the study aims to provide valuable suggestions of how best to provide quality, non-professional higher education in the 21st century.

Kevin Hamilton is a Professor at the University of Illinois, Urbana-Champaign, where he holds appointments in the School of Art and Design and the program in Media and Cinema Studies, and serves as Senior Associate Dean in the College of Fine and Applied Arts.

Working in collaborative and cross-disciplinary modes, Kevin produces artworks, archives, and scholarship on such subjects as race and space, public memory, history of technology, and state violence. His articles with Ned O'Gorman on Air Force film production have appeared in Rhetoric & Public Affairs, Visual Culture, and Communication & Critical/Cultural Studies. Their book-in-progress and accompanying digital archive traces the history of the Air Force's most famous film unit, Lookout Mountain Laboratory, from 1948 through 1969. At Illinois Kevin also co-directs the Center for People and Infrastructures, an effort currently focused on the ethics and civics of algorithmic culture through research, design, and outreach. Kevin's artworks in digital form have appeared in Rhizome, Turbulence, Neural, and the ASPECT DVD series. Recognition for his work has included grants from the National Science Foundation and National Endowment for the Humanities, presentation at conferences across Europe and North America (ISEA/ DEAF/CAA/NCA/ACM-SIGCHI), publication in edited journals and anthologies (Routledge/CCCS/Palm Press/UCLA), and invited residencies (Banff/USC-IML/Bratislava.

As an educator, administrator, and researcher, Kevin is focused on integration of practice-based, historical and theoretical approaches to learning about technological mediation. This work has included the development of several interdisciplinary project-based courses, workshops, and initiatives for students and faculty from the sciences, arts and humanities, with emphases on prototyping, reflection, and methodologies of collaboration.

Edward M. Hundert is the Dean for Medical Education and the Daniel D. Federman M.D. Professor in Residence of Global Health and Social Medicine and Medical Education at Harvard Medical School, where he also serves as Associate Director of the Center for Bioethics and directs the Medical Ethics and Professionalism curriculum. Over the past 25 years, he has served as President of Case Western Reserve University, Dean of the University of Rochester School of Medicine and Dentistry, and Associate Dean for Student Affairs at Harvard Medical School. An internationally known scholar, educator, psychiatrist, and ethicist, he has held professorial appointments in psychiatry, medical ethics, cognitive science, and medical humanities.

Dr. Hundert earned his bachelor's degree in mathematics and the history of science and medicine, summa cum laude, from Yale University, where he received Yale's Chittenden Prize "to the graduating senior with highest standing in mathematics or the natural sciences." He attended Oxford University as a Marshall Scholar, receiving the Batterbee Prize from Hertford College for "highest first class honours in philosophy, politics and economics." Four years later he earned the M.D. from Harvard Medical School, receiving the Sanger Prize for "excellence in psychiatric research." He completed his psychiatric residency at McLean Hospital, where he served as chief resident. He has received numerous teaching, mentoring, and diversity awards, and he was voted the "faculty member who did the most for the class" by Harvard Medical School graduates in five different years.

Dr. Hundert is a member of the board of TIAA-CREF. He has previously served on the boards of the Association of American Universities, the American Association of Medical Colleges, the Liaison Committee on Medical Education, and the Rock and Roll Hall of Fame. He co-chaired the Institute of Medicine's National Summit on Health Professions Education, and he chaired the national task force on the status of the humanities at America's research universities, an initiative co-sponsored by the American Council of Learned Societies and the Association of American Universities. Dr. Hundert has written dozens of articles and chapters on a variety of topics in psychiatry, philosophy, medical ethics, and medical education, as well as two books: Philosophy, Psychiatry and Neuroscience: Three Approaches to the Mind (Oxford University Press) and Lessons from an Optical Illusion: On Nature and Nurture, Knowledge and Values (Harvard University Press).

Joel T. Katz, MD, is the director of the Harvard Medical School course "Training the Eye: Improving the Art of Physical Diagnosis," which helps medical students improve their skills in physical diagnosis by studying the fine arts.

A graduate of Earlham College and the Johns Hopkins University School of Medicine, Joel T. Katz, MD, is an infectious diseases consultant, director of the internal medicine residency program, and vice chair for education at Brigham and Women's Hospital, where he is the Marshall A. Wolf Chair in Medical Education. He is an Associate Professor of Medicine at Harvard Medical School.

Formerly a commercial artist, Dr. Katz has an interest in utilizing the humanities to improve medical education.

He is the director of the Harvard Medical School course "Training the Eye: Improving the Art of Physical Diagnosis," in which students hone their physical diagnosis acumen through the study of fine arts at the Boston Museum of Fine Arts.

Matthew J. Mayhew is the William Ray and Marie Adamson Flesher Professor in Educational Administration. He is interested in how collegiate conditions, educational practices, and student experiences influence learning and democratic outcomes, including moral reasoning; pluralism; productive exchange across worldview differences; and innovation capacity. To support the study of college and its impact on student development and learning, Mayhew has been awarded more than $14 million in funding from sources including but not limited to the U.S. Department of Education, the Ewing Marion Kauffman Foundation, and the Merrifield Family Trust.

Mayhew has published more than 50 peer-reviewed articles in journals, including Research in Higher Education; Journal of Higher Education; Review of Higher Education; the Journal of College Student Development; and the Journal of Moral Education. Complementing these peer-reviewed journal articles are other empirical works, including How College Affects Students: Volume 3; two pieces selected for the ASHE Reader series; a book chapter written for Higher Education: Handbook of Theory and Research, and a co-edited volume with Routledge of the Taylor and Francis Group. Mayhew has won many awards for his research and teaching. He received his doctorate from the University of Michigan in 2004.

Michelle Morse serves as Founding Co-Director of EqualHealth and Deputy Chief Medical Officer for Partners in Health (PIH). She also serves as an advisor to the Medical Director of Mirebalais Hospital, a newly built public academic medical center established through a partnership between the government of Haiti and PIH. Previously, she served as Director of Medical Education at Mirebalais Hospital.

In July 2015, she assumed the position of Assistant Program Director for the Internal Medicine residency program at the Brigham and Women's Hospital in Boston, a Harvard Medical School affiliate. Dr. Morse also works as a Hospitalist at Brigham and Women's Hospital, a Clinical Instructor on the faculty at Harvard Medical School, and as an affiliate of the School's Department of Global Health and Social Medicine.

In 2010, Dr. Morse co-founded EqualHealth (www.equalhealth.org), an NGO that aims to inspire and support the development of Haiti's next generation of healthcare leaders through improving medical education and creating opportunities for health professionals in Haiti. She continues to strengthen medical education globally, expand teaching on social medicine in the US and abroad, and to support clinical systems strengthening through EqualHealth and PIH.

As a Howard Hiatt Global Health Equity resident in Internal Medicine at Brigham and Women's Hospital, Dr. Morse worked in Haiti, Rwanda, and Botswana. She focused her international work in Haiti where she helped to coordinate Partners In Health's earthquake relief efforts, was a first-responder for the cholera epidemic, and worked on women's health and quality improvement projects. Dr. Morse earned her B.S. in French in 2003 from the University of Virginia, her M.D. from the University of Pennsylvania School of Medicine in 2008, and her MPH from the Harvard School of Public Health in May 2012.

Steve Olson has been a consultant writer since 1979 for the National Academy of Sciences, the National Academy of Engineering, the Institute of Medicine, the National Research Council, the President's Council of Advisors on Science and Technology, the Office of Science and Technology Policy, the Howard Hughes Medical Institute, the National Institutes of Health, the National Science Foundation, the Institute for Genomic Research, and many other organizations. He is the author of several award-winning books, including *Mapping Human History: Genes, Race, and Our Common Origins*, which was one of five finalists for the 2002 nonfiction National Book Award and received the Science-in-Society Award from the National Association of Science Writers. His most recent book is *Eruption: The Untold Story of Mount St. Helens*, which Amazon named one of the 20 best nonfiction books published in 2016 and which was shortlisted for the Boardman Tasker Prize for Mountain Literature. He also has written for the *Atlantic Monthly*, *Science*, *Smithsonian*, *Seed*, the *Washington Post*, the *Los Angeles Times*, *Scientific American*, *Wired*, the *Yale Alumni Magazine*, the *Washingtonian*, *Slate*, *Astronomy*, *Science 82-86*, and many other magazines. In September 2004 he published with two coauthors a research article in *Nature* that presented a fundamentally new perspective on human ancestry. From 1989 through 1992 he served as Special Assistant for Communications in the White House Office of Science and Technology Policy. He earned a bachelor's degree in physics from Yale University in 1978.

Steve Olson is author of *Eruption: The Untold Story of Mount St. Helens*, which Amazon named one of the 20 best nonfiction books published in 2016 and which was shortlisted for the Boardman Tasker Prize for Mountain Literature. He also is the author of *Mapping Human History: Genes, Race, and Our Common Origins*, which was nominated for the National Book Award, and other books, and he has written for the *Atlantic Monthly*, *Science*, the *Smithsonian*, and many other magazines. Since 1979, he has been a consultant writer for the National Academy of Sciences, the President's Council of Advisors on Science and Technology, and other national scientific organizations. A native of Washington State, he now lives in Seattle.

Lee Pelton is the 12th president of Emerson College in Boston. He is a nationally and internationally known speaker and writer on the value of a liberal education and the importance of leadership development, civic engagement, and diversity in higher education. He came to Emerson on July 1, 2011, after serving for 13 years as the president of Willamette University in Salem, Oregon.

Since arriving at Emerson, Pelton has outlined an exciting vision for the College. In particular, he has focused on increasing Emerson's institutional capacity and effectiveness, while deepening community engagement. He has created new incentives and resources for faculty development, interdisciplinarity, global engagement, and innovation; promoted and renewed the College's civic leadership; and improved financial planning and operations.

He has overseen the creation of several new programs and departments, including Emerson Launch, an accelerator program that provides opportunities for students to launch new businesses before graduation; the creation of a business of creative enterprises major and program; the first of its kind comedic arts major and program; the Office of Research and Creative Scholarship, which set records for

the number of grants and grant funds awarded to the College for innovative scholarly pursuits; the Office of Internationalization and Global Engagement, which supports faculty and research exchanges and strategic partnerships with universities abroad; HowlRound, an international center of online communication and collaboration tools for researching processes, opportunities, and best practices for developing new theatrical work; the Elma Lewis Center for Civic Engagement, Learning, and Research, further establishing the College's commitment to neighboring communities and addressing a variety of issues of societal importance; and in January 2014, the opening of Emerson College Los Angeles, an architecturally stunning 107,000-square-foot living-learning facility in the heart of Hollywood on Sunset Boulevard, which dramatically advances Emerson's rapid growth as the world's hub for the arts, communication, and liberal arts disciplines in higher education.

Pelton began his academic career at Harvard University, where he earned a PhD in English literature with an academic focus on 19th-century British prose and poetry. He taught English and American literature at Harvard and served as senior tutor at Winthrop House. He later served on the Harvard Board of Overseers and as a vice-chair of its executive committee. After Harvard, Pelton served as dean of the college at Colgate University and Dartmouth College.

Catherine Pride is an Associate Professor of Psychology at Middlesex Community College, where her career has spanned a wide array of positions in both Student Affairs and Academic Affairs. Prior to her current faculty role, Pride served as the Associate Dean for Academic Programs and Articulation for eleven years, managing the Liberal Arts and Science, Liberal Studies, and Honors Programs, supervising the Experiential Learning office and overseeing Academic Planning. Pride is a Past-President of the New England Transfer Association, and worked with the Massachusetts Department of Higher Education to establish a statewide office on Transfer and Articulation. In her role as faculty, she is involved in several departmental, institutional and national assessment projects. She is an AAC&U STIRS Fellow, an Assessment Fellow for Middlesex, a Faculty Collaboratives Fellow for the Commonwealth of Massachusetts, and is a Disciplinary Sector Leader for the Massachusetts Academic Transfer Pathways Project. Pride earned her B.A. in Mathematics and her M.Ed. in Counseling at the University of Maine. Her Ph.D., from Boston College, is in Higher Education and Psychology with an emphasis on College Student Development.

Bob Pura is the President of Greenfield Community College. In addition to 37 years' experience as a teacher and administrator in the Massachusetts Community College System, the past fifteen as President of Greenfield Community College, Dr. Robert L. Pura is also a proud graduate of a community college. As the first in his family to attend college and the child of an immigrant, he understands what a community college education can mean to students. "Opening the doors to higher education to all who aspire to a better life for themselves and their families while at the same time maintaining high academic standards is the noblest mission in higher education."

Pura earned his A.A. at Miami Dade Community College, Florida; B.A. at the University of South Florida; M.S. from St. Thomas University, Miami; and Ph.D. in Educational Administration from the University of Texas in Austin. He has chaired the Massachusetts President's Council and served on its Executive Committee. He was a member of the Working Group on Assessment of Student Learning for the Massachusetts Department of Higher Education and currently serves on the Commission on Academic Student and Community Development for the American Association of Community Colleges. He sits on the Baystate Health Board of Directors and the New England Association of Schools and Colleges Higher Education Commission.

Benjamin Schmidt is an assistant professor of history at Northeastern University and core faculty at the NULab for Texts, Maps, and Networks. His research interests are in the digital humanities and the intellectual and cultural history of the United States in the 19th and 20th centuries. His dissertation, "Paying Attention," described how new ways of measuring attention in early 20th century psychology found unexpected uses in teaching, advertising, and media. His digital humanities research focuses particularly on text mining and the potential of large historical datasets for humanistic research. His recent work has been in topic modeling, visualization of historic data, and thematic mapping.

Prior to coming to Northeastern, he was the graduate fellow at the Cultural Observatory @ Harvard, in Harvard University's School of Engineering and Applied Sciences; he earned a Ph.D. in history was at Princeton University, and an A.B. in Social Studies at Harvard University.

Vandana Singh is professor and chair of the Physics and Earth Sciences Department at Framingham State University near Boston. Her PhD work is in the area of theoretical particle physics; however since she joined FSU (a liberal arts state university with an emphasis on scholarship of teaching and learning) about twelve years ago, she has been researching creative and innovative pedagogical approaches in physics education. Her work includes dynamical activities ('physics theater') as a learning tool, the use of NASA Science News articles as a means for students to shift their mindsets (inspired by educational psychologist Carol Dweck's groundbreaking work), and the uses of science fiction in physics teaching. More recently, during her sabbatical in Spring 2014, she won a program award from the AAC&U's STIRS Initiative (Scientific Thinking and Integrative Reasoning Skills) for which she developed a comprehensive, interdisciplinary case study for undergraduate education entitled "To Drill or Not to Drill: A Dilemma in the Context of Climate Change in the Arctic." In 2011 she participated in (and in the last year, led and co-led) a three-year state-funded STEM Vision project at Framingham State, aimed at transforming gateway STEM courses so as to increase student interest, retention and performance. The project was inspired by the work of Ken Bain ("What the Best College Teachers Do") and in particular his concept of the 'Natural Critical Learning Environment,' which validated and enhanced her interdisciplinary approach to physics teaching. It resulted in a long-term study ("Raising Standards and Expectations in a Physics Classroom) that is currently ongoing. In 2010 she created a new transdisciplinary course for non-science majors called Physics, Nature and Society, now in its 6th year, which combines conceptual

and mathematical rigor with explorations in the history and philosophy of science and urgent current issues such as climate change.

Vandana Singh is also an award-winning writer of science fiction; several of her short stories have been reprinted in Year's Best anthologies, and she has won a Tiptree Honor and a Parallax award. Her work in science, science education and science fiction influence and inform each other. For the past three years she has been an invited participant in three projects of the Center for Science and the Imagination at Arizona State University, where her consultations with experts in climate science, climate policy, polar biology and Inuit culture resulted in a novella that was published in the groundbreaking Futures anthology Hieroglyph: Stories and Visions for a Positive Future in 2014.

Richard F. Vaz is the Director of WPI's Center for Project-Based Learning, which provides support to colleges and universities looking to implement or enhance project-based learning.

From 2006 to 2016 Vaz served as WPI's dean of interdisciplinary and global studies, with responsibility for the Interactive Qualifying Project, WPI's interdisciplinary degree requirement. He oversaw substantial growth of WPI's Global Projects Program, a worldwide network of 46 centers where more than 900 students and faculty per year address problems for local agencies and organizations. His interests include experiential and global learning, sustainable design and appropriate technology, curricular reform, and institutional change.

He has authored over 70 peer-reviewed or invited publications and directed student research projects in 14 locations worldwide, including Australia, Hong Kong, Italy, Ireland, Namibia, Puerto Rico, and Thailand. He is a member of ASEE, and from 2004 to 2010 was a senior science fellow of the Association of American Colleges and Universities. He is a 2016 recipient of the National Academy of Engineering Bernard M. Gordon Prize for Innovation in Engineering and Technology Education.

Dr. Vaz received his BS, MS, and PhD in electrical engineering from WPI, and has been a member of the WPI Electrical and Computer Engineering faculty since 1984. He has also held systems and design engineering positions with Raytheon, GenRad, and the MITRE Corporation.

Rosalind Williams attended Wellesley College and received degrees from Harvard University (B.A. History and Literature), the University of California at Berkeley (M.A. Modern European History) and the University of Massachusetts at Amherst (Ph.D. History). Beginning in 1982 she taught in the Program in Writing and Humanistic Studies at MIT. From 1995 to 2000 she served as MIT's first Dean of Students and Undergraduate Education. In 2001 she joined the Program in Science, Technology, and Society, serving as program head from 2002-06. Her main scholarly affiliation is the Society for the History of Technology (SHOT), of which she served as president in 2005-06, and from which she received its highest award, the Leonardo da Vinci Prize, in 2013. She has been awarded honorary degrees from KTH in Stockholm and the Technical University of Eindhoven.

Her first three books (Dream Worlds, Notes from the Underground, Retooling) address this question: what are the implications for human life, both individual and collective, when we live in a predominantly self-constructed world? In responding to it, she has studied the emergence of consumer culture in late l9th century France; in the creation of underworlds, both imagined and actual, as models of a technological environment; and the retooling of MIT as the Institute confronts the effects of an information age of which it has been such a prime generator.

Her latest book, The Triumph of Human Empire (University of Chicago Press, 2013) surveys the overarching historical event of our time: the rise and triumph of human empire, defined by the dominance of human presence on the planet. The book examines the works and lives of three well-known writers (Jules Verne, William Morris, and Robert Louis Stevenson) to illuminate the event of consciousness at the end of the l9th century, when humans realized that they were close to mapping the entire globe and that the global frontier was closing. Human Empire is about a still unfolding event of consciousness, as grasped by three writers exceptionally successful in conveying its depth and significance.

Emma Smith Zbarsky is an Associate Professor of Applied Mathematics at the Wentworth Institute of Technology, where she has worked since 2009. Her educational background includes undergraduate degrees in mathematics and physics from MIT (2004) and graduate degrees from the University of Chicago (Ph.D in mathematics, 2009) and the University of Washington (Master's in applied mathematics, 2014).

Emma continues to be interested in many things. Her active research interests include mathematical modeling and pedagogy, while she has also worked in number theory, ecology, algebraic topology, and graph theory. She plans to continue learning more about the applications of mathematics to 'real world' problems.

At Wentworth, Emma was involved in designing and implementing a major in applied mathematics as well as designing and redesigning curricula in engineering mathematics. Emma has worked to implement a push toward externally-collaborative, interdisciplinary project-based learning in a variety of ways including in her own courses, as the co-chair of her department curriculum committee, and as the co-chair of the Institute-level Innovations and Experiential Learning Council.

Musician Biographies

Justin Lo is an MD-PhD student at Harvard Medical School who recently completed his PhD thesis on nanoparticle drug delivery to pancreatic cancer in the lab of Prof. Sangeeta Bhatia. He is a member and former co-president of the HMS Chamber Music Society, and he serves as associate concertmaster of the Longwood Symphony Orchestra, which he joined in 2008.

Michael Wu is a 3rd year medical student at Harvard Medical School in the Harvard-MIT Division of Health Sciences and Technology. Currently on a research year, Michael works in the lab of Sandro Santagata, studying the pathogenesis of glioblastoma. Outside of his studies, Michael is an avid cellist and has been the co-president of the HMS Chamber Music Society. For Michael, music has provided an invaluable expressive outlet and community during medical school. Originally from Minnesota, Michael attended Harvard College.

3. Committee Information

INTEGRATION OF EDUCATION IN THE SCIENCES, ENGINEERING, AND MEDICINE WITH THE ARTS AND HUMANITIES AT THE UNDERGRADUATE AND GRADUATE LEVELS

A Project of the
Board on Higher Education and Workforce

An ad hoc committee overseen by the Board on Higher Education and Workforce (BHEW), in collaboration with units in PGA, NAE, IOM, and DBASSE, will produce a consensus report that examines the evidence behind the assertion that educational programs that mutually integrate learning experiences in the humanities and arts with science, technology, engineering, math, and medicine (STEMM) lead to improved educational and career outcomes for undergraduate and graduate students. In particular, the study will examine the following:

- Evidence regarding the value of integrating more STEMM curricula and labs into the academic programs of students majoring in the humanities and arts in order to understand the following: (1) how STEMM experiences provide important knowledge about the scientific understanding of the natural world and the characteristics of new technologies, knowledge that is essential for all citizens of a modern democracy; (2) how technology contributes essentially to sound decision making across all professional fields; and (3) how STEMM experiences develop the skills of scientific thinking (a type of critical thinking), innovation, and creativity that may complement and enrich the critical thinking and creativity skills developed by the arts and humanities.

- Evidence regarding the value of integrating curricula and experiences in the arts and humanities--including , history, literature, philosophy, culture, and religion--into college and university STEMM education programs, in order to understand whether and how these experiences: (1) prepare STEMM students and workers to be more effective communicators, critical thinkers, problem-solvers and leaders; (2) prepare STEMM graduates to be more creative and effective scientists, engineers, technologists, and health care providers, particularly with respect to understanding the broad social and cultural impacts of applying knowledge to address challenges and opportunities in the workplace and in their communities; and (3) develop skills of critical thinking, innovation, and creativity that may complement and enrich the skills developed by STEMM fields.

- New models and good practices for mutual integration of the arts and humanities and STEMM fields at 2-year colleges, 4-year colleges, and graduate programs, drawing heavily on an analysis of programs that have been implemented at institutions of higher education.

The report will summarize the results of this examination and provide recommendations for all stakeholders to support appropriate endeavors to strengthen higher education initiatives in this area.

Committee Member Biographies

Chair

David J. Skorton (NAM) is the 13th Secretary of the Smithsonian. He assumed his position July 1, 2015. As Secretary, Skorton oversees 19 museums and galleries, 20 libraries, the National Zoo and numerous research centers, including the Smithsonian Astrophysical Observatory, the Smithsonian Tropical Research Institute and the Smithsonian Environmental Research Center. He is responsible for an annual budget of $1.3 billion, 6,500 employees and 6,300 volunteers. The Smithsonian's federal appropriation for fiscal year 2015 is $819.5 million, which accounts for 62 percent of the Institution's funding. The Smithsonian generates additional funding from private contributions and business revenues.

Skorton, 65, a board-certified cardiologist, previously was the president of Cornell University, a position he held from July 2006. He was also a professor in the Departments of Medicine and Pediatrics at Weill Cornell Medical College in New York City and in Cornell's Department of Biomedical Engineering at the College of Engineering. His research focus is congenital heart disease and cardiac imaging and image processing. Skorton is the first physician to lead the Smithsonian.

An ardent and nationally recognized supporter of the arts and humanities, Skorton has made the advancement of the arts a priority at the Smithsonian.

Members

Susan Albertine is Senior Scholar and Director, LEAP States Initiative and formerly Vice President of the Office of Diversity, Equity, and Student Success, at the Association of American Colleges & Universities. She provides leadership for the overall program of LEAP partner state initiatives. She has led AAC&U's efforts to support undergraduate education in integrative public health since 2008. Albertine received her BA in English from Cornell University, her MA in English from SUNY Cortland, and her Ph.D. in English from the University of Chicago. She was active in AAC&U before becoming vice president, serving as co-leader of the Educated Citizen and Public Health initiative, a collaborative project co-sponsored by AAC&U, the Association for Prevention Teaching and Research, the Council of Colleges of Arts and Sciences, the Association of Schools and programs of Public Health, and other organizations. She was dean of the School of Culture and Society and professor of English at the College of New Jersey from 2002 to 2008.

Previously, she served as vice provost for undergraduate studies, Temple University, and assistant to the provost, University of Pennsylvania. She has held faculty positions at the University of North Florida, St. Olaf College, and Susquehanna University, where she was chair of the Department of English. Her scholarship in American literature of the late 19th century led to research and an array of publications on women's work in print culture and on businesswomen's careers (in fiction and history) during the growth phase of industrialization in the U.S. A former public school teacher, Albertine has been nationally active to advance pre-school through college alignment, working with the Education Trust and

the American Diploma Project. Her board service has included the Camden Academy Charter High School in Camden, New Jersey; the Advisory Board for the Delaware Study of Instructional Costs and Productivity—Faculty Study, University of Delaware; the Art Sanctuary, an African-American arts and letters organization based in Philadelphia; the Council of Colleges of Arts and Sciences. Albertine is a member of the Advisory Board, National Center for the First-Year Experience and Students in Transition.

Norman Augustine (NAS/NAE) is retired chairman and CEO of Lockheed Martin Corporation. Augustine was raised in Colorado and attended Princeton University where he graduated with a BSE in Aeronautical Engineering, magna cum laude, and an MSE. He was elected to Phi Beta Kappa, Tau Beta Pi and Sigma Xi.

In 1958 he joined the Douglas Aircraft Company in California where he worked as a Research Engineer, Program Manager and Chief Engineer. Beginning in 1965, he served in the Office of the Secretary of Defense as Assistant Director of Defense Research and Engineering. He joined LTV Missiles and Space Company in 1970, serving as Vice President, Advanced Programs and Marketing. In 1973 he returned to the government as Assistant Secretary of the Army and in 1975 became Under Secretary of the Army, and later Acting Secretary of the Army. Joining Martin Marietta Corporation in 1977 as Vice President of Technical Operations, he was elected as CEO in 1987 and chairman in 1988, having previously been President and COO. He served as president of Lockheed Martin Corporation upon the formation of that company in 1995, and became CEO later that year. He retired as chairman and CEO of Lockheed Martin in August 1997, at which time he became a Lecturer with the Rank of Professor on the faculty of Princeton University where he served until July 1999.

Augustine served on the President's Council of Advisors on Science and Technology under Democratic and Republican presidents and led the 1990 Advisory Committee on the Future of the U.S. Space Program and the 2005 National Academies commission that produced the landmark report, Rising Above the Gathering Storm: Energizing and Employing America for a Brighter Economic Future.

Augustine has been presented the National Medal of Technology by the President of the United States and received the Joint Chiefs of Staff Distinguished Public Service Award. He has five times received the Department of Defense's highest civilian decoration, the Distinguished Service Medal. He is co-author of The Defense Revolution and Shakespeare In Charge and author of Augustine's Laws and Augustine's Travels. He holds 23 honorary degrees and was selected by Who's Who in America and the Library of Congress as one of "Fifty Great Americans" on the occasion of Who's Who's fiftieth anniversary. He has traveled in over 100 countries and stood on both the North and South Poles of the earth.

Laurie Baefsky is Executive Director for ArtsEngine and the Alliance for the Arts in Research Universities (a2ru). She has served in this position since August 2014. Housed at The University of Michigan, a2ru is a partnership of over thirty institutions committed to ensuring the greatest possible institutional support for interdisciplinary research, curricula, programs and creative practice between the arts and other

disciplines. Laurie has developed, led and taught within other interdisciplinary arts education initiatives for over 20 years. From 2007-2011 she established the USU ArtsBridge program at Utah State University, connecting university students with area schools and community organizations through arts-based interdisciplinary service-learning initiatives. During this time she also directed professional development efforts for northern Utah schools for the Beverley Taylor Sorenson Arts Learning Program. Prior to joining ArtsEngine / a2ru she served as grants manager for the Utah Division of Arts and Museums in Salt Lake City, where she oversaw the annual distribution of $1.3 million in state and federal funding for individuals, organizations, communities and educators. A skilled grant writer herself, her efforts have resulted in over $4.5 million in arts funding through grants from federal, state and private sources. Also an active performer and arts educator, Laurie has appeared on flute and piccolo with the Minnesota Orchestra, Utah Symphony, New World Symphony, and as a tenured member of the Virginia Symphony. As a chamber artist, her performance venues have ranged from Symphony Space and Chamber Music Society of Lincoln Center, NYC to northeastern Morocco and Umbria, Italy.

Paul Bevilaqua (NAE) is Retired Manager of Advanced Development Programs at Lockheed Martin Aeronautics Company. Paul Bevilaqua has spent much of his career developing Vertical Take Off and Landing aircraft. He joined Lockheed Martin as Chief Aeronautical Scientist and became Chief Engineer of the Skunk Works, where he played a leading role in creating the Joint Strike Fighter. He invented the dual cycle propulsion system that made it possible to build a stealthy supersonic VSTOL Strike Fighter, and suggested that conventional and Naval variants of this aircraft could be developed to create a common, affordable aircraft for all three services.He subsequently led the engineering team that demonstrated the feasibility of building this aircraft. Prior to joining Lockheed Martin, he was Manager of Advanced Programs at Rockwell International's Navy aircraft plant, where he led the design of VSTOL interceptor and transport aircraft. He began his career as an Air Force officer at Wright Patterson AFB, where he developed a lift system for an Air Force VSTOL Search and Rescue Aircraft. He received degrees in Aeronautical Engineering from the University of Notre Dame and Purdue University. He is a Fellow of the American Institute of Aeronautics and Astronautics and a member of the National Academy of Engineering. He is also the recipient of a USAF Scientific Achievement Award, AIAA and SAE Aircraft Design Awards, AIAA and AHS VSTOL Awards, and Lockheed Martin AeroStar and Nova Awards.

Kristin Boudreau is Professor and Department Head of Humanities and Arts at the Worcester Polytechnic Institute. Boudreau's research interests involve the ways literature reflects on and intervenes in cultural transformations. Professor Boudreau has written about the literature of slavery, the labor movement, capital cases, and modernization. After teaching in English departments for 17 years, she came to WPI in 2009 to chair the Department of Humanities and Arts, where she has taught HUA writing courses, Inquiry Seminars, and literature courses, has co-taught the Great Problems Seminar "Feed the World," and has advised and co-advised IQPs.

Like many faculty in the Humanities and Arts Department, Boudreau enjoys not only digging into her disciplinary research (19th-century American literature) but also stretching to join that disciplinary perspective to the topics of science and technology that are so important to WPI's students and faculty. Long interested in the literature of the nineteenth century and African American and working-class history and culture, she is now collaborating with colleagues in the Gordon Library and the Departments of Computer Science and Social Science and Policy Studies to bring these interests into conversation with the engineering challenge of restoring clean water to developing communities. Her team's goal is to design a series of classroom simulations that can approximate projects where actual projects are unfeasible. With students and colleagues she has developed an interdisciplinary role-playing simulation, "Worcester 1899: The Sanitary Engineering Challenge," and is working on another simulation based in contemporary rural Ghana. These simulations approach the engineering challenge of ensuring clean water while providing a rich cultural context that attends to historical particulars while also teaching a variety of disciplinary approaches.

Norman Bradburn is a Senior Fellow at NORC at the University of Chicago. He also serves as the Tiffany and Margaret Blake Distinguished Service Professor Emeritus in the faculties of the University of Chicago's Irving B. Harris Graduate School of Public Policy Studies, Department of Psychology, Booth School of Business and the College. He is a former provost of the University (1984-1989), chairman of the Department of Behavioral Sciences (1973-1979), and associate dean of the Division of the Social Sciences (1971-1973). From 2000-2004 he was the assistant director for social, behavioral, and economic sciences at the National Science Foundation. Associated with NORC since 1961, he has been its Director and President of its Board of Trustees. Bradburn has been at the forefront in developing theory and practice in the field of sample survey research in the cultural sector. He co-directs the American Academy of Arts and Sciences' Humanities Indicators project and Principal Investigator of the CPC's Cultural Infrastructure project. For the Humanities

Indicators project he oversees the collation and analysis of data, the creation of reliable benchmarks to guide future analysis of the humanities, and the development of a consistent and sustainable means of updating the data. For the Cultural Infrastructure project he oversees the systematic measurement of recent building projects and their consequences, modeling levels of creativity and sustainability of individual arts organizations before and after building projects, and the overall cultural vibrancy and vitality of their cities or regions as a result. Bradburn is a fellow of the American Statistical Association, a fellow of the American Association for the Advancement of Science and an elected member of the International Institute of Statistics. He was elected to the American Academy of Arts and Sciences in 1994. In 1996 he was named the first Wildenmann Guest Professor at the Zentrum for Umfragen, Methoden und Analyse in Mannheim, Germany. In 2004 he was given the Statistics Canada/American Statistical Association Waksberg Award in recognition of outstanding contributions to the theory and practice of survey methodology.

Al Bunshaft is the Senior Vice President of Dassault Systèmes' Americas Corporation where he spearheads key strategic initiatives and corporate leadership programs. He was a key architect in Dassault Systèmes' acquisition of IBM's PLM business and led the selection, design, construction and opening of the company's North American headquarters, an award-winning campus recognized for sustainable innovation and located in Boston's technology belt. Prior to joining Dassault Systèmes, Bunshaft served as global vice president of IBM PLM where he helped major manufacturing companies transition from physical to digital design practices and played a key role in the first digitally-designed automobile. He is a leading voice in corporate citizenship and science, technology, engineering and mathematics (STEM) initiatives, such as Teachers at Dassault Systèmes and "Day of Service at Dassault Systèmes." He is a member of the STEM subcommittee of the Clinton Global Initiative, a board member of the Massachusetts High Technology Council, and an advisory board member at the University at Albany, State University of New York's Department of Information and Computer Science. He received his Bachelor of Science in Computer Science and Mathematics from the school and has a Master of Science in Computer Engineering from Rensselaer Polytechnic Institute (RPI).

Gail Burd is the Senior Vice Provost for Academic Affairs and a Distinguished Professor in Molecular and Cellular Biology and Cellular and Molecular Medicine at the University of Arizona. Burd was appointed the Vice Provost for Academic Affairs in August 2008. In this role, Dr. Burd works closely with campus leaders to coordinate programs that will advance the academic mission of the University and help colleges and departments develop and assess their academic degree programs. Dr. Burd's research program has focused development and neural plasticity in the vertebrate olfactory system. She is the P.I. on a successful research project on Undergraduate STEM Education funded by the Association of American Universities and the Leona and Harry A. Helmsley Charitable Trust, and her more recent research has centered around undergraduate science education. In prior administrative roles at the University of Arizona, Dr. Burd served as the Associate Dean for Academic Affairs in the College of Science, the Interim Department Head of Molecular and Cellular Biology, and the Associate Department Head of Molecular and Cellular Biology. A fellow of the American Association for the Advancement of Science, she has chaired several committees for national professional organizations, served on numerous government panels for the National Institutes of Health and the National Science Foundation, and received awards for her undergraduate teaching.

Edward Derrick became director of the AAAS Center of Science, Policy & Society Programs (CSPSP) in July 2011 after serving as deputy director then acting director of the AAAS Science and Policy Programs. The Center of Science, Policy & Society Programs bridges the science and engineering community on one side, and policymakers and the interested public on the other. The programs address an array of topics in science and society, including the interplay of science with religion, law and human rights; they also connect scientists and policymakers through programs in science and government, including the S&T Policy Fellowship program; and help improve the conduct of research through peer review and discussion of standards of responsible conduct. As chief program director, Derrick oversees the

programs, which combined have a staff of about 35 and an annual budget of over $20 million, and serves as a member of senior management at AAAS. Ed first joined AAAS in 1998 as a member of the AAAS Research Competitiveness Program (RCP). RCP provides review and guidance to the science and innovation community. He became director of the program in January 2004, with responsibility for the development of new business and oversight of all aspects of the design and execution of projects. Ed has participated directly in over 50 RCP projects, having led committees to assist state and institutional planning for research, to review research centers and institutions and to advise state and international funds on major investments. He holds the Ph.D. from the University of Texas at Austin, with a dissertation in theoretical particle physics, and the B.S. from the Massachusetts Institute of Technology, with an undergraduate thesis in biophysics. Between degrees, he worked for Ontario Hydro in the Nuclear Studies and Safety Division. Prior to joining AAAS, he spent two years as an Alexander von Humboldt Fellow in Germany.

E. Thomas Ewing is History Professor and Associate Dean of Graduate Studies, Research, and Diversity at the College of Liberal Arts and Human Sciences of Virginia Tech. is education included a BA from Williams College and a PhD in history from the University of Michigan. He teaches courses in Russian, European, Middle Eastern, and world history, gender / women's history, and historical methods. His publications include, as author, *Separate Schools: Gender, Policy, and Practice in the Postwar Soviet Union (2010)* and *The Teachers of Stalinism*: *Policy, Practice, and Power in Soviet Schools in the 1930s (2002)*; as editor, *Revolution and Pedagogy: Transnational Perspectives on the Social Foundations of Education (2005)*; and as co-editor, with David Hicks, *Education and the Great Depression: Lessons from a Global History (2006)*. His articles on Stalinist education have been published in Gender & History, American Educational Research Journal, Women's History Review, History of Education Quarterly, Russian Review, and The Journal of Women's History. He has received funding from the National Endowment for the Humanities, the Spencer Foundation, and the National Council for Eurasian and East European Research.

J. Benjamin Hurlbut is Assistant Professor of Biology and Society in the School of Life Sciences at Arizona State University. Dr. Hurlbut is trained in science and technology studies with a focus on the history of the modern biomedical and life sciences. His research lies at the intersection of STS, bioethics and political theory. He studies the changing relationships between science, politics and law in the governance of biomedical research and innovation in the 20th and 21st centuries. Focusing on controversy around morally and technically complex problems in areas like human embryo research, genomics, and synthetic biology, he examines the interplay of science and technology with shifting notions of democracy, of religious and moral pluralism, and of public reason. He holds an A.B. from Stanford University, and a Ph.D. in the History of Science from Harvard University. He was a postdoctoral fellow in the Program on Science, Technology and Society at the John F. Kennedy School of Government at Harvard.

Pamela L. Jennings, PhD has been the Director of Center for Design Innovation- a UNC multi-campus research center in Winston Salem, North Carolina since 2014. She is also the CEO & President of CONSTRUKTS, Inc. a Delaware corporation.

Jennings is a former National Science Foundation Program Officer where she led the NSF CreativeIT and co-managed the Human Centered Computing research funding programs. She was a Professor at Carnegie Mellon University in the Human Computer Interaction Institute. And she worked as a Design Researcher at IBM Almaden Research Center and the Center for Technology in Learning at SRI International.

Jennings completed her MBA at the University Of Michigan Ross School Of Business in 2013. She completed her Ph.D. in Human Centered Systems Design and Digital Media at the University of Plymouth, UK; M.F.A. in Computer Art at the School of Visual Arts, NYC; M.A. in Studio Art in the International Center of Photography/New York University Program; and B.A. in Psychology at Oberlin College.

Youngmoo Kim is Director of the Expressive and Creative Interaction Technologies (ExCITe) Center and Associate Professor of Electrical and Computer Engineering at Drexel University. His research group, the Music & Entertainment Technology Laboratory (MET-lab) focuses on the machine understanding of audio, particularly for music information retrieval. Other areas of active research at MET-lab include human-machine interfaces and robotics for expressive interaction, analysis-synthesis of sound, and K-12 outreach for engineering, science, and mathematics education.

Youngmoo also has extensive experience in music performance, including 8 years as a member of the Tanglewood Festival Chorus, the chorus of the Boston Symphony Orchestra. He is a former music director of the Stanford Fleet Street Singers, and has performed in productions at American Musical Theater of San Jose and SpeakEasy Stage Company (Boston). He is a member of Opera Philadelphia's newly-formed American Repertoire Council.

Youngmoo was named "Scientist of the Year" by the 2012 Philadelphia Geek Awards and was recently honored as a member of the Apple Distinguished Educator class of 2013. He is recipient of Drexel's 2012 Christian R. and Mary F. Lindback Award for Distinguished Teaching. He co-chaired the 2008 International Conference on Music Information Retrieval hosted at Drexel and was invited by the National Academy of Engineering to co-organize the "Engineering and Music" session for the 2010 Frontiers of Engineering conference. His research is supported by the National Science Foundation and the John S. and James L. Knight Foundation.

Tom Nelson Laird is Director of the Center for Postsecondary Research (CPR) as well as principal investigator for the Faculty Survey of Student Engagement (FSSE), a companion project to the National Survey of Student Engagement (NSSE). Tom is also an associate professor in the Higher Education and Student Affairs program at IU and an associate editor for The Journal of Higher Education. As a member of the CPR staff, he is responsible for the center's overall management and for FSSE operations. Tom received a PhD in higher education from the University of Michigan (2003), an MS in mathematics from Michigan State University (1997), and a BA in mathematics from Gustavus Adolphus College (1995). His work focuses on improving teaching and learning at colleges and universities, with emphasis on the design, delivery, and effects of curricular experiences with diversity. Through dozens of journal articles, book chapters, scholarly papers, and reports, his work has appeared in key scholarly and practitioner publications. Tom also consults with higher education institutions and related organizations on topics ranging from effective assessment practices to the inclusion of diversity in the curriculum.

Robert Martello is Professor of the History of Science and Technology at Olin College of Engineering. Martello received his Ph.D. from MIT's Program in the History and Social Study of Science and Technology, following his completion of a Master of Science degree in civil and environmental engineering and Bachelor of Science degree in earth, atmospheric, and planetary science from MIT. Prior to joining the Olin College faculty in 2001 during Olin's "partner" year, Martello lectured in MIT's history of technology program and served as the Producer for the "Digital History" component of Inventing America, an American history textbook. Martello's Ph.D. dissertation and ensuing research use Paul Revere's many manufacturing and entrepreneurial endeavors to tell the story of America's transition from craft practices to industrial capitalism. He published his first book, Midnight Ride, Industrial Dawn: Paul Revere and the Growth of American Enterprise, in the fall of 2010, and is currently researching his next book project, a study of Benjamin Franklin's innovative printing career and identity as an artisan. Martello frequently offers public history talks on the subjects of Paul Revere's groundbreaking manufacturing career or Benjamin Franklin's adventures as a printer, and enjoys collaborating with the Paul Revere Memorial Association on different educational initiatives. At Olin, Martello frequently co-chairs the Arts, Humanities, and Social Science committee and helps students cross disciplinary lines and apply their communication and contextual analysis skills to global challenges. He is the co-principal investigator on three National Science Foundation grants studying the integration of humanities and technical pedagogies, the development and deployment of lifelong learning skills, and the importance of intrinsic motivation. Martello has also delivered numerous talks and has facilitated many workshops for fellow educators interested in student motivation, interdisciplinary education, and project-based teaching.

Gunalan Nadarajan is Dean and Professor at the Penny W. Stamps School of Art and Design at the University of Michigan. His publications include Ambulations (2000), Construction Site (edited; 2004) and Contemporary Art in Singapore (co-authored; 2007), Place Studies in Art, Media, Science and Technology: Historical Investigations on the Sites and Migration of Knowledge (co-edited; 2009), The Handbook of Visual Culture (co-edited; 2012) and over 100 book chapters, catalogue essays, academic articles and reviews. His writings have also been translated into 16 languages. He has curated many international exhibitions including Ambulations (Singapore, 1999), 180KG (Jogjakarta, 2002), media_city (Seoul, 2002), Negotiating Spaces (Auckland, 2004), DenseLocal (Mexico City, 2009) and Displacements (Beijing, 2914). He was contributing curator for Documenta XI (Kassel, Germany, 2002) and the Singapore Biennale (2006) and served on the jury of a number of international exhibitions, including ISEA2004 (Helsinki / Talinn), transmediale 05 (Berlin), ISEA2006 (San Jose) and FutureEverything Festival (Manchester, 2009). He was Artistic Co-Director of the Ogaki Biennale 2006, Japan and Artistic Director of ISEA2008 (International Symposium on Electronic Art) in Singapore.

He is active in the development of media arts internationally and has previously served on the Board of Directors of the Inter Society for Electronic Art and is on the Advisory Boards of the Database of Virtual Art (Austria), Cellsbutton Festival (Indonesia) and Arts Future Book series (UK). He currently serves on the International Advisory Board of the ArtScience Museum in Singapore. In 2013, he was elected to serve on the Board of Directors of the College Art Association. He has also served as an advisor on creative aspects of digital culture to the UNESCO and the Smithsonian Institution. He continues to work on a National Science Foundation funded initiative to develop a national network for collaborative research, education and creative practice between sciences, engineering, arts and design. He is a member of several professional associations including Special Interest Group in Graphics and Interactive Techniques (SIGGRAPH), Association for Computing Machinery (ACM), College Art Association, National Council of University Research Administrators, International Association of Aesthetics, International Association of Philosophy and Literature and the American Association for the Advancement of Science. In 2004, he was elected a Fellow of the Royal Society of Art.

He has served in a variety of academic roles in teaching, academic administration and research for over two decades. Prior to joining University of Michigan, he was Vice Provost for Research and Dean of Graduate Studies at the Maryland Institute College of Arts. He also had previous appointments as Associate Dean for Research and Graduate Studies at the College of Arts and Architecture, Pennsylvania State University and Dean of Visual Arts at the Lasalle College of the Arts, Singapore.

Lynn Pasquerella is President of the Association of American Colleges and Universities. Assuming the presidency of the Association of American Colleges and Universities on July 1, 2016, throughout her career, Lynn Pasquerella has demonstrated a deep and abiding commitment to access to excellence in liberal education regardless of socioeconomic background. A philosopher, whose career has combined teaching and scholarship with local and global engagement, Pasquerella's presidency of Mount Holyoke College was marked by a robust strategic planning process, outreach to local, regional, and international constituencies, and a commitment to a vibrant campus community.

A graduate of Quinebaug Valley Community College, Mount Holyoke College, and Brown University, Pasquerella joined the Department of Philosophy at the University of Rhode Island in 1985, rising rapidly through the ranks to the positions of Vice Provost for Research, Vice Provost for Academic Affairs, and Dean of the Graduate School. In 2008, she was named Provost at the University of Hartford. In 2010, her alma mater appointed her the eighteenth President of Mount Holyoke College.

Pasquerella has written extensively on medical ethics, metaphysics, public policy, and the philosophy of law. At the core of her career is a strong commitment to liberal education and inclusive excellence, manifested in service as senator and vice president of Phi Beta Kappa; her role as host of Northeast Public Radio's The Academic Minute; and her public advocacy for access and affordability in higher education.

Suzanna Rose is the founding Associate Provost for the Office to Advance Women, Equity and Diversity at Florida International University (FIU). Dr. Rose previously served in several different capacities within the College of Arts and Sciences, including as the founding executive director of the School of Integrated Science and Humanity, Senior Associate Dean for the Sciences, Chair of Psychology, and Director of the Women's Studies Center. Prior to coming to FIU, she was Professor of Psychology and Director of Women's Studies at the University of Missouri-St. Louis. Dr. Rose has published extensively on issues related to gender, including professional networks, career development, leadership, and personal relationships. She has consulted with many universities both nationally and internationally concerning strategies for recruiting and retaining women faculty in science and engineering. She also initiated and oversees the FIU Mastery Math Project that has been effective at improving student success in mathematics and and led the formation of several interdisciplinary research centers at FIU, including the Biomolecular Sciences Institute and the Cognitive Neuroscience and Imaging Center.

Bonnie Thornton Dill is dean of the University of Maryland College of Arts and Humanities and professor of Women's Studies. A pioneering scholar studying the intersections of race, class and gender in the U.S. with an emphasis on African American women, work and families, Thornton Dill's scholarship has been reprinted in numerous collections and edited volumes. Her recent publications include an edited collection of essays on intersectionality with Ruth Zambrana entitled Emerging Intersections: Race, Class, and Gender in Theory, Policy, and Practice (Rutgers University Press, 2009), and numerous articles.

Prior to assuming the position of dean, Thornton Dill chaired the Women's Studies Department for eight years. In addition, she has worked with colleagues to found two research centers that have been national leaders in developing and disseminating the body of scholarship that has come to be known by the term "intersectionality." Today she holds the title of Founding Director for both the Center for Research on Women at the University of Memphis and the Consortium on Race, Gender and Ethnicity at the University of Maryland. She is currently President of the National Women's Studies Association

(2010-2012) and prior to that was Vice President of the American Sociological Association. Thornton Dill also serves as Chair of the Advisory Board of Scholars for Ms. Magazine.

Professor Thornton Dill has won a number of prestigious awards including two awards for mentoring; the Jessie Bernard Award and the Distinguished Contributions to Teaching Award both given by the American Sociological Association; the Eastern Sociological Society's Robin Williams Jr. Distinguished Lectureship; and in 2009-2010, was appointed Stanley Kelley, Jr. Visiting Professor for Distinguished Teaching in the Department of Sociology at Princeton University. Her current research pulls together her knowledge and experience as a teacher, mentor and institution builder around issues of race/ethnicity, class and gender in higher education to examine the experiences of historically underrepresented minority faculty in research universities, focusing specifically upon the impact of occupational stress on their physical and mental health and their career paths.

Laura Vosejpka is a Professor of Physical Science at Mid Michigan Community College in Harrison, Michigan. She is responsible for the Physics program and the Non-majors Science program and she shares responsibility for the Chemistry program. As chair of the General Education Committee, she leads work in mapping General Education program goals to both transfer agreements and the DQP. She is also leading the college's participation in the Michigan Community College Association Guided Pathways Institute aimed at improving retention and completion rates for MMCC students. Her organic chemistry students, were recently awarded First Prize in the college wide T-Summit Student Showcase for their hands-on presentation of the history and chemistry of organic dyes.

A 25 year resident of the Mid Michigan area, Vosejpka has held a number of academic and industrial positions in the immediate area. Prior to joining MMCC, she served as the Executive Communications Director for Global R&D for the Dow Chemical Company. There she was responsible for providing internal and external executive communications support for the Chief Technology Officer, William F. Banholzer, and the R&D Leadership Team. Laura led all initiatives in Innovation and Technology communication, developing strategy and creating materials for internal & external use by numerous groups, such as Media Relations and Investor Relations. She coordinated the role of R&D in VIP visits and external events including executive speeches, R&D displays and tours and led Dow's participation in national TED conferences. Laura had an earlier role at Dow as an R&D Specialist in Core R&D, working in the areas of biocatalysis, and electroactive organic polymers (pLED). She is the author of 6 internal Dow research reports and was awarded the 2002 Chemical Sciences Technical Award for her work on pLED polydispersity and lifetime relationships.

A passionate advocate for liberal arts education, Vosejpka was a dual major in science and the humanities, graduating with Honors from The Ohio State University with BA degrees in both chemistry and English. She earned her Ph.D. in Organic Chemistry from the University of Wisconsin – Madison in 1989, working in the research group of Professor Charles P. Casey, and then spent 18 months as a postdoctoral research associate at the University of Maryland in the synthetic organic chemistry labs of Professor Philip DeShong before beginning her position at Alma College.

Lisa M. Wong is a musician, pediatrician, and past president of the Longwood Symphony Orchestra. She grew up in Honolulu, Hawaii where she attended Punahou School, an independent school centered on education, the arts and community service. She began the piano at age 4, violin at age 8, guitar at age 10 and viola at age 40. Wong is married to violinist Lynn Chang. They have two grown children, Jennifer and Christopher Chang. Wong graduated from Harvard University in East Asian Studies in 1979, and her M.D. from NYU School of Medicine in 1983. After completing her pediatric residency at Massachusetts General Hospital in 1986, she joined Milton Pediatrics Associates and is an Assistant Clinical Professor of Pediatrics at Harvard Medical School.

Wong is inspired by the work of Nobel Peace Prize laureate Dr. Albert Schweitzer, a humanitarian, theologian, musician and physician. During her twenty year tenure as president of the Longwood Symphony Orchestra, was honored to work with remarkable leaders in healthcare and humanitarianism including Dr. Lachlan Forrow, Jackie Jenkins-Scott, Dr. Jim O'Connell and Dr. Paul Farmer. Although she retired as President of the LSO in 2012, Wong continues her involvement with the orchestra as a violinist in the section. A passionate arts education advocate, Wong has worked closely with the New England Conservatory of Music's Preparatory School and traveled with NEC's Youth Philharmonic Orchestra to Brazil, Cuba, Guatemala, Panama, and Venezuela as a pediatric chaperone. Wong continues to be actively involved in El Sistema USA and has had the privilege of observing El Sistema in Venezuela several times over the past ten years.

Wong served as Board member of Young Audiences of Massachusetts for over 15 years and helped start Bring Back the Music (now renamed Making Music Matters), a program that revitalized in-class instrumental music instruction in the four Boston public elementary schools. In 2009, Wong was appointed to the Board of the Massachusetts Cultural Council by Governor Deval Patrick. In April 2010, Wong received the Community Pinnacle Award from Mattapan Community Health Center for LSO's pivotal role in their capital campaign to build a new neighborhood healthcare facility. Her first book Scales to Scalpels: Doctors Who Practice the Healing Arts of Music and Medicine, co-written with Robert Viagas, was published in April 2012 by Pegasus Books. It was released as a paperback in May 2013, and recently translated into Chinese. The AudioBook version will be released in early 2014.

Staff Biographies

Ashley Bear, Ph.D. is a Program Officer with the Board on Higher Education and Workforce at the National Academies of Sciences, Engineering, and Medicine. Before coming to the Academies, Dr. Bear was a Presidential Management Fellow with the National Science Foundation's (NSF) Division of Biological Infrastructure in the Directorate for Biological Sciences, where she managed a portfolio of mid-scale investments in scientific infrastructure and led analyses of the impact of NSF funding on the career trajectories of postdoctoral researchers. During her fellowship years, Dr. Bear also worked as a Science Policy Officer for the State Department's Office of the Science and Technology Adviser to the Secretary of State, where she worked to promote science diplomacy and track emerging scientific trends with implications for foreign policy, managed programs to increase the scientific capacity of State

Department, and acted as the liaison to the Bureau of Western Hemisphere Affairs and the Bureau of East Asian and Pacific Affairs.

Dr. Bear holds a Sc.B. in Neuroscience from Brown University and a Ph.D. in Ecology and Evolutionary Biology from Yale University. While working on her doctoral research on the developmental basis of courtship behavior in butterflies, Dr. Bear co-founded the Evolution Outreach Group, a volunteer organization composed of students and postdoctoral researchers that visit schools, museums, and camps in the greater New Haven, CT area to teach K-12 students about evolution through hands-on activities and demonstrations. Dr. Bear is passionate about science outreach to the public and about promoting diversity and inclusion in science, technology, engineering, and math (STEM).

Jay B. Labov is Senior Advisor for Education and Communication for the National Academies of Sciences, Engineering, and Medicine. He has directed or contributed to 25 Academies reports focusing on undergraduate education, teacher education, advanced study for high school students, K-8 education, and international education. He has served as Director of committees on K-12 and undergraduate science education, the Academies' Teacher Advisory Council, and was Deputy Director for the Academy's Center for Education. He directed a committee of the NAS and the Institute of Medicine that authored Science, Evolution, and Creationism and oversees the National Academy of Sciences' efforts to confront challenges to teaching evolution in the nation's public schools. He coordinates efforts at the Academies to work with professional societies and with state academies of science on education issues. He also oversees work on improving education in the life sciences under the aegis of the Academy's Board on Life Sciences. Dr. Labov is an organismal biologist by training. Prior to accepting his position at the Academy in 1997, he spent 18 years on the biology faculty at Colby College (Maine). He is a Kellogg National Fellow, a Fellow in Education of the American Association for the Advancement of Science, a Woodrow Wilson Visiting Fellow, and a 2013 recipient of the "Friend of Darwin" award from the National Center for Science Education. In 2013 he was elected to a three year term beginning in 2014 in which he served as chair-elect for 2014, chair for 205 and past chair for 2016 of the Education Section of the American Association for the Advancement of Science. In 2014 he was named a Lifetime Honorary Member by the National Association of Biology Teachers, that organization's highest award and recognition. He received an Academies Staff Award for Lifetime Achievement in December, 2014 and was named by the Society for Integrative and Comparative Biology as the John A. Moore Lecturer for 2016.

Irene Ngun is a Research Associate with the Board on Higher Education and Workforce (BHEW) at the National Academies of Sciences, Engineering, and Medicine. She also serves as Research Associate for the Committee on Women in Science, Engineering, and Medicine (CWSEM), a standing committee of the National Academies. Before joining the National Academies she was a congressional intern for the U.S. House Committee on Science, Space, and Technology (Democratic Office) and served briefly in the office of Congresswoman Eddie Bernice Johnson of Texas (D-33).

Irene Ngun received her M.A. from Yonsei Graduate School of International Studies (Seoul, South Korea), where she developed her interest in science policy. She received her B.A. from Goshen College in Biochemistry/Molecular Biology and Global Economics.

Tom Rudin is the Director of the Board on Higher Education and Workforce (BHEW) at the National Academies of Sciences, Engineering, and Medicine —a position he assumed in mid-August 2014. Prior to joining the Academies, Mr. Rudin served as senior vice president for career readiness and senior vice president for advocacy, government relations and development at the College Board from 2006-2014. He was also vice president for government relations from 2004-2006 and executive director of grants planning and management from 1996-2004 at the College Board. Before joining the College Board, Mr. Rudin was a policy analyst at the National Institutes of Health in Bethesda, Maryland.

In 1991, Mr. Rudin taught courses in U.S. public policy, human rights, and organizational management as a visiting instructor at the Middle East Technical University in Ankara, Turkey. In the early 1980s, he directed the work of the Governor's Task Force on Science and Technology for North Carolina Governor James B. Hunt, Jr., where he was involved in several new state initiatives, such as the North Carolina Biotechnology Center and the North Carolina School of Science and Mathematics. He received a Bachelor of Arts degree from Purdue University, and he holds master's degrees in public administration and in social work from the University of North Carolina at Chapel Hill.

JD Talasek is the director of Cultural Programs of the National Academy of Sciences (www.cpnas.org). Talasek is creator and moderator for a monthly salon called DASER (DC Art Science Evening Rendezvous) held at the NAS.

He is currently on the faculty at Johns Hopkins University in the Museum Studies Master's Program. Additionally, Talasek serves on the Contemporary Art and Science Committee (CASC) at the Smithsonian's National Museum of Natural History. He is the art advisor for Issues in Science and Technology Magazine and is currently the Art and Design Advisor for the National Academies Keck Futures Initiative based in Irvine, CA. Talasek is a board member of Leonardo/ International Society for Art Science and Technology and is chair of the Leonardo Education Arts Forum

He was the creator and organizer of two international on-line symposia (and coeditor of the subsequent published transcripts: Visual Culture + Bioscience (2009, DAP) and Visual Culture + Evolution (2010, DAP).

Deeply Affecting First-Year Students' Thinking: Deep Approaches to Learning and Three Dimensions of Cognitive Development

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Deeply Affecting First-Year Students' Thinking: Deep Approaches to Learning and Three Dimensions of Cognitive Development

This study estimates the effects of a deep approaches to learning scale and its subscales on measures of students' critical thinking, need for cognition, and positive attitudes toward literacy, controlling for pre-college scores for the outcomes and other covariates. Results suggest reflection is critical to making gains across the outcomes.

Put simply, students should become better thinkers as they proceed through college. They should leave their institutions inclined to learn more, and they should be ready to take up the intellectual challenges imbedded in their lives. This is evident in even a cursory examination of the twenty-first century collegiate learning outcomes articulated by the Association of American Colleges and Universities (AAC&U, 2007) and those found in innumerable other documents from previous eras that describe what students should gain as a result of completing their postsecondary education. Yet, not all college students come out of their postsecondary experience equally equipped in these areas, nor have they

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all made the same amount of progress. The findings from Arum and Roksa (2011) illustrate this point, but so too does a long line of research within the higher education literature (Pascarella & Terenzini, 2005).

To understand what makes for better learning and improved thinking, researchers have been investigating what are known as "deep" approaches to learning (DAL) for almost forty years. DAL focus on the substance of learning and its underlying meanings (Marton & Säljö, 1976), including seeking to grasp key concepts, understanding relationships, and transferring ideas from one circumstance to another (Beatie, Collins, & McInnes, 1997; Bowden & Marton, 1998). This contrasts with "surface" approaches where the focus is almost exclusively on the substance of information, where rote learning is predominant, and where the educational goals amount to avoiding failure (Biggs, 1989; Tagg, 2003).

Approaching learning deeply is important because students who use such approaches tend to earn higher grades and retain, integrate, and transfer information at higher rates (Biggs 1988; Entwistle & Ramsden, 1983; Prosser & Millar, 1989; Ramsden, 2003; Whelan, 1988). DAL are also associated with greater enjoyment of learning, reading widely, drawing on a variety of resources, discussing ideas with others, reflecting on how individual pieces of information relate to larger constructs or patterns, and applying knowledge in real world situations (Biggs, 2003; Entwistle, 1981; Ramsden, 2003; Tagg, 2003).

While the evidence for DAL suggests a connection to valued college outcomes, the literature is lacking in two areas germane to our study. First, the range of outcomes examined in the literature about DAL is still fairly narrow. For example, few studies examine relationships between DAL and standardized measures of critical thinking or students' orientations toward thinking and learning. Second, much of the study of DAL has been done very locally, within classrooms or tied to particular learning tasks. To complement the work that has already been done, researchers need to conduct larger-scale investigations that cover significant periods of time during college and examine outcomes that are less task or classroom specific.

Deep Approaches to Learning in College

Underscoring most major ontological and epistemic assumptions about education and its purposes is the idea that learning is existent and measurable and can change over time as a result of being exposed to and participating in certain educational experiences. Rather than summarizing or synthesizing definitions of learning (if that is your interest,

see Evans, Forney, & Guido-DiBrito, 1998), we simply submit that college learning is an amalgam of many mutually reinforcing forms, three of which were measured and tested in this study: critical thinking, need for cognition, and positive attitudes toward literacy (PATL).

Deeper learning, learning that takes root in the ways we understand and lasts beyond a short amount of time, is that which would be marked by growth or development in areas like critical thinking, need for cognition, and PATL. That kind of learning takes intentional effort on the part of educators and students to attain. It takes an approach to study and learning that is also deep (Biggs, 1987, 2003; Ramsden, 2003). While by definition a deep approach to learning leads to deeper learning, the empirical connections between DAL and measured outcomes that reflect deeper learning, like the three learning outcomes in this study, have yet to be made with much certainty. Establishing those connections is the focus of this study.

In the following subsections, we define DAL and describe how they have been measured. Then we discuss the connections between DAL and a variety of outcomes, paying particular attention to known relationships between the measures of DAL used in this study and collegiate outcomes and areas where relationships should be established or investigated further.

Describing and Measuring Deep Approaches to Learning

Scholars distinguish between "approaches to learning" and the learning that results. What a student does, her or his study activities and behaviors, compose that student's approach to learning (e.g., Biggs, 1987, 2003; Ramsden, 2003). An approach leads to learning, with qualitative distinctions existing between approaches taken and the quality of learning that results. By definition, a deep approach leads to deeper learning and a surface approach leads to more surface learning.

In developing the distinctions between deep and surface approaches, researchers found that students who use DAL more often show a personal commitment to understand the material. They tend to use multiple strategies, such as reading widely, discussing ideas with others, pulling from multiple resources, reflecting on the learning process, and applying knowledge in real world situations (Biggs, 1987, 1989, 2003; Entwistle, 1981; Ramsden, 2003; Tagg, 2003). Integrating and synthesizing information with what one has learned previously also reflects a deep approach. Deep learners update their ways of thinking and approaches to new phenomena throughout the learning process as they make efforts to see problems and issues from different perspectives (Ramsden, 2003; Tagg, 2003). Not surprisingly, students using "surface" approaches

focus mostly on the substance of information and privilege memorization techniques over others (Biggs, 1989; Tagg, 2003). In using a surface approach, one is seeking to avoid failure, instead of understanding core concepts and seeing the relationships among them or figuring out how to apply information in new ways (Bowden & Marton, 1998).

When measured through questionnaires, researchers generally capture at least two types of approaches (deep and surface, or something analogous) by tapping the motivations and strategies that inform those approaches (Biggs, 1987; Entwistle & Ramsden, 1983; Ramsden & Entwistle, 1981). Such instruments have been used widely on college students and updated periodically (Biggs, Kember, & Leung, 2001; Entwistle & McCune, 2004; Entwistle & Tait, 1994; Gibbs, Habeshaw, & Habeshaw, 1989). Such instruments are most often administered with a focus on a course context or a particular learning task.

In this study, we used measures of DAL derived from the National Survey of Student Engagement (NSSE). Unlike other instruments measuring approaches to learning, the NSSE items attempt only to measure one's use of deep approaches, rather than measuring both deep and surface approaches to learning, but also the items capture three different components to DAL (higher-order, integrative, and reflective learning) instead of simply contrasting deep approaches to surface ones (Nelson Laird, Shoup, & Kuh, 2006; Nelson Laird, Shoup, Kuh, & Schwarz, 2008). Since NSSE items are aimed at students' experiences at an institution in a given year, as opposed to a student's approaches to learning within a specific course or task context, the NSSE measures of DAL are also best thought of as general measures of DAL or indicators of a student's preferred approach. This fits with previous work that indicates that students have a general tendency to approach learning in similar ways across tasks or contexts (Biggs, 1987; Entwistle, 1981; Ramsden, 2003).

Deep Approaches to Learning and Their Associated Outcomes

Research connecting DAL to outcomes is limited in two ways. First, there is an overwhelming focus on linking DAL to academic achievement, particularly grades. Second, studies generally target students in a small number of courses (often a single course) at a single institution. Still, the body of research suggests that DAL foster improved thinking and learning for students.

Early studies connected DAL and increased retention, integration, and transfer of information (Biggs, 1988; Entwistle & Ramsden, 1983; Prosser & Millar, 1989; Whelan, 1988), which set the foundation for further work. Since then, many scholars established relation-

ships between DAL and academic achievement. Though prior academic achievement is considered the primary predictor of current academic achievement, results show a positive relationship exists between DAL and achievement (e.g. Hall, Bolen, & Gupton, 1995; McKensie & Schweitzer, 2001; Zeegers, 2004; Zhang 2000). For example, a study of Australian students indicated that, even though multiple factors contribute to learning outcomes, both deep and surface approaches had direct effects on overall GPA (Zeegers, 2004). In particular, DAL positively affected first- and third-year students' overall GPA, while surface approaches negatively affected students' GPA (and the effect was actually stronger in the 3rd year). Similarly, Zhang (2000) found use of DAL positively associated with higher GPAs controlling for US students' self-rated analytic, creative, and practical abilities. Other studies show that altering teaching practices can lead to increased use of DAL and consequently improved grades (Gow, Kember, & Cooper, 1994; Meyer, Parsons, & Dunne, 1990; Woods, Hrymak, & Wright, 2000).

Similarly, adoption of DAL was positively associated with exam and portfolio grades (Lonka, Keikkila, Lindblom-Ylanne, & Maury, 1997; Vermunt, 1992; Vermunt & Vermetten, 2004). Students who took deep approaches also failed and withdrew from a course less often (Rowell, Dawson, & Pollard, 1993) and were more likely to achieve higher GPAs and earn more credits per year (Tynjälä, Salminen, Sutela, Nuutinen, & Pitkänen, 2005).

In one study using the NSSE scales (Nelson Laird, Shoup, et al., 2008), positive relationships were established between DAL and three outcomes: average grades, satisfaction with college, and self-reported educational gains. The major finding in that study was that, while DAL use varied considerably by major, the effects of DAL on the outcomes did not vary much by major. A minor finding in that paper bears on the current investigation. That study showed that the DAL subscales had different size effects on different outcomes and their relative import varied by outcome. For example, higher-order learning was often the strongest predictor of satisfaction and self-reported educational gains, while integrative learning was generally the strongest predictor of grades.

In many studies that utilize grades as an outcome, the assumption is that students' grades reflect deeper understanding, greater critical thought, and other outcomes. Particularly in some of the course-specific studies this may well be the case, but across courses we are dubious about the use of GPA as a proxy for important thinking and learning outcomes (see the fairly small relationship found by Nelson Laird, Shoup,

et al., 2008). In the current study, we focus on three particular thinking and learning outcomes: critical thinking, need for cognition, and PATL.

Critical Thinking. While a positive relationship between DAL and critical thinking is regularly assumed, only a small number of studies empirically investigated the connection between DAL and critical thinking. For example, Chapman (2001) found that the adoption of teaching methods that favored DAL led to improved higher-order and critical thinking skills among students in an introductory biology course. While such results are encouraging, two studies that examined the relationship between NSSE's DAL scale and standardized tests of critical thinking skills found no relationship (Nelson Laird, Garver, Niskode-Dossett, & Banks, 2008; Reason, Cox, McIntosh, & Terenzini, 2010). It is important to mention, however, both studies were cross-sectional and neither investigated the relationships with the DAL subscales.

Need for Cognition. It has been noted that use of DAL is associated with the enjoyment of learning and at least one study has established a positive relationship between DAL and students' need for cognition (Evans, Kirby, & Fabrigar, 2003), which is defined as the "tendency to engage in and enjoy effortful cognitive activity" (Cacioppo, Petty, Feinstein, & Jarvis, 1996, p. 197). However, that study only looked at the correlations between the two and not the development of need for cognition over time. With only a single study to date, it is not surprising that the relationships between NSSE's DAL measures and need for cognition still need to be established.

Positive Attitudes Toward Literacy. PATL is a concept that covers students' enjoyment of such literacy activities as reading poetry and literature, reading scientific and historical material, and expressing ideas in writing (Bray, Pascarella, & Pierson, 2004). Scholars suggest that DAL are positively associated with reading widely and enjoying the learning process (Biggs, 2003; Ramsden, 2003; Tagg, 2003), which implies a connection to PATL, though a direct empirical link has not been established using any DAL measures.

Purpose and Research Questions

Given that relatively few studies have investigated empirically the deeper learning outcomes presumed to result from a student's use of DAL, the purpose of this study was to estimate the relationships between DAL and three dimensions of cognitive development. In particular, we sought to estimate the effects of four DAL measures, an overall DAL scale and its three subscales, on measures of students' critical

thinking skills, inclination to inquire, and orientation toward literacy controlling for many covariates and students' scores on the outcome measures prior to college. The following questions guided our study:

1. How strong is the relationship between DAL and critical thinking at the end of the first year of college after controlling for a pre-test of students' critical thinking skills and controls for students' backgrounds and experiences?
2. How strong is the relationship between DAL and need for cognition at the end of the first year of college after controlling for a pre-test of students' need for cognition and controls for students' backgrounds and experiences?
3. How strong is the relationship between DAL and positive attitude toward literacy at the end of the first year of college after controlling for a pre-test of students' positive attitude toward literacy and controls for students' backgrounds and experiences?

For the first three questions, the focus was on testing the overall relationships between DAL and the three cognitive measures. The following questions guided our examination of how different components of DAL affected the outcome measures and allowed us to determine if any subcomponents of DAL affect certain outcomes more than others:

4. What are the unique effects of higher-order, integrative, and reflective learning on critical thinking at the end of the first year of college after controlling for a pre-test of students' critical thinking skills and controls for students' backgrounds and experiences?
5. What are the unique effects of higher-order, integrative, and reflective learning on need for cognition at the end of the first year of college after controlling for a pre-test of students' need for cognition and controls for students' backgrounds and experiences?
6. What are the unique effects of higher-order, integrative, and reflective learning on positive attitude toward literacy at the end of the first year of college after controlling for a pre-test of students' positive attitude toward literacy and controls for students' backgrounds and experiences?

This study is an explicit examination of thinking and learning within the first college year connecting students' use of DAL, as measured by NSSE (Nelson Laird et al., 2006; Nelson Laird, Shoup et al., 2008), with the Critical Thinking Test (CTT) from the Collegiate Assessment of Academic Proficiency (CAAP) (American College Testing Program [ACT], 1991), the Need for Cognition Scale (NCS) (Cacioppo et al., 1996), and the PATL scale (Bray et al., 2004). As such, this study is both an assessment of the impact of the first year of college as well as a test

of the relationships between NSSE's DAL scale and subscales and the three outcome measures.

Conceptual Framework

Consistent with conceptions of DAL and the three outcomes of interest, learning in this study is understood as a structural-developmental cognitive process involving the interaction between the individual and the environment and the individual's ability to ascribe meaning to that interaction. Individuals structure meaning by interacting with the environment—by engaging, evaluating, synthesizing, and interpreting information presented through environmental cues (Perry, 1968; Piaget, 1948). With increased exposure to environmental cues comes change in individual processing (i.e., learning).

Consistent with this theoretical orientation, Biggs (2003), in his 3-P model, suggests that Student Factors and the Teaching Context (both a part of Presage) lead to students' choice of Learning-Focused Activities (the Process; e.g., DAL), which in turn affect the Learning Outcomes (the Products). We used the 3-P model to guide our study (see Figure 1). The 3-P model encouraged our inclusion of student background characteristics (e.g., gender, race, parental education, academic ability), learning environment characteristics (e.g., courses taken), and learning process indicators such as approaches to learning. While the Biggs model is not substantially different from other models of college impact (e.g., Astin, 1977, 1993; Pascarella, 1985), it highlights how aspects of students' background and the college context influence students' choices of learning approaches, something central to our study that is not emphasized in the other models.

Theoretically, then, we assert that the mechanisms embedded within DAL will engender movement in each of the three cognitive outcomes examined in this study: critical thinking, need for cognition, and PATL. Although we expect that certain mechanisms will help students make cognitive gains across these three outcomes, we also hypothesize that certain mechanisms may be more prevalent for one outcome than another—that is, one dimension of DAL may influence critical thinking to a greater degree than need for cognition, for example. As an exploratory study focusing on the relationship between DAL and three cognitive outcomes, we chose to use the same conceptual framework and analytic scheme for interrogating these relationships but leave room for the nuances reflecting each: DAL and critical thinking, DAL and need for cognition, and DAL and PATL, respectively.

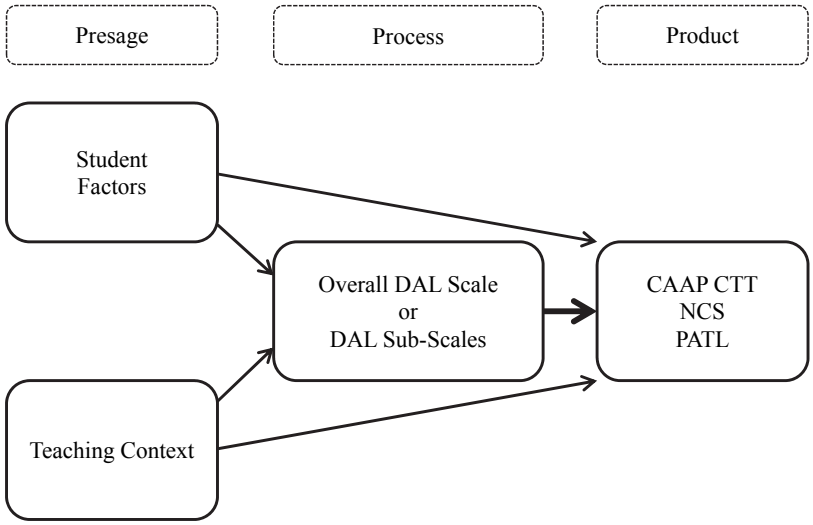

FIGURE 1. Conceptual Framework (adapted from Biggs, 2003)

Methods

In this largely exploratory study using secondary data analysis, we relied on data gathered through the Wabash National Study of Liberal Arts Education (WNS), a longitudinal investigation funded by the Center of Inquiry in the Liberal Arts at Wabash College aimed at understanding the effects of liberal arts colleges and liberal arts experiences on the cognitive and personal outcomes theoretically associated with a liberal arts education. In the following subsections we describe our samples, the data collection processes, measures, analytic procedures, and the study's limitations.

Samples

Institutional Sample. The participants in the study consisted of incoming first-year students at 19 four- and two-year colleges and universities located in 11 different states in the Northeast, Southeast, Midwest, or Pacific Coast regions of the United States. The 19 institutions were selected from more than 60 colleges and universities that responded to a national invitation to participate in the WNS. The institutions were selected to represent differences in college and universities nationwide on a variety of characteristics including institutional type and control, size, location, and patterns of student residence. However, liberal arts

colleges were purposefully overrepresented because the study's focus on the impacts of liberal arts colleges and liberal arts experiences.

The selection process produced a sample of institutions with a wide range of academic selectivity, from some of the most selective institutions in the country to some that were essentially open admissions. Undergraduate enrollments also varied considerably, from institutions with entering classes between 3,000 and 6,000, to institutions with entering classes between 250 and 500. According to the 2007 Carnegie Classification of Institutions, 3 of the participating institutions were considered research universities, 3 were regional universities that did not grant the doctorate, 2 were two-year community colleges, and 11 were liberal arts colleges.

Student Sample. The individuals in the sample were first-year, full-time undergraduate students participating in the WNS at each of the 19 institutions in the study. At each institution students were selected in either of two ways. First, for larger institutions, the sample was selected randomly from the incoming first-year class at each institution. The only exception to this was at the largest participating institution in the study, where the sample was selected randomly from the incoming class in the College of Arts and Sciences. Second, for a number of the smallest institutions in the study—all liberal arts colleges—the sample was the entire incoming first-year class. The students in the sample were invited to participate in a national longitudinal study examining how a college education affects students, with the goal of improving the undergraduate experience. They were informed that they would receive a monetary stipend for their participation in each wave of data collection, and were also assured in writing that any information they provided would be kept in the strictest confidence and never become part of their institutional records.

Data Collection

Initial Data Collection. The initial data collection was conducted in the early fall of 2006 with 4,501 students from the 19 institutions. This first data collection lasted between 90–100 minutes and students were paid a stipend of $50 each for their participation. The data collected included a WNS pre-college survey that sought information on student demographic characteristics, family background, high school experiences, political orientation, educational degree plans, and the like. Students also completed a series of instruments that measured dimensions of cognitive and personal development theoretically associated with a liberal arts education, including a measure of critical thinking skills, a

measure of inclination to inquire, and a measure of orientation toward involvement in literacy activities. These three instruments are described in greater detail in the Dependent Variables section below. Due to instrument length and concerns about the use of student time during the assessment, not all students in the sample completed the measure of critical thinking skills. Rather, at each institution, it was randomly assigned to half of the student study participants, while the other random half of the sample completed a different instrument of almost identical length. All students in the sample at each institution completed the need for cognition and positive attitude toward literacy measures.

Follow-Up Data Collection. The follow-up data collection was conducted in spring 2007. This data collection took about two hours and participating students were paid an additional stipend of $50 each. Two types of data were collected. The first was based on questionnaire instruments that collected extensive information on students' experience of college. Two complementary instruments were used: NSSE and the WNS Student Experiences Survey (WSES). However, for the purposes of this study, we focus on information provided by the NSSE. The second type of data collected consisted of follow-up (or posttest) measures of the instruments measuring dimensions of cognitive and personal development that were first completed in the initial data collection. All students completed the NSSE and WSES prior to completing the follow-up instruments assessing cognitive and personal development. Both the initial and follow-up data collections were administered and conducted by ACT (formerly the American College Testing Program).

Of the original sample of 4,501 students who participated in the fall 2006 testing, 3,081 participated in the spring 2007 follow-up data collection, for a response rate of 68.5%. These 3,081 students represented 16.2% of the total population of incoming first-year students at the 19 participating institutions. To provide at least some adjustment for potential response bias by sex, race, academic ability, and institution in the sample of students, a weighting algorithm was developed. Using information provided by each institution on sex, race, and ACT score (or appropriate SAT equivalent or COMPASS score equivalent for community college students), follow-up participants were weighted up to each institution's first-year undergraduate population by sex (male or female), race (Caucasian, African American/Black, Hispanic/Latino, Asian/Pacific Islander, or other), and ACT (or equivalent score) quartile. While applying weights in this manner has the effect of making the overall sample more similar to the population from which it was drawn, it cannot totally adjust for nonresponse bias.

Dependent Variables (Products)

The study had three dependent variables: a measure of critical thinking skills, a measure of need for cognition, and a measure of positive attitude toward literacy To measure critical thinking skills we used the Critical Thinking Test (CTT) from the Collegiate Assessment of Academic Proficiency (CAAP) developed by ACT. The CAAP CTT is a 40-minute, 32-item instrument designed to measure a student's ability to clarify, analyze, evaluate, and extend arguments. The test consists of four passages in a variety of formats (e.g., case studies, debates, dialogues, experimental results, statistical arguments, and editorials.). Each passage contains a series of arguments that support a general conclusion and a set of multiple-choice test items. The internal consistency reliability for the CTT ranges between 0.81 and 0.82 (ACT, 1991). It correlates 0.75 with the Watson-Glaser Critical Thinking Appraisal (Pascarella, Bohr, Nora, & Terenzini, 1995).

Need for cognition, which refers to the engagement in and enjoyment of effortful thinking, was measured with the 18-item Need for Cognition Scale (NCS). Those who have a high need for cognition "tend to seek, acquire, think about, reflect back on information to make sense of stimuli, relationships, and events in the world" (Cacioppo et al., 1996, p. 198). In contrast, those with low need for cognition are more likely to rely on others, such as celebrities and experts, cognitive heuristics, or social comparison processes to provide or make sense of their world. The reliability of the NCS ranges from 0.83 to 0.91 in samples of undergraduate students (Cacioppo et al., 1996). With samples of undergraduates, the NCS has been positively associated with the tendency to generate complex attributions for human behavior, high levels of verbal ability, engagement in evaluative responding, one's desire to maximize information gained rather than maintain one's perceived reality (Cacioppo et al., 1996) and college grades (Elias & Loomis, 2002). The NCS is negatively linked with authoritarianism, need for closure, personal need for structure, the tendency to respond to information reception tasks with anxiety, and chronic concern regarding self-presentation (Cacioppo et al., 1996).

Finally, orientation toward involvement in literacy activities was measured with the six-item Positive Attitude Toward Literacy (PATL) scale. The PATL assesses a student's enjoyment of such literacy activities as reading poetry and literature, reading scientific and historical material, and expressing ideas in writing, and has an internal consistency reliability of 0.71. The PATL score at entrance to college correlated 0.36 with three-year cumulative scores on a measure of library use during

college, 0.48 with the cumulative number of unassigned books read during three years of college, and 0.26 with a measure of reading comprehension administered after three years of college (Bray et al., 2004).

Independent Variables (Process)

The independent variables in the study were four scales developed by Nelson Laird and colleagues (Nelson Laird et al., 2006; Nelson Laird, Shoup et al., 2008) to measure DAL. The scales are based on NSSE items completed by the student sample in spring 2007. Three of the four scales are termed: Higher-Order Learning, Integrative Learning, and Reflective Learning. According to Nelson Laird, Shoup et al. (2008), the four-item Higher-Order Learning Scale "focuses on the amount students believe that their courses emphasize advanced thinking skills such as analyzing the basic elements of an idea, experience, or theory and synthesizing ideas, information, or experiences into new, more complex interpretations" (p. 477). The Integrative Learning Scale consists of five items and measures "the amount students participate in activities that require integrating ideas from various sources, including diverse perspectives in their academic work, and discussing ideas with others outside of class" (p. 477). Reflective Learning is a three-item scale that asks "how often students examined the strengths and weaknesses of their own views and learned something that changed their understanding" (p. 477). Nelson Laird and his colleagues also developed the Overall DAL Scale that yields a score based on all 12 items. We present the specific items constituting each of the three deep learning subscales and the overall scale in Table 1. The overall scale and subscales were calculated by taking means of the component items after rescaling each item to range from 0 to 100.

Control Variables/Covariates (Presage)

A particular methodological strength of the WNS is that it is longitudinal in nature. This permitted us to introduce a wide range of statistical controls, not only for student background and pre-college traits and experiences, but also for other experiences during the first year of college.

In completing our regression models, we were guided by the 3-P model (Biggs, 2003), but consulted a number of longitudinal conceptual models for studying the impact of college on students when selecting variables (e.g., Astin, 1977, 1993; Pascarella, 1985). Together these models argue that to validly understand the net impact of any specific college experience one must take into account at least three additional sets of variables: the background characteristics with which the

TABLE 1
NSSE DAL Scales and Component Items[a]

Scales/Items
Higher-Order Learning (alphas = 0.82, 0.75)[b]
Analyzed the basic elements of an idea, experience, or theory, such as examining a particular case or situation in depth and considering its components (0.66)[c]
Synthesized and organized ideas, information, or experiences into new, more complex interpretations and relationships (0.70)[c]
Made judgments about the value of information, arguments, or methods, such as examining how others gathered and interpreted data and assessing the soundness of their conclusions (0.65)[c]
Applied theories or concepts to practical problems or in new situations (0.51)[c]
Integrative Learning (alphas = 0.72, 0.67)[b]
Worked on a paper or project that required integrating ideas or information from various sources (0.50)[c]
Included diverse perspectives (different races, religions, gender, political beliefs, etc.) in class discussion or writing assignments (0.57)[c]
Put together ideas or concepts from different courses when completing assignments or during class discussions (0.59)[c]
Discussed ideas from your readings or classes with faculty members outside of class discussions (0.50)[c]
Discussed ideas from your readings or classes with others outside of class (students, family members, co-workers, etc.) (0.53)[c]
Reflective Learning (alphas = 0.81, 0.76)[b]
Examined the strengths and weaknesses of your own views on a topic or issue (0.72)[c]
Tried to better understand someone else's views by imagining how an issues looks from his or her perspective (0.77)[c]
Learned something that changed the way you understand an issue or concept (0.66)[c]
Overall DAL Scale (alphas = 0.72, 0.82)[b]
Includes all 12 items in the scales above

Note. Response options for the *Integrative Learning* and *Reflective Learning* scales were: 1 = Never, 2 = Sometimes, 3 = Often, 4 = Very Often. Response options for the *Higher-Order Learning* scale were: 1 = Very little, 2 = Some, 3 = Quite a bit, 4 = Very often.
[a]Adapted from Nelson Laird, Shoup, et al. (2008).
[b]First alpha reliability from Nelson Laird, Shoup, et al. (2008); second alpha reliability from the WNS sample.
[c]Factor loadings from a confirmatory factor analysis run with STATA using maximum likelihood estimation on the WNS sample in parentheses next to each item. $X^2 = 440.33$, $p < 0.001$; RMSEA = 0.05; CFI = 0.95; TLI = 0.94.

student begins postsecondary education (Student Factors part of Presage in Biggs' model), the institutional/learning context (this is covered in the Teaching Context, also in Presage, in Biggs' model), and other college experiences that might influence or co-vary with the particular experience in question (we also treated these as a part of the Teaching Context).

Presage—Student Factors. The student factors in our study were a pre-college measure of each of the three outcome variables (described above), race (0 = non-Caucasian and 1 = Caucasian), sex (0 = female and 1 = male), parental education (the average of the respondent's parents' education ranging from 1 = did not finish high school to 9 = Doctorate), a measure of tested pre-college academic preparation (student's actual ACT score, SAT equivalent score, or COMPASS equivalent score for community college students), and measures of involvement/engagement in secondary school (a seven-item scale with an internal consistency reliability of 0.58) and pre-college academic motivation (eight-item, Likert-type scale with internal consistency reliability of 0.69). All were collected during the pre-college data collection in fall 2006. Many of the pre-college variables had significant correlations, either with the dependent measures, and/or with the DAL scales. For example, the pre-college measures of critical thinking, need for cognition, and positive attitude toward literacy correlated 0.796, 0.741, and 0.742, respectively, with the end-of-first-year scores on the three measures. The pre-college measure of need for cognition had correlations with the four deep learning scales that ranged between 0.256 and 0.382, while the pre-college positive attitude toward literacy score correlated from 0.163 to 0.327 with the deep learning scales. Finally, the measure of academic motivation had correlations with the deep learning scales ranging from 0.23 to 0.31.

Presage—Teaching Context. To take into account institutional context, we created dummy variables (i.e., coded 1 or 0) to represent the four types of institutions attended by the WNS sample: liberal arts colleges, research universities, regional institutions, and community colleges. Finally, we also took into account the influence of other first year college experiences which we hypothesized might shape a student's opportunity for engagement in deep learning experiences, or confound the link between deep learning experiences and the three first year outcomes. These included: living on- or off-campus, work responsibilities, and the type of first year coursework taken (all collected during the follow-up data collection in spring 2007).

Data Analyses

Our analyses for the Overall DAL Scale (research questions one through three) were conducted in two stages. First, we estimated the relationship between the Overall DAL Scale and the three outcome measures using correlations. These analyses were based on the zero-order correlations between the Overall DAL Scale and both the pre-college and end-of-first-year scores for critical thinking, need for cognition,

and PATL, as well as the partial correlations between the deep learning scales and end-of-first-year outcome scores controlling for the precollege scores. These analyses were intended to be preliminary and so did not take into account the nested (students within institutions) nature of the data. This likely led to underestimated standard errors (Raudenbush & Bryk, 2001). As a result, we used a more stringent alpha level ($p < 0.01$) to indicate statistical significance.

The second stage of analysis involved regressing end-of-first-year (spring 2007) scores for each dependent measure (i.e., the CAAP CTT, NCS, and PATL) on the Overall DAL Scale and all control variables described above. In these regressions, we standardized all continuous variables so that model parameter estimates could be interpreted as effect sizes. We also adjusted for the clustered or nested nature of our data, which results from the fact that the individuals in our sample were not drawn from a random individual sample but a sample in which their postsecondary institution was the primary sampling unit. Because students within a school are more similar than across schools, the error terms from the prediction model are correlated, which violates one of the assumptions of Ordinary Least Squares regression and results in underestimated standard errors (Ethington, 1997; Raudenbush & Bryk, 2001). We accounted for the nested nature of the data by using appropriate statistical techniques that adjust for this clustering (Groves et al., 2004). Specifically, we employed the regression option (svy) in the STATA software package that adjusts standard errors in coefficient estimates for the clustering effect. Complete data on all variables was available for 1,451 students in the analysis of the CAAP CTT, and 3,010 students in the analyses of NCS and PATL. All analyses are based on weighted sample estimates adjusted to the actual sample size for correct standard errors.

To address research questions four through six, we repeated the same two-stage analytic process. However, instead of including the Overall DAL Scale, the three DAL subscales (Higher-Order Learning, Integrative Learning and Reflective Learning) were included in each analysis.

Limitations

This study has several limitations. Because we studied students nested within institutions, we restricted the number of covariates included in the analytic models. For example, we reduced the number of process variables included in the model, coded race into two discrete categories, and used limited course-taking measures due to the limits on our degrees of freedom.

The NSSE measure of DAL contains fewer items (only 12) than other such measures and does not tap other types of learning approaches (Biggs et al., 2001; Entwistle & McCune, 2004). It may be that a finer tuned measure or including a measure of another approach (e.g., surface) would result is modified findings. Future research should consider whether a more robust measure or measures of DAL would show stronger relationships even with controls, particularly for critical thinking.

Also, our sample consisted of only first-year students. This meant that certain covariates of interest, particularly year in school and major, did not vary or were much less meaningful. In addition, we tested these students at only two time points; we cannot speak to stability of change scores over time. Future research, including studies using more years of WNS data, should address these limitations.

Including community college students as part of our longitudinal sample presents some potential limitations. The institutional mission of community colleges differs from those at other types of colleges (Cohen & Brawer, 2003; Grubb, 1996) and this difference can make it problematic to include students enrolled at community colleges with four-year college students in studies of college impact. However, many first-year students at community colleges experience cognitive changes that are quite similar in direction and magnitude to those of their four-year college counterparts (Pascarella, 1999; Pascarella & Terenzini, 2005). Further, too often community college students are ignored in research on college impact. As a result, we opted to include community college students in our sample and control for student clustering and pre-college ACT or equivalent. Future researchers may want to specifically investigate DAL and cognitive outcomes at community colleges because of their embedded and distinctive educational practices.

Finally, since the focus of this study was on the individual-level effects of DAL on three cognitive outcomes, we chose not to model institutional-level effects but simply account for the clustered nature of the sampling design. We believe examining institutional-level effects is an area for further research, but studies need to ensure enough statistical power for examining institution-level variables.

Results

Table 2 summarizes the descriptive statistics for all variables used in the analyses. The two different samples were quite similar in characteristics and, for all dependent measures, the overall averages changed very little over the course of the first year. Tables 3 to 5 summarize the

results of our first stage analyses for the Overall DAL Scale as well as the DAL subscales. Table 6 gives the results for the regression models containing the Overall DAL Scale and Table 7 gives the results for the regression models containing the DAL subscales.

Overall DAL Scale Findings

As Table 3 indicates, the zero-order correlations between the Overall DAL Scale and both the pre-college and end-of-first-year CAAP CTT scores were modest in magnitude (0.126 and 0.132, respectively, $p < 0.001$ for both). The zero-order correlations between the Overall DAL Scale and the pre-college and end-first-year measures of the other outcomes were relatively large (ranging from 0.327 to 0.414, $p < 0.001$), as seen in Tables 4 and 5. Across the outcomes, there was a clear trend for the associations between DAL and the three cognitive outcomes to be stronger at the end of the first year of college than the associations between DAL and the pre-college scores. Indeed, even controlling for pre-college scores, the partial correlations between the Overall DAL Scale and end-of-first-year NCS and PATL scores were statistically significant, if somewhat modest in magnitude (0.211 and 0.184, respectively, $p < 0.001$ for both). Only for CAAP CTT was the partial correlation small and not significant (0.051, $p > 0.05$). These findings show that DAL were related to two important college outcomes even after controlling for pre-college scores, but do not determine the unique effects of the Overall DAL scale controlling for a set of pre-college and college experience measures.

Table 6 shows the results of the general effects regression analysis on each dependent measure for the models that included the Overall DAL Scale. The Overall DAL Scale had no significant effect on CAAP CTT, but had modest and statistically reliable, positive effects on both NCS and PATL that persisted even in the presence of controls for a wide range of potential confounding influences—including pre-college academic preparation and pre-college scores on each dependent measure. In each model, the pre-college scores for the dependent measures were the largest predictors by far (0.558 to 0.671, $p < 0.001$). For CAAP CTT, pre-college academic preparation was the second largest predictor (0.277, $p < 0.001$). For NCS and PATL, the Overall DAL Scale was the second largest predictor in the models (0.150 and 0.127, respectively, $p < 0.01$ and $p < 0.001$). The regression findings suggest DAL had a modest positive relationship with two end-of-first-year outcomes even after controlling for a host of student environmental characteristics, including a pre-college score for the outcomes.

TABLE 2
Weighted Descriptive Statistics for All Variables by Sample

			Samples			
			CAAP CTT (n = 1,451)		NCS and PATL (n = 3,010)	
Variable	Min	Max	M	SD	M	SD
Pre-college CAAP CTT	48	73	62.41	5.29		
End-of-first-year CAAP CTT	47	73	62.63	5.80		
Pre-college NCS	1.22	4.94			3.40	0.62
End-of-first-year NCS	1	5			3.39	0.62
Pre-college PATL	1	5			3.21	0.76
End-of-first-year PATL	1	5			3.15	0.82
Male	0	1	0.47	N/A	0.45	N/A
Caucasian	0	1	0.82	N/A	0.82	N/A
Parental education[a]	11	20	15.14	2.15	15.22	2.20
Tested pre-college academic preparation[b]	13	36	24.78	4.91	24.91	4.84
High school involvement[c]	1.71	5.00	3.57	0.67	3.62	0.61
Pre-college academic motivation[d]	1.00	5.00	3.51	0.56	3.52	0.56
Attends a research university	0	1	0.35	N/A	0.35	N/A
Attends a regional institution	0	1	0.24	N/A	0.25	N/A
Attends a community college	0	1	0.17	N/A	0.15	N/A
Lives on campus	0	1	0.72	N/A	0.75	N/A
Hours of on- and off-campus work	0	65	7.57	10.22	7.05	9.53
Liberal arts emphasis of coursework[e]	0	20	6.15	2.20	6.25	2.18
Overall DAL scale	0	100	59.32	15.50	59.46	15.54
Higher-order learning	0	100	68.95	20.07	68.43	20.11
Integrative learning	0	100	52.97	16.56	53.45	17.08
Reflective learning	0	100	57.04	22.46	57.60	22.39

[a]The average of the respondent's parents' education where 1 = did not finish high school to 9 = doctorate.
[b]Students actual ACT scores, SAT equivalent scores, or COMPASS equivalent scores.
[c]7-item scale with an internal consistency reliability of 0.58, with items such as: "During your last year in high school, how often did you talk with teachers outside of class?" "During your last year in high school, how often did you participate in extra-curricular activities?" Response options ranged from 1 = never to 5 = very often.
[d]8-item scale with an internal consistency reliability of 0.69, Likert-type items (1 = strongly disagree to 5 = strongly agree) like "a willingness to work hard to learn material even if it doesn't lead to a higher grade."
[e]Total number of courses in the first year of college taken in "Fine Arts, Humanities, and Languages" (e.g., art, music, philosophy, history); "Mathematics/Statistics/Computer Science"; "Natural Sciences" (e.g., chemistry, physics); and "Social Science" (e.g., anthropology, economics, psychology, political science, sociology).

TABLE 3
Correlations Between DAL Scales and CAAP CTT (n = 1,451)

	1	2	3	4	5	6
1. Higher-order learning	1.000					
2. Integrative learning	0.467***	1.000				
3. Reflective learning	0.433***	0.523***	1.000			
4. Overall DAL scale	0.797***	0.837***	0.783***	1.000		
5. Pre-college CAAP CTT	0.050	0.093***	0.175***	0.126***	1.000	
6. End-of-first-year CAAP CTT	0.045	0.103***	0.183***	0.132***	0.796***	1.000
End-of-first-year CAAP CTT (partial r)[a]	0.009	0.018	0.073**	0.051		

[a]Controlling for pre-college CAAP CTT.
**p < 0.01. ***p < 0.001.

TABLE 4
Correlations Between DAL Scales and NCS (n = 3,010)

	1	2	3	4	5	6
1. Higher-order learning	1.000					
2. Integrative learning	0.464***	1.000				
3. Reflective learning	0.387***	0.520***	1.000			
4. Overall DAL scale	0.783***	0.845***	0.765***	1.000		
5. Pre-college NCS	0.256***	0.318***	0.349***	0.382***	1.000	
6. End-of-first-year NCS	0.271***	0.350***	0.382***	0.414***	0.741***	1.000
End-of-first-year NCS (partial r)[a]	0.125***	0.180***	0.196***	0.211***		

[a]Controlling for pre-college NCS.
**p < 0.01. ***p < 0.001.

TABLE 5
Correlations Between DAL Scales and PATL (n = 3,010)

	1	2	3	4	5	6
1. Higher-order learning	1.000					
2. Integrative learning	0.464***	1.000				
3. Reflective learning	0.387***	0.520***	1.000			
4. Overall DAL scale	0.783***	0.845***	0.765***	1.000		
5. Pre-college PATL	0.163***	0.303***	0.327***	0.327***	1.000	
6. End-of-first-year PATL	0.178***	0.343***	0.346***	0.359***	0.742***	1.000
End-of-first-year PATL (partial r)[a]	0.086***	0.185***	0.163***	0.184***		

[a]Controlling for pre-college PATL.
**p < 0.01. ***p < 0.001.

TABLE 6
Estimated General Effects of the Overall Deep Learning Scale and Control Variables on End-of-First-Year CAAP CTT, NCS, and PATL

	CAAP CTT		NCS		PATL	
Predictor	B	SE	B	SE	B	SE
Process-DAL						
Overall DAL scale	0.028	0.023	0.150***	0.036	0.127***	0.033
Presage-Student Factors						
Pre-college measure[a]	0.558***	0.032	0.605***	0.029	0.671***	0.026
Male	–0.100*	0.047	0.018	0.044	–0.082**	0.023
Caucasian	0.039	0.044	0.025	0.045	–0.057	0.042
Parental education	0.019	0.019	0.014	0.016	0.022	0.015
Tested pre-college academic preparation	0.277***	0.046	0.109***	0.024	0.079***	0.017
High school involvement	0.012	0.039	–0.003	0.019	–0.027	0.017
Pre-college academic motivation	–0.001	0.016	0.056**	0.015	0.030	0.016
Presage-Teaching Context						
Attends a research university	0.033	0.063	–0.074*	0.032	–0.110**	0.034
Attends a regional institution	–0.103*	0.051	–0.047	0.047	–0.070*	0.034
Attends a community college	–0.202	0.150	0.172*	0.081	–0.147	0.120
Lives on campus	–0.156*	0.068	0.033	0.046	–0.083	0.161
Hours of on- and off-campus work	–0.046	0.036	–0.025	0.024	0.004	0.013
Liberal arts emphasis of coursework	0.019	0.029	0.028*	0.013	0.023	0.022
R^2	0.706***		0.589***		0.577***	

[a]Pre-college measure of CAAP CTT, NCS, and PATL, respectively.
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

DAL Subscale Findings

As Table 3 indicates, the zero-order correlations between the DAL subscales and both the pre-college and end-of-first-year CAAP CTT scores were, at most, modest in magnitude (ranging from 0.045 to 0.183, with various *p*-values). The zero-order correlations between Higher-Order Learning and the critical thinking scores were near zero and not significant ($p > 0.05$). The zero-order correlations between the DAL subscales and the two other measures were modest (0.163, $p < 0.001$) to relatively large (0.382, $p < 0.001$). Across all measures, as with the Overall DAL Scale, there was a general trend for the associations between the DAL subscales and the three cognitive outcomes to be

stronger at the end of the first year of college than the associations between DAL and the pre-college scores. Beyond this, even after controlling for pre-college scores, the partial correlations between each of the DAL subscales and end-of-first-year NCS and PATL scores were all statistically significant, but somewhat modest in magnitude (ranging from 0.086 to 0.196, $p < 0.001$). For CAAP CTT, only Reflective Learning was significantly associated with end of first-year scores controlling for pre-college scores and the size of the effect was small (0.073, $p < 0.01$), though, given the strong relationships between the pre-college and end-of-first-year measures, even a small relationship is notable. Among the subscales, Reflective Learning also had the strongest relationship with NCS (0.196, $p < 0.001$), but it was not much higher than the coefficient for Integrative Learning (0.180, $p < 0.001$) and actually a little bit less than that for the Overall DAL Scale (0.211, $p < 0.001$). The strongest relationship for PATL was with Integrative Learning (0.185, $p < 0.001$). These findings show that specific DAL were related to three important college outcomes even after controlling for pre-college scores, but they do not determine the unique effects of the DAL measures controlling for a set of pre-college and college experience measures as well as the other two DAL subscales.

Table 7 provides the estimated effects on the dependent measures for the models containing the three DAL subscales. As expected, the effects of the control variables stayed largely the same relative to the models in Table 6. Higher-Order Learning had no significant unique influence on any outcome. However, even with statistical adjustments made for the entire list of control variables, Reflective Learning had statistically reliable and positive links to all three outcomes (ranging from 0.060 to 0.096, with $p < 0.05$ for the smallest and $p < 0.001$ for the other two) and Integrative learning had similarly modest positive links with both NCS and PATL (0.073 and 0.113, respectively, $p < 0.001$), suggesting that reflective and integrative learning experiences help students develop in these cognitive areas.

Discussion

As institutions become increasingly scrutinized for their focus on learning or lack thereof (Arum & Roksa, 2011), educators may need to respond by adopting more rigorous approaches to the study and practice of higher education, especially in the context of teaching and learning. This study takes a small but important step towards this end, as we attempted to uncover specific learning approaches and their influences on three outcomes related to cognitive development: critical thinking, need

TABLE 7
Estimated General Effects of Deep Learning Sub-Scales and Control Variables on End-of-First-Year CAAP CTT, NCS, and PATL

	CAAP CTT		NCS		PATL	
Predictor	B	SE	B	SE	B	SE
Process-DAL						
Higher-order learning	–0.027	0.028	0.023	0.056	–0.019	0.028
Integrative learning	0.007	0.027	0.073**	0.025	0.113***	0.029
Reflective learning	0.060*	0.026	0.096***	0.015	0.069***	0.014
Presage-Student Factors						
Pre-college measure[a]	0.550***	0.032	0.599***	0.027	0.658***	0.025
Male	–0.100*	0.046	0.017	0.034	–0.089**	0.026
Caucasian	0.046	0.044	0.026	0.045	–0.059	0.041
Parental education	0.019	0.018	0.013	0.017	0.020	0.016
Tested pre-college academic preparation	0.275***	0.045	0.108***	0.024	0.082***	0.017
High school involvement	0.010	0.039	–0.003	0.020	–0.030	0.016
Pre-college academic motivation	0.000	0.017	0.059	0.014	0.032*	0.015
Presage-Teaching Context						
Attends a research university	0.043	0.067	–0.071*	0.032	–0.105**	0.033
Attends a regional institution	–0.106	0.052	–0.050	0.045	–0.069	0.036
Attends a community college	–0.203	0.149	0.165	0.082	–0.149	0.114
Lives on campus	–0.154*	0.071	0.036	0.050	–0.083	0.158
Hours of on- and off-campus work	–0.048	0.036	–0.024	0.024	0.008	0.012
Liberal arts emphasis of coursework	0.020	0.029	0.028*	0.013	0.024	0.023
R^2	.708***		.591***		.581***	

[a]Pre-college measure of CAAP CTT, NCS, and PATL, respectively.
*$p < 0.05$. **$p < 0.01$. ***$p < 0.001$.

for cognition, and positive attitude toward literacy. Consistent with previous efforts, our findings suggest that cognitive development is as nuanced as the approaches taken to spur it.

That cognitive developmental trajectories varied based on the outcome examined was expected given the theoretical essence of each and its relationship with DAL. As the DAL literature makes clear (Biggs, 2003; Ramsden, 2003), it is one's approach to a learning task that effects how and how well one learns. Though our measures of DAL likely tap a general or preferred approach, it is important to remember that they are indicative of the approaches taken in relation to the learning

tasks of college. We know from classroom studies (e.g., Chapman, 2001), when the learning task is designed to promote critical thinking skill development and DAL are emphasized, critical thinking skills are gained. Our results and those of others (Nelson Laird, Garver et al., 2008; Reason et al., 2010), which show a lack of connection between overall DAL and critical thinking skills among a general college population, suggest that college students may not be facing tasks that encourage the kind of critical thinking skills tapped by tests such as the CAAP CTT. So, if such skills are important, faculty members and others at colleges and universities need to start creating more tasks that require these skills and emphasizing a deep approach to learning those skills.

Like the overall DAL scale, integrative approaches to learning shared a significant relationship with need for cognition and positive attitude toward literacy but not with critical thinking. Perhaps, the cognitive effort needed to integrate information from varied perspectives relies more heavily on the enjoyment rather than the critical nature of learning. Perhaps the affective dimension of learning shared by students with higher needs for cognition and a more positive attitude toward literacy serves as part of an internal motivation needed to examine truth claims from a variety of perspectives, a hallmark of someone adopting an integrative approach to learning. Alternatively, these results could be an artifact of measurement similarities among the three scales; unlike the critical thinking measure, the integrative learning, need for cognition, and positive attitude toward literacy scales were all assessed using face-valid, Likert-type scales. Clearly, future research is needed to further illuminate the relationship between integrative learning and cognitive development.

Not only are the differences among cognitive outcomes of interest, but so are the similarities. It appears as though reflection is a critical component to helping students make developmental gains in the cognitive outcomes examined for this study. Although varying in degree of influence, more frequent reflection activities engendered movement across all three learning dimensions, including critical thinking, need for cognition, and positive attitude toward literacy. Theoretically, this finding is no surprise given that reflection has been a central component of learning since the beginning of discourse concerning the philosophy of education (Smith, 2001). Exemplifying this point and connecting directed reflection to cognitive gains, John Dewey (1916) noted: "Without initiation into the scientific spirit one is not in possession of the best tools humanity has so far devised for effectively directed reflection. [Without these, one] fails to understand the full meaning of knowledge" (p. 223).

Another similarity is notable for the lack of significance found between higher-order learning and each cognitive outcome. Although higher-order learning has a significant relationship with end-of-first-year NCS and PATL scores even when controlling for the pre-college measures of those outcomes (see Table 3), the unique effect of higher-order learning is near zero in each full model. Given the existence of unique effects for integrative and reflective learning on two and three of the outcomes, respectively, this suggests that the variance higher-order learning could potentially explain in the outcomes is explained by other variables, most likely the other two DAL subscales. Rather than suggesting that higher-order learning is not important, this pattern of findings suggests that emphasizing higher-order learning alone would be unwise. Faculty should be looking for ways to tie higher-order learning activities to integrative and reflective experiences, something the literature on reflective teaching has emphasized as far back as Dewey (Rodgers, 2002) and something AAC&U (2007) has been pushing recently with their emphasis on integrative learning.

An additional similarity is that the effects of DAL on each cognitive outcome were not conditional on other variables in the models. In other words, the effects of DAL were largely the same for first-year students of different racial/ethnic backgrounds, genders, levels of academic preparation, and so on. This differs from some evidence that suggests that better prepared students benefit more from DAL (Nelson Laird, Garver et al., 2008). The differences in the studies point to interesting questions that need more investigation. Nelson Laird, Garver et al.'s study was cross-sectional, done on a fairly small sample of students largely from two campuses, looked at different outcomes, and included first-year students through seniors. Our study was longitudinal, done on a much larger sample and 19 campuses, but was limited to first-year students. Do the conditional effects appear with only certain outcomes (e.g., reflective judgment and critical thinking dispositions) and not others (e.g., critical thinking skills and need for cognition)? Do the conditional effects largely appear after the first year? Or, are the findings from Nelson Laird and colleagues limited to their more specific sample? An affirmative answer to this latter question would suggest the need to better understand the characteristics of the contexts that matter. Reason et al. (2010) showed that average DAL scores at the institutional level did not explain variation in average critical thinking scores or averages on three self-reported gains. Future analyses with WNS data can help to answer some of these questions, but we encourage other researchers to look into this as well.

One simple yet consistent finding in our study is that the means for CAAP CTT, NCS, and PATL barely changed from the beginning of the first year to the end. In other words, according to our measures, the average student's critical thinking skills, engagement and enjoyment of effortful thinking, and enjoyment of various literacy activities did not change as a result of their first year of college. Such results are not uncommon in college impact research (Pascarella & Terenzini, 2005), but remind us that colleges and universities, their faculties and students can do better.

Implications

If we expect to observe cognitive gains over the course of the first-year in school, we should also expect educators to create developmentally-appropriate learning environments for first-year students. Educators need to be trained in student learning and development theory, with particular attention to how first-year students can be appropriately challenged and supported (see Sanford, 1967) as they make the transition from high school to college. Too often the curricular experiences of first-year students emphasize the latter at expense of the former, with educators more interested in using class time to put students at ease than in putting them to work, academically-speaking (see Engberg & Mayhew, 2007).

To make the cognitive gains suggested by this study, educators of first-year students need to enact practices that more frequently encourage students to examine the strengths and weaknesses of their own views, and to a lesser degree, integrate ideas from various sources, including diverse perspectives in their academic work. In short, first-year students make cognitive gains when asked to engage metacognitive processes, including reflecting on themselves and integrating diverging perspectives into a formative, working epistemology. Teaching college educators how to enact such practices that then spur the processes responsible for helping students make cognitive gains remains a challenge, as few graduate programs require courses on learning, student development, or effective pedagogy. Expecting students to learn from faculty who have not been adequately trained to teach remains a ubiquitous problem in American higher education and one underscored by findings from this study.

Yet, faculty need not feel they are without support in crafting learning environments and experiences that promote students' deep approach to learning and thus deeper learning. Increasingly colleges and univer-

sities are creating and relying on centers for teaching and learning in which the mandate typically is to assist faculty in developing pedagogical strategies to enhance student learning. To the extent that critical thinking is ubiquitously identified as a key college learning outcome, educational developers can assist faculty in creating assignments and assessments that call on students to reflect on their learning and the assumptions upon which it is based as they clarify, analyze, evaluate, and extend arguments, sometimes from one context to another (the skills assessed in the CAAP CTT). Creating centers to support faculty pedagogy is a necessary but not sufficient step if the goal of higher education is to graduate alumni who think critically and who are motivated to learn throughout their lives. Institutional policy also plays a critical role in advancing these goals. One can envision institutional policy that includes assessing faculty teaching in this regard as part of the promotion and tenure review. Given that faculty typically educate in a single department, one may also envision a place for an interdisciplinary capstone experience being developed as a matter of curricular policy to ensure deeper learning beyond disciplinary boundaries. These findings simply suggest that institutions examine their practice and policy in light of encouraging faculty to foster students' DAL and deeper learning.

Conclusion

The results of this study suggest that DAL have important effects on first-year students' need for cognition and positive attitudes toward a range of literacy activities. We also show that reflective learning had a small effect on critical thinking skills. Though small, this effect should not be over trivialized because it was found after controlling for pre-college scores on the outcome and pre-college academic ability. Further, we show that among first-year students, the effects of DAL did not vary significantly by student groups or academic ability. Though these findings are important, there is room to improve the development of critical thinking skills, need for cognition, and PATL in the first year. Such improvement will likely require designing more effective learning tasks and the deliberate connection of those tasks to DAL.

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Integration of Learning: A Grounded Theory Analysis of College Students' Learning

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This article presents a grounded theory of "integration of learning" among traditional aged college students, which is characterized by the demonstrated ability to link various skills and knowledge learned in a variety of contexts. The author analyzed 194 interviews with students at liberal arts colleges to investigate empirically the ways undergraduates bring knowledge and experiences together so that educators might be able to more intentionally promote the integration of learning. Three distinct types of integration of learning emerged during analysis: (a) connection, the discovery of a similarity between ideas that themselves remain distinctive; (b) application, the use of knowledge from one context in another; and (c) synthesis, the creation of new knowledge by combining insights.

KEYWORDS: higher education, learning, liberal arts, meaning making, grounded theory

The ability to make connections among disparate elements of information, meaningfully synthesize concepts, and make ideas mobile from one context to another has been heralded as a necessary skill for success in the knowledge economy of the 21st century (American College Personnel Association, 1994; Association of American Colleges and Universities [AAC&U], 2002, 2007; AAC&U & Carnegie Foundation, 2004; Joint Task Force on Student Learning, 1998; Keeling, 2004; U.S. Department of Labor, 1991). As access to technology grows and limitless information is literally at our fingertips, the ability to connect information has become increasingly valued in society and a crucial skill for higher education to cultivate among students.

Despite the increasing desire for college graduates to be proficient in broadly linking knowledge and skills, there is a lack of detailed information

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about the ways in which learning is integrated. That is, we do not understand the *process* of integration. To fill this gap, this study explores how traditionally aged undergraduates integrate learning; in particular, I look at the ways in which students undertake this process in their first two years of college. Thus, the intent of this study is to investigate empirically the ways in which college students bring knowledge and experiences together so that educators can better understand undergraduate student learning and more intentionally promote the integration of learning.

Integrating Concepts and Definitions

Integration of learning has received much attention as of late and is identified as a primary outcome of a college education by AAC&U and Carnegie Foundation's (2004) *Statement on Integrative Learning*: "Fostering students' abilities to integrate learning—over time, across courses, and between academic, personal, and community life—is one of the most important goals and challenges of higher education" (p. 1). However, based on a review of literature in student development, learning, and psychology, it is apparent that there is no clear description about how students undertake this process of integration.

Use of the generic term *integration* in the literature complicates studying this area of student learning because integration and related words (integrative, integrated) are used to describe the *learning process* as an educational outcome (AAC&U, 2002; Huber et al., 2007; Leskes, 2004), as well as the *educational practices*, sometimes referred to as high-impact practices, that promote this kind of learning (Kuh, 2008; Nelson Laird, Shoup, Kuh, & Schwarz, 2008). This array of descriptors and conceptualizations reflects both a terminology problem and a conceptual problem for those in higher education interested in promoting and assessing integrated learning among college students. In short, the *practices* facilitate the *process*. The sort of practices described as integrative (e.g., working on a paper/project that requires drawing on multiple sources, taking an interdisciplinary studies course, or participating in a service learning initiative) may facilitate integration of learning, but they do not describe an individual's learning process per se.

Interdisciplinarity is another term often conflated with integration. Interdisciplinarity is a subset of integrative educational practices that fosters connections among disciplines and interdisciplinary fields (Klein, 2005) and that may lead a student to the process of integration. Boix Mansilla (2005) has comprehensively explored the characteristics of interdisciplinary work and proposed the following definition of *interdisciplinary understanding*:

> the capacity to integrate knowledge and modes of thinking drawn from two or more disciplines to produce a cognitive advancement—for example, explaining a phenomenon, solving a problem, creating

> a product, or raising a new question—in ways that would have been unlikely through single disciplinary means. (p. 16)

Boix Mansilla and colleagues used this definition of interdisciplinary understanding to develop an empirically grounded assessment of interdisciplinary work (Boix Mansilla & Dawes Duraisingh, 2007; Boix Mansilla, Dawes Duraisingh, Wolfe, & Haynes, 2009). My conceptualization of integration of learning is broader in scope than interdisciplinarity itself, extending beyond academe and traditional disciplinary boundaries to encompass multiple contexts, life experiences, and identity roles.

Cognitive developmental theory also informs the conceptualization of integration of learning. Bloom's (1956) taxonomy of educational objectives is useful for considering the *process* of learning and envisioning learning as a hierarchy of increasingly sophisticated ways of thinking. Fischer's (1980) skill theory presented a framework for understanding the increasing cognitive complexity indicative of integration of learning. This theory posited that as people develop into adulthood, they have an escalating number of ways to make connections among the discrete facts that compose their knowledge base and lived experience.

Just as there are a number of routes for connections within Fischer's theory as the level of abstraction increases, there are multiple potential pathways to integration of learning. King and VanHecke (2006) applied Fischer's skill theory to student development and clarified that "cocurricular as well as curricular learning contexts offer many rich opportunities for students to learn and practice skills associated with making connections . . . developing these skills improves students' capacity to function in a complex world" (p. 16). This statement emphasizes the point that the study of integration of learning should consider student experiences broadly, investigating learning within the disciplines (Schwartz & Fischer, 2006) and among disciplines (interdisciplinary), as well as with a keen interest in the cocurriculum and experiences wholly outside of academe (intercontextual).

Integration of Learning Defined

The current article is concerned with examining integration of learning as an educational outcome, specifically focusing on the process (i.e., the *how*) of integration of learning, opposed to the content (i.e., the *what*) being learned. I see the capacity to undertake this process successfully as a critical outcome of undergraduate education. This outcome includes the ability to integrate one's learning into both a larger framework and a frame of reference for making meaning from the information and knowledge one possesses. The definition I created for integration of learning takes into consideration various definitions discovered in a review of the literature; it

has been developed and refined as a result of the analyses described in this article:

> Integration of learning is the demonstrated ability to connect, apply, and/or synthesize information coherently from disparate contexts and perspectives, and make use of these new insights in multiple contexts. This includes the ability to connect the domain of ideas and philosophies to the everyday experience, from one field of study or discipline to another, from the past to the present, between campus and community life, from one part to the whole, from the abstract to the concrete, among multiple identity roles—and vice versa.

My definition is intentionally broad in terms of context to allow for consideration of experiences not traditionally linked to the formal curriculum, for example, work experience, family life, and living situation. The growing interest in integration of learning among college students and the lack of a shared definition of terms underscore the current need for a more detailed investigation of the ways in which learning is integrated. To this end, the ideas of *transfer of learning* and *experiential learning* have been beneficial in building a conceptual framework for exploring integration of learning.

Conceptual Framework

The conceptual framework for this study is anchored in the literature describing individual learning, which has an established foundation of theory, research, and practice that is robust enough to provide theoretical support for an in-depth inquiry into the development of integration of learning (Bruner, 1960; Dewey, 1938; Judd, 1939; Thorndike, 1924). The transfer of learning literature provides a rich source for a discussion of how knowledge becomes mobile, which is an important component of integration of learning. Experiential learning offers a strong knowledge base about the contexts and conditions that facilitate learning, including both formal and informal educational environments.

Transfer of learning. Transfer of learning as a body of knowledge is concerned with how individuals think about ideas, beliefs, and information; it is centered on how people know and apply knowledge (Perkins & Salomon, 1988, 1992; Tuomi-Gröhn & Engeström, 2003). Transfer theory contributes a sense of *how* individuals mobilize knowledge and is a useful lens for studying the development of integration of learning among college students. The current understandings of cognitive and learning processes are the result of over a century of research and theorizing on how, why, where, and when a transfer of learning takes place. There are two main classical theories of transfer, the first of which is Thorndike's (1924) concept of *identical elements*. Thorndike concluded the ability to transfer learning depended not

on learning specific subjects but rather on the presence of identical elements in two situations.

Judd (1939) disagreed with Thorndike's theory of identical elements and posited that understanding the *general principles* of subject matter was most important (rather than the specific context or task); this concept of general principles is the second major classical theory of transfer. The shift to a focus on general principles rather than discrete details introduced a new way of thinking about teaching and learning that privileged conceptual learning over memorizing pieces of information. These seminal ideas are critical to the conceptualization of integration of learning and paved the way for more recent theories about transfer of learning, which explore in more depth issues of how influential the environment is on individuals' cognition and ability to transfer learning. Such concepts set the stage for the more recent discussion of a transition from an instruction paradigm to a learning paradigm in American higher education (Barr & Tagg, 1995).

Perkins and Salomon (1988, 1992) categorized transfer into two dichotomies, positive and negative, and near and far. Positive transfer occurs when learning in one situation improves learning in another. For example, learning a new language such as French might help a student to learn another similar language, such as Spanish. Negative transfer occurs when learning in one area inhibits learning in another. To continue with the language acquisition example, a native Mandarin speaker might initially engage in negative transfer when learning German due to assumptions about grammar, pronunciation, or syntax, creating a challenge to learning (Perkins & Salomon, 1992). Near transfer refers to mobility of learning between similar contexts (suggesting a contextual version of Thorndike's *identical elements* concept), while far transfer involves larger, often more abstract leaps between situations.

Experiential learning. Many scholars explored the role of context and experience in learning during the 20th century (Bruner, 1960; Dewey, 1916, 1938; Kolb, 1984), investigating learning in both formal and informal settings. Dewey's (1938) theory of experience argued that students' past experiences, including those outside of the formal educational environment, figure prominently in the learning process. This key perspective fits well with 21st-century approaches to holistic education and supports the broad contextual view I put forward in my definition of integration of learning above.

The notion that experience plays an important role in learning complements the findings of the transfer literature; both areas of research are deeply rooted in the interaction of individual and context captured in Lewin's (1936) assertion that behavior is a function of the interaction between person and environment. Bruner (1960) captured the relationship between transfer and experience in *The Process of Education*, explaining,

> The teaching and learning of structure, rather than simply the mastery of facts and techniques, is at the center of the classic problem of

> transfer. . . . If earlier learning is to render later learning easier, it must do so by providing a general picture in terms of which the relations between things encountered earlier and later are made as clear as possible. (p. 12)

Bruner's suggestion for scaffolding learning aligns closely with Perkins and Salomon's (1988) model of teaching for transfer.

Ideas about the role of experience in the learning process such as those advanced by Lewin, Dewey, and Bruner underlie many modern approaches to learning in American higher education (e.g., service learning, living learning communities, study abroad/away) and hold great relevance for inquiry into college students' integration of learning (Eyler & Giles, 1994; Rowan-Kenyon, Soldner, & Inkelas, 2007). Despite the significant contributions of scholars in the domains of transfer theory and experiential learning, existing conceptualizations are not sufficient to fully understand the process of integration of learning among college students. As such, it is necessary to engage in theory building to advance the discussion and scholarship about integration as a collegiate outcome.

Method

The following analysis of college student learning is rooted in a constructivist paradigm using grounded theory methodology and is shaped by the epistemological belief that individuals make meaning of their experiences differently, and therefore construct their own unique perspectives of the world.[1] In terms of axiology, an authentic respect for individuals' viewpoints and the personal meaning that they make from their accumulated experiences factors prominently in my investigation of integration of learning, and I positioned the students as co-constructors of the research. Using a grounded theory approach, the researcher does not attempt to be objective in the analysis, but rather surfaces his or her personal assumptions and biases in an effort to manage subjectivities. As such, I immersed myself in the analytical process and played an active role in theory construction (Strauss & Corbin, 1998). The outcome of this analysis is a perspective on student learning that emerged from nearly 300 hours of conversations with college students and is firmly grounded in the experiences of the participants in the study.

The data for this analysis originated from the Wabash National Study of Liberal Arts Education (hereafter, WNS). The WNS employed a longitudinal mixed-methods design in which two types of data (surveys and interviews) were collected for investigating related but separate research questions; this article focuses on findings from the interview data. Participating institutions were chosen using a two-step process. Initially, 19 colleges and universities were selected from more than 60 institutions responding to a national invitation to join the study; selection criteria included a commitment to and

success implementing practices of liberal arts education. These institutions were also selected to create a national sample that included a variety of institutional types, sizes, and locations. Students from these campuses were randomly selected to participate in the survey portion of the study. In the second step, six colleges and universities were selected from the survey campuses to also participate in the in-depth interview portion of the study. I was a member of the research team that selected the campuses for the interview sample and subsequently collected and analyzed data.

Data Collection

Interview participants were selected from the students at these six institutions who completed the quantitative survey component of the study and also indicated interest in participating in a one-on-one interview about their experiences while in college, oversampling men and students of color to yield a more balanced distribution. Students were offered compensation of $30 for participation in each interview.

These steps yielded a sample of 315 first-year students who were interviewed in the fall of 2006 (hereafter, Year 1). About one third of these students identified as students of color (African American/Black, Hispanic, or Asian/Pacific Islanders); the remainder identified as White. About 10% were born in countries other than the United States. Researchers were able to contact and reinterview 228 of these students in the fall of 2007 (Year 2). The interviews were 60 to 90 minutes in length, recorded digitally, and transcribed verbatim. Students were offered a copy of each year's interview transcript and invited to make corrections, fill in words that were inaudible, and offer comments or additional insights after receiving the transcript.

The interview protocol used for this study was Baxter Magolda and King's (2007) WNS Interview, which was designed to yield information about important student experiences and how students make meaning of them. The WNS Interview is composed of three sections. The first is designed to establish rapport between the interviewer and the student and collect basic background information about the student (e.g., hometown, information about family, intended major). The second seeks to access the student's process for meaning making through asking questions about significant experiences and challenging decisions for the student that reveal how he or she thought about and interpreted the experiences. The third and final section of the interview is specifically targeted toward synthesis of information and the assessment of integration of learning as a liberal arts outcome. However, examples of integration of learning may appear at any point in the interview due to the conversational and semistructured design.

The interview data were well suited to the study of a complex process such as integration of learning, which is one of seven liberal arts outcomes of interest in the overarching WNS (King, Kendall Brown, Lindsay, &

VanHecke, 2007). The richness of the data gained from longitudinal personal interviews lends itself well to the type of in-depth analysis necessary to explore the process of integration of learning. For purposes of learning about how students integrate learning, the semistructured interview allowed the student to discuss how he or she put things together (as opposed to a course assignment that is more likely to be instructor driven) and, in some cases, provided a context for students to integrate learning in situ. In addition, in-depth constructivist interviews are effective in assessing the complex meaning making indicative of integration of learning (Baxter Magolda, 2001; Baxter Magolda & King, 2007; Berger, 2010; Kegan, 1994).

Two of the six campuses were selected for the in-depth investigation into integration of learning that is the focus of this article, Hudson College (pseudonym) and Wabash College (actual name). I chose these two campuses for this specific analysis based on the richness of the data from student interviews and because these sites offered a variety of experiences in both curricular and cocurricular settings that are intentionally designed to promote integration of learning. Selecting campuses with established programs to facilitate integration of learning was of the utmost importance because the study was concerned with *how* students integrate learning (as opposed to *whether* students integrate learning). As such, it was vital to select campuses with a strong likelihood of providing examples of integration of learning.

The data from these two campuses are composed of 194 longitudinal interviews (n = 97 individuals) for this study. This sample included 45 students from Hudson College (30 women and 15 men) and 52 students from Wabash College (all-male institution). Students of color accounted for 19% students in the sample (n = 18). I visited both campuses and personally conducted 28 of the 194 interviews. Classroom observations at Wabash College were used to add context to the student narratives. The following section provides brief profiles of these two campuses.

Campus Contexts

Hudson College. This institution is a small, private liberal arts college in the eastern United States situated in a rural town. The institution prides itself as a residential liberal arts college, and 85% of its 2,000 students live on campus. At the time of the study, the racial/ethnic demographics of the undergraduate population were approximately 69% White, 14% students of color, and 8.5% international students, with 8.5% of the students not identifying race or ethnicity. Hudson College has two academic programs that are of interest to my study of integration of learning: the Liberal Arts Workshop and the Freshman Symposium. The Liberal Arts Workshop is an intentionally integrative program in which students participate for the three weeks immediately preceding their first year in college. The aims of this program are for students to learn to read and listen more thoughtfully, to express ideas, to review their

own work critically, and to recognize the link between thinking and expressing. The curriculum of this program culminates in a written assignment that a student must pass in order to matriculate. Upon matriculating to the college, all students must enroll in Freshman Symposium. This is a two-semester sequence focused on what the college considers the important cultural and intellectual ideas that form a basis for liberal arts education.

Wabash College. Wabash College is an all-male private liberal arts college in the rural Midwest. There are currently 900 students enrolled, most of which (86.7%) live on campus in one of four residence halls or 10 fraternity houses. At the time of the study, the racial/ethnic demographics of the undergraduate population were 80% White, 13% students of color, and 5% international students, with 2% of the students not identifying race or ethnicity. A program at Wabash that is of interest in terms of integration of learning is the Freshman Tutorial, which all students take either first or second semester during their first year. Each section of the Freshman Tutorial enrolls approximately 15 students. The main objective of the Wabash Freshman Tutorial is to give students the skills they need to be critical thinkers, successful in a discussion-based seminar environment, and well prepared for the intensity of college writing. This course is followed in the second year with a two-semester sequence on classic world texts, Cultures and Traditions, a requirement for all sophomores.

Data Analysis

Based on the nature of my question, that is, learning about the *ways* in which students begin to bring together information, I used grounded theory methodology to analyze the data. I found grounded theory best suited to this study of integration of learning because of the flexibility it allows in analyzing and conceptualizing the data. Since there is not an existing model delineating the process of integration of learning for college students, it was necessary to develop theory. I wanted to allow the ways in which students integrate learning (or fail to do so), what learning they integrate, and how they make meaning of that process to emerge from the data rather than to establish a priori the steps of this learning process.

Data reduction began with what Strauss and Corbin (1998) called microanalysis, "the detailed line-by-line analysis necessary at the beginning of a study to generate initial categories (with their properties and dimensions) and to suggest relationships among categories" (p. 57). To operationalize this overall plan for examining the data, I organized my analytical process into four basic steps (Charmaz, 2006; Glaser & Strauss, 1967): initial coding, ongoing memoing, and focused and axial coding. In utilizing the constant comparison process recommended in grounded theory (Charmaz, 2006; Glaser & Strauss, 1967), categorization was a fluid process, and categories were merged or broken apart as needed as the analysis progressed.

Trustworthiness

To bolster the trustworthiness of my work, I recruited a peer debriefer, who played an invaluable role in the analytical process. Her role was to review my coding as I went along, providing a check against personal biases, and to aid with consistency and reliability throughout the coding process. I encouraged her to challenge me to acknowledge my sensitizing concepts as they may influence my work. She reviewed the initial coding of 48 interviews (25%) as well as over 20% of the examples of integration of learning identified across all 194 interviews. We met in person to discuss the similarities and differences in our coding, and any discrepancies were debated and resolved during each meeting. The peer debriefer's memos and all notes from our meetings were added to the file for each interview we discussed to maintain a complete record of analysis.

Sensitizing Concepts and Subjectivities

As I consider the issues surrounding integration of learning among college students, I also consider what draws me to this topic as a researcher. Within the qualitative research tradition, it is important to discuss the personal assumptions and biases that I bring to the study. As the researcher, I am intimately involved in the interpretation of the data I analyze in this study. As such, it is relevant to disclose my own background and the sensitizing concepts that accompany me in my inquiry.

I once worked as an administrator at a liberal arts college, so the environment of a private liberal arts institution was familiar to me, albeit not my personal education experience. I attended public institutions of higher education for all of my postsecondary study, though my undergraduate institution prides itself on offering a liberal arts education. For many years I was a student affairs practitioner, and I have a strong belief that learning takes place both inside and outside of the classroom. This is one reason I am drawn to the concept of integration of learning, I see it as essential for college students to integrate learning from the formal curriculum with the learning they are doing at home, at work, with family and friends, through student organizations, and so on. These are my lenses. Each of these characteristics, and certainly others, affects the ways I interact with college students and interpret their narratives.

Findings

I was initially concerned that there might not be a wealth of data contained in the interviews related to integration of learning as an educational outcome, given the burgeoning literature stressing a need for more integration of learning among undergraduates. However, I was met with quite a different situation. The initial line-by-line read of the 194 interviews yielded 662

examples of integration of learning. The pool was deep as well as wide; the information present in the interviews provided rich descriptions of the many ways that students experienced integration of learning in their first year of college.

In the categorization phase of data analysis, all 662 examples were reviewed in greater detail. Under increased scrutiny, some examples were deemed not to illustrate integration of learning and excluded from further analysis. This resulted in a total of 577 examples; 484 of these were categorized into one category alone, with the other 93 examples (16%) categorized in multiple categories.

Categories of Integration

Three main categories emerged from the data during the analysis, which I see as distinct in their complexity. Arranging the categories in order of increasing cognitive complexity aligns with prominent models of intellectual and personal development, including Bloom's (1956) taxonomy, Perry's (1970) scheme of intellectual and ethical development, the reflective judgment model (King & Kitchener, 1994), and self-authorship theory (Baxter Magolda, 2001, 2009; Kegan, 1994). Therefore, I consider degree of complexity a logical way to organize the emergent categories of integration: (a) *Establishing a Connection* (n = 172), the discovery of a similarity or common bond between ideas or skills which themselves remain distinctive; (b) *Application Across Contexts* (n = 296), the use of knowledge or skills from one context in another; and (c) *Synthesis of a New Whole* (n = 201), the creation of new knowledge or understanding by combining two or more insights.

Connection is a relationship between two things, often at a single point in time in a single context; this can be as straightforward as recognizing a similarity between two ideas. By contrast, *application* is an action on the student's part to make use of knowledge in a new context; this requires a greater degree of complexity on the student's behalf than recognizing or establishing a connection. Last, *synthesis* is an evolution into something new, the student's creation of a new insight; this construction of a novel concept entails an even deeper involvement with the information, experiences, or skills. Table 1 provides more detailed definitions of each category; common student language associated with each category is also listed. Figure 1 illustrates the frequency of integration of learning (delineated by category) in Years 1 and 2 of the study.

In the following sections, I illustrate each category with excerpts from student interviews. I limited the number of examples due to space considerations and have chosen the most clear and concise passages. The demographics of the students quoted are not intended to characterize the categories as a whole; men and women and students of a variety of races and ethnicities were represented in each category.

Table 1
Definitions of Integration of Learning Categories

Category	Definition	Common Student Language
Establishing a Connection	Find a common thread between concepts or experiences that remain distinct; identifying similar elements, foundation, or characteristics.	*Compare, compare and contrast, connect, relate, use of analogy, something is like something else*
Application Across Contexts	An idea or skill learned in one context is used in a different context; similar conceptually to transfer of learning. Often appears as use of a high school skill or knowledge in college.	*Apply, use, transfer*
Synthesis of a New Whole	Two or more ideas or skills are brought together to create a new whole; combining knowledge to enhance understanding and gain new insights.	*Incorporate, adapt, collaborate, put together, interpret, bounce ideas off one another*

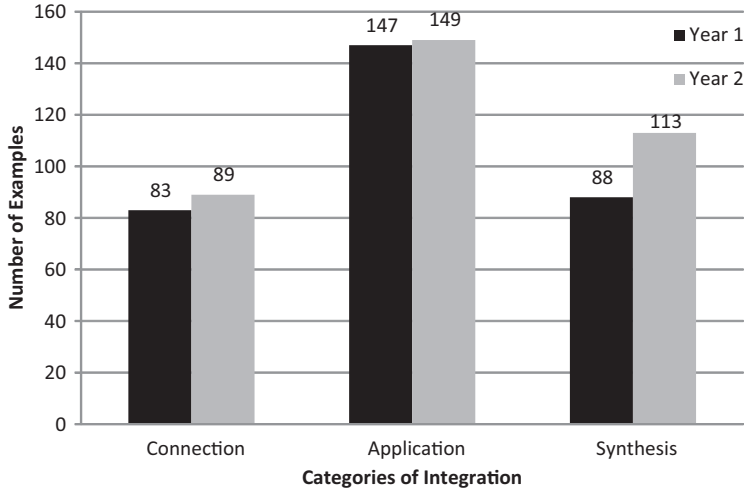

Figure 1. **Distribution of integration of learning examples by category and year.**

The longitudinal data examined in this analysis support that there is a developmental process at work in relation to integration of learning, meaning that it evolves over time. Due to space considerations, I chose to focus

on identifying the types of integration of learning in this article; future analyses will explore the development of students' integration over time.

Category 1: Establishing a Connection The first category of integration of learning involves identifying a similarity or common thread between ideas, skills, or pieces of information. In this type of integration, a student finds that two or more ideas have a common element. Students recognize that a novel concept is similar to something well known, one skill relates to another, or a new text illustrates a familiar point.

Experiences within the Establishing a Connection category were most often in the realm of ideas, such as making a connection mentally between ideas or pieces of information. Connections can be literal in nature or more abstract. Below, Aisling and Fran offer examples that illustrate the types of experiences that compose the Connection category of integration of learning.[2]

Aisling, a White woman in her sophomore interview at Hudson College, talked about an experience of connecting information in the moment, within a relatively brief time frame. Her example described a connection that happened among several classes she was taking concurrently. She said,

> Sometimes there are classes that weave together but it's always very short periods of time. It doesn't work out in the whole two-month, three-month-type nice, continuous, sameness way. It's more the points of contact and radiating out in different directions rather than constantly being, constantly contacting and constantly linking. It's more like one point and then they each go different ways.

For Aisling, although she saw her classes weaving together, she viewed the connections she made in her academic experiences as temporary, fleeting, and local. She made connections among courses she took in the same semester, but not from one semester to another. Her description of the connections suggests a coincidental nature to the similarities that was not planned or sought after on the part of the faculty or the student.

By contrast, Fran, in her first year at Hudson College, described connections that spanned long periods of time, and bridged in-class and out-of-class experiences. In this excerpt, Fran talked about integrating learning by making connections among her courses as well as with her past experience living abroad as an exchange student in high school. She explained,

> Just connecting two things in my classes that supposedly would have nothing to do with each other. Like my literature class, that Freshman Symposium, what this essay's for, and we're reading Plato right now, and I'm taking another class called Race and Ethnicity in Brazil, and with this one thing we're talking about Plato and . . . how we use all these things with eugenics. Well, it just so happens that we just finished a book that had a section on that and now I'm able to connect that like, "Oh, I can see how we got the idea from this and now I can write about them both in my paper." It's just I never thought about that. Who would've thought Plato, and I could connect those—I

> don't know. That's what I'm saying, the classes can go together, which I thought they were so unrelated, but they're not.

Fran is White and spent a year in high school as an exchange student in Brazil, where she became fluent in Portuguese; she was able to bring these experiences to the conversation about race and ethnicity as well.

In this instance, Fran connected several experiences, studying Plato in two different classes (in two semesters) as well as connecting her class on Brazil to her experience living there as an exchange student. She readily spoke about these connections when prompted but did not indicate that she actively made contributions to the class discussion that allowed others to hear about the connections she was making.

Both of the students who illustrate connections have established a mental link between ideas or skills. Some links are small steps akin to near transfer discussed in the transfer of learning literature (i.e., transfer between closely related contexts; Perkins & Salomon, 1992), such as Aisling's observations about the fleeting similarities of ideas within a single semester's courses. Other connections are more complex, such as Fran's comparison of distinct international contexts. The defining characteristic of the Connection category of integration of learning is the establishment of a link that associates two or more ideas in a student's mind.

Category 2: Application Across Contexts The largest and most concrete category of integration of learning experiences focuses on application. Although the experiences described in the Connection category above are most often mental links among concepts, the examples in the Application category carry the connotation of action (i.e., the student is applying an idea or skill). In this category, students described experiences where they used one idea or skill elsewhere in both formal and informal contexts, both in and out of the classroom. This group of examples is aligned closely with the transfer of learning literature. Sometimes this application was in the realm of ideas, using concepts learned in one class to inform study in another. Other times, the application was literally more hands-on, for example applying woodworking skills learned at home to construction of the fraternity homecoming float.

Elliott and Braxton each provide a rich example to bring this category to life. Elliott was a first year student at Wabash College when he talked about integration of learning outside of classroom contexts. He is a White student, who attended small Catholic schools for all of his education prior to college. In this excerpt from his interview, he shared how his previous interests and skills acquired at home had been put to use in building a homecoming float in college. His father worked in construction, and Elliott often helped him with construction projects around the family home. Elliott realized that he was good with his hands, and when asked about his initial awareness that he was talented in building things, he explained,

> I can't put my finger on a first memory, but I've always liked to do puzzles. I've always liked, not just pieces of puzzles in general, but mind puzzles. I don't know if you are familiar with the Sudokus, in the newspaper. I thoroughly enjoy doing those. I really like those a lot so it kind of transfers over into thinking of the many different things that can go on a piece of paper. Different ways the float could have been constructed.

Elliott later made the application across contexts more explicit, stating, "I've done things like that [designing and constructing the float] in the past, so it can also go back to my past experiences knowing what I've done in similar situations and applying them to the now."

By contrast, in his first year at Hudson College, Braxton talked about a more abstract type of application, applying an idea rather than a skill. Braxton is a White, first-generation American and received a scholarship to attend Hudson. In the following passage, he described a time when he applied a concept learned in one class (Liberal Arts Workshop) to a different context.

> What the teacher said and what I keep repeating whenever I usually write, is that what you write and what you produce isn't you, it's just what you produce. So, he'd say, it may reflect certain aspects of you, but it's not you and you can't be judged upon it because of it. . . . It allowed me, at least, more free[dom] in my writing because I didn't put as much pressure on it to be a representative of me, of my mind. . . . When I'm writing or when I'm making a sculpture or when I'm on Facebook . . . that's one of the things he [the professor] said, "Always keep in mind that what you make in your Facebook is not you. It's just a picture of you. . . . It's not you, it's just a tool." He said to always keep that in mind with everyone else's profile you look at too.

Braxton discussed applying a concept he learned from a professor (the idea that what he writes does not define him) to his writing in nonclassroom environments such as Facebook, and also to other forms of expression such as sculpting. Braxton's story is unusual in this data set because of the direct involvement of a faculty member. Very few of the examples of integration of learning I found in this analysis noted faculty/staff as mentors.

These two students integrated learning in a manner that indicated an application of knowledge from one context to another. Elliott demonstrated that application is not limited to the academic arena, as he used his love of Sudoku and previous experience learning carpentry from his dad to assist with the construction of his fraternity's float for homecoming. Braxton's example of applying a concept learned in class to other academic and non-academic contexts illustrates a more abstract variety of application in that it he took a way of thinking about writing and applied it to sculpting and social networking on Facebook. Elliott and Braxton's experiences demonstrate that

application can involve both in-class and out-of-class contexts. Taken together, these examples demonstrate two main characteristics of the Application category of integration, the mobility of knowledge across contexts, and the active role of the student in this mobility.

The mobility of knowledge across contexts is also a key link to the transfer of learning literature. The concepts of transfer of learning are concentrated in the Application category and hold much more relevance with this group of examples than with those of Connection or Synthesis, in large part because of the practical (i.e., applied) nature of transfer of learning.

Category 3: Synthesis of a New Whole. The third category of integration of learning experiences is Synthesis of a New Whole. This group of experiences is the least concrete and includes instances when two or more ideas come together to form a new idea or concept. It is different from Application, which centers on the utilization of knowledge or skill from one context to another, and is also set apart from Connection, which describes finding a similarity between two or more items that remain distinct. Synthesis is at its foundation a process of constructing new understanding or skills. In the following excerpts, Colin and Tom provide examples of synthesis as a means of integrating learning.

Colin is a White student from rural Indiana. In his sophomore interview at Wabash, he talked about bringing together his education in a Christian school that taught intelligent design and the perspectives he was gaining in college biology courses that taught evolution. When asked about how he processed different opinions he encountered in his classes, Colin replied,

> I take them [different opinions] all in and chew on them and then go to through the digestive process, mentally check it against what I think or thought and how I kind of add this to my ideas and subtract some of the stuff and then combine it all. Kind of getting what I feel is the best of everything.

Colin provided a vivid description of his synthesis process in this example. He talked about the "digestive process" of comparing new information to his previously held views and deciding what to add in, what to subtract, and how to reconcile divergent beliefs. There are also other elements of integration of learning noticeable in Colin's response. He later noted that the new classes that he was taking in college allowed him to compare and contrast different religious and scientific ideas and ultimately synthesize them into his own belief system, in effect creating a new belief system, a "new whole" composed of familiar concepts and new insights. Boix Mansilla (2005) used the term *integrative leverage* to describe synthesizing perspectives to create "a new and preferred understanding" that would not have been possible with a single lens (p. 19). Colin's example also fits into the Connection category because he makes a connection between the concepts

of intelligent design and evolution, compares and contrasts them, and then takes his thinking further in order to synthesize them.

In Tom's sophomore interview at Hudson, he discussed what I call the collaborative nature of synthesis, where ideas are combined through group process rather than by an individual. Tom is White and grew up in a suburban environment. He enjoyed the discussion-based classes at Hudson and described how the act of engaging in a discussion could lead to new understanding. He reflected,

> . . . [T]he courses are run, in large part, as sort of like a guided discussion, so to really take part in the course you have to contribute. But in that act of contributing, it becomes a much more active engagement, at least for me, when I'm having to just talk about what I think about something, and then as I'm talking the thought sort of folds out on itself and it leads somewhere and it doesn't lead somewhere unless somebody else picks it up and takes it somewhere. It works really well to get into understanding and to go about it that way.

Tom's description indicated the importance of dialogue in synthesizing knowledge and in the integration of learning process broadly. His description of the thought folding out on itself is an illustration of meaning making in action in the course of the discussion. He also noted that this process happens in interaction with other students; it is a collaborative process. In his explanation, in order for the thought to lead somewhere, somebody else must pick it up, and the result was a greater understanding.

The central characteristic of the examples in the Synthesis category is the fusion of two or more ideas, perspectives, or items to form a new view. This creative form of integration goes beyond the link established in the Connection category and is also distinct from the examples reported in the Application category. In the act of synthesis, there is a creation of something greater than the sum of its parts. Colin highlighted the role of evaluation in synthesis and talked about how he decided which ideas to integrate and in what way they were synthesized, and Tom talked about how this process unfolded in classroom discussions, where individual perspectives come together to form shared understandings. The examples from both Colin and Tom are indicative of a more abstract form of integration, more similar to high-road transfer of learning than to low-road variety (Perkins & Salomon, 1992).

Discussion

In this section, I discuss the relationship of integration of learning to the models of transfer and experiential learning introduced as the conceptual framework. I explore the implications of context and introduce the idea of intercontextuality as a hallmark of integration of learning. To conclude the

article, I offer several detailed recommendations for practice and ongoing research based on my findings and revisit the definition I developed for integration of learning.

Relation to Transfer and Experiential Learning

The conceptual lens of transfer of learning was a useful in the initial stage of considering what processes might underlie integration of learning. Its rich history and the manner in which the literature tries to explain how information or concepts learned in one context can be moved or applied to another context were valuable. This focus on mobility and application resonated with the notion of integrating learning and ideas. However, the transfer of learning research is not sufficient to characterize integration of learning. Despite the similar terminology, I make a distinction between *transfer of learning* and *integration of learning* as follows: Transfer of learning is applying the skills and knowledge from one context to another, while integration of learning is a more complex, iterative phenomenon than transfer.

Similarly, the established literature related to experiential learning was helpful in thinking about integration of learning, but not sufficient to describe the concept completely. I find the main tenets of Dewey's work to be very relevant to today's student learning, nearly 75 years after his original writing. He explained that many of the educational benefits of experience are lost when the learning is not connected: "Each experience may be lively, vivid, and 'interesting,' and yet their disconnectedness may generate dispersive, disintegrated, centrifugal habits" (Dewey, 1938, p. 14). The environment of many 21st-century college students in the United States is much more complex than the world that the early experiential learning theorists knew. Student demographic data indicate that just under half of students take classes at more than one institution while earning the bachelor's degree (Peter & Forrest Cataldi, 2005). Nearly 75% of undergraduate students are employed part- or full-time while attending college (Horn & Nevill, 2006). Students today move between contexts frequently and easily; how do we, as educators, structure our work to promote integration of learning given this often dispersive landscape?

Intercontextual Nature of Integration

For college students, the majority of life's day-to-day activities, problems, and choices are neither disciplinary nor interdisciplinary. The world is more complex than that and rarely organized into orderly disciplines. Ours is an arguably intercontextual world in which daily life spills over many disciplines and contexts simultaneously. The data in this study illustrate the wide variety of contexts in which integration of learning happens—in classroom discussions, at work, in the residence hall or fraternity/sorority house, and even in online virtual spaces, just to name a few. As educators interested in

promoting integration of learning for college students, we are missing untold opportunities for learning if we are focused only on the classroom and curricular contexts. Although the contexts of integration were not a focus of this analysis, I would be remiss not to point out a compelling finding, that integration of learning was by no means limited to academic content or settings. For many students in this study, out-of-the-classroom experiences were vitally important to integration of learning.

Based on the data in this study, I conclude that students' experiences on college and university campuses are much more related and fluid than our organizational charts might suggest. The stories from students indicate that it is in fact *the students* who are bridging boundaries to integrate learning, often unaided by a mentor or guide. Braxton's example in the Application section, of responding directly to feedback from an adult, is not typical of the data in this study. More often, students described turning to peers when seeking advice.

Despite the pleas for more and better integration and critiques that integrative programs may involve only a select few students on a campus (AAC&U & Carnegie Foundation, 2004; Huber et al., 2007), the data from the WNS demonstrated a surprisingly great amount of integration of learning (often outside of those programs developed by institutions to promote integration). These data lead me to believe that integration of learning is happening much more often than many educators may realize and frequently without the support of faculty or staff. This lack of involvement and feedback from adults (in academic affairs, student affairs, or outside of the university entirely) was surprising and represents an opportunity for educators to facilitate integration of learning more intentionally. This point was highlighted on several occasions when the interview itself appeared to be the context for integration.

Importance of the interview as intervention. In several cases, it became clear that a student was integrating "in the moment" during the interview. In these instances, it appeared integration of learning was sparked by the interview questions, in particular the probing follow-up questions typical of semistructured interview protocols. I interpret this as evidence regarding the role of reflection as an important tool for integration; the interview is indeed a context that intentionally tries to promote reflection among the participants. For example, Kayla expressed one of these moments of discovery promoted by the interview in her sophomore interview at Hudson College. Kayla is an international student of East Asian descent, although her family has lived in India for more than a decade. Here, she reflects on the impact of an ongoing community service project working with children:

> Kayla: . . . I feel being a good student, you also have to be very involved with your community because essentially the purpose of your education is to become I think a productive individual. And just with books you cannot, I mean even if you're a stellar academic student, if you don't have the people skills, if you haven't

> learned how to work with people in need, if you're not a good leader, you are not a whole productive individual.
> Interviewer: How did you develop these ideas? Where did they come from? . . .
> Kayla: I think it's been, I think this is the first I've articulated whatever I felt. . . . This is the first time I actually put [these ideas] into words. . . . It feels good now. I can tell this to other people [chuckle]. It's out now.

Kayla has a difficult time responding to the questions "How did you develop these ideas?" and "Where did they come from?" referring to her ideas about community involvement and outreach. Although she says she has been thinking about these ideas for some time, it was not until the interview that she transformed her ideas into words. This example of integration of learning, a synthesis of her academic work and community outreach, is in part a result of Kayla's conversation with the interviewer. Conversation about what is important to the student and how she is thinking about her college life created a context for reflection and ultimately integration (Baxter Magolda & King, 2007).

Limitations

This study of integration of learning is based on students on only two campuses, and specific types of campuses at that. The findings should not be generalized for all college students or institutions. Both Hudson College and Wabash College are small, private liberal arts colleges in rural settings. Both had intentionally integrative programs for first year students established at their institutions (Liberal Arts Seminar and Freshman Symposium at Hudson; First-Year Tutorial courses and Culture and Traditions sequence at Wabash), and both were selected for the larger WNS based on interest in and programs on liberal arts education.

Working with a large-scale, complex project such as the WNS brings both benefits and limitations. This situation increased the amount of data I could include in this analysis, but also increased the opportunity for inconsistencies in data collection and analysis. Although such inconsistencies are inevitable, systematic review of a random selection of the analyzed data served to minimize areas of discrepancy and maintain high quality in both data collection and analysis.

The gender balance in the sample was skewed toward men in part because Wabash is an all-male institution. This two to one ratio of men to women in the sample (30 women, 67 men) may have played a role in the findings. Although gender was not an area of interest in my research question, the predominately male sample may have affected the outcome as it is not representative of the current college student population: 57.3% women, 42.7% men (Knapp, Kelly-Reid, & Ginder, 2011).

Last, the similar ages of students in the sample (all were traditionally aged first year college students, 18 to 20 years old) may also have limited the types of integration I observed in the interviews and thus limited the

number of categories. It is to be expected that students early in college have less complex ways of thinking than more advanced students (Baxter Magolda, 1999; Kegan, 1994).

Implications for Practice

A central implication of my research for practice is an awareness of the components of integration of learning. I encourage colleagues in all areas of higher education to consider ways in which they might intentionally create new opportunities both in and out of the classroom that will promote integration for students and become involved in some of the integration of learning that students are already doing. The concept of integration of learning also holds promise and utility for assessment and accreditation. Systematically investigating and documenting how students on our campuses are integrating learning will not only illuminate areas where student learning is exceptional but also guide curricular design to promote integration further.

The next logical step is to operationalize these recommendations and determine how to create scaffolding that promotes integration of learning for college students. As demonstrated in this study, many students are quite adept at multitasking and making connections among various tasks and concepts, but based on the literature calling for increased integration among undergraduates, this skill is often unrecognized in academe. Based on what I have learned about integration of learning in the course of this analysis, I offer four recommendations for how college educators both inside and outside the traditional classroom can use these insights to foster a culture of integration for undergraduates.

Invite conversations with students. The data in this analysis revealed that (a) students often did not have a faculty or staff mentor to whom they turned for guidance, (b) students were eager to share their experiences with an interested adult (in this case, the interviewer), (c) the interview conversations promoted reflection for students that in some cases prompted integration of learning (see Kayla's excerpt above), and (d) there is a great deal of integration of learning happening in students' lives of which many educators are unaware. Intentionally creating opportunities for individual conversations with students can positively address each of these items. Faculty, staff, and students alike have full schedules and hectic lives. However, making time in the day for authentic conversations with students, even if only for 10 to 20 minutes, can encourage reflection, build relationships, and promote integration of learning.

Actively bridge contexts for and with students. The intercontextual nature of integration of learning, that integration can happen in and across multiple contexts simultaneously, is a characteristic that emerged from the data. Students (in fact, most members of an academic community) live in a complex and interconnected world. The issues that we face each day

are not limited to one context or discipline. Our lives are a nexus of various, and at times competing, environments, discourse communities, and belief systems. Educators can work to actively bridge contexts for students who have difficulty doing so and can encourage students who are already skilled in thinking intercontextually. For example, asking students to present an artifact from their home life, work experience, childhood, and so on can provide a venue for individuals to illustrate their understanding of material by connecting the curriculum to a context outside of the classroom. This can help to promote integration of learning by deliberately inviting students' previous experience into the classroom and signaling that it is encouraged for students to bring their unique identities, characteristics, and stories into class discussions.

Promote perspective taking. Perspective taking (standing in another's shoes) can be a powerful exercise for encouraging students to see multiple perspectives, just as bridging contexts can aid students in connecting curricula to their own personal perspectives. However, stepping outside of one's own position and trying to see the world from someone else's vantage point can be a difficult (and sometimes frightening) task. I understand this and suggest providing a number of spaces, both public (e.g., class activities, discussions, service learning) and private (e.g., reflective journals, writing assignments), for students to experiment with perspective taking. Stretching to see an issue from an alternative point of view can help students clarify their own values and beliefs while gaining a greater understanding of others' experiences.

Encourage reflection. Integration of learning is too often approached as an end point. I see the process to be cyclical in nature. Even after learning is integrated, a number of factors can cause an individual to take another look: New information, changing contexts, and evolution of meaning making can all lead to a new perspective. As a collegiate educational outcome, I believe integration of learning should be conceptualized as a continuous, iterative process—a habit of mind rather than an accomplishment. Challenging students to regularly reflect and reconsider what they know can assist them in developing this frame of reference for integration of learning.

Writing assignments can be useful for giving individuals the space to reflect and organize thoughts; such assignments are also helpful for understanding someone's way of seeing the world. Writing can also allow students who may not be inclined to participate in a classroom discussion or debate an opportunity to explore ideas and communicate their ideas, questions, and insights to the teacher. Imagine the possibilities for harnessing students' integration of learning if faculty, staff, or other mentors invited students into conversation and guided the discussion (either in written reflections or spoken conversation) away from objective questions such as "Do you have questions about the material in this class?" to more reflective prompts such as "How are you thinking about the concepts?" or simply "Tell me about what's

important to you.'' Students might have a difficult time responding to these questions initially, as illustrated by Kayla in the excerpt above, but the questions may prompt the reflection crucial for integration of learning.

Implications for Research

In addition to the implications for educational practice, the analysis of integration of learning has also introduced several opportunities for future study. Following are five areas of continued investigation that will contribute to the knowledge about how college students integrate their learning.

Expand the analyses within the WNS data. As discussed, the campuses from which the data were drawn for my study are two of six campuses across the country where we conducted interviews. As a reminder, these two liberal arts colleges were chosen primarily because they offered environments rich in potential to learn about integration. However, at the time of this study, they were less diverse in terms of race and ethnicity than the overall college student population in the United States and the other four institutions where interviews were collected in the WNS. The other four campuses would add greater racial, ethnic, and gender diversity to the sample as well as expand the study to different institutional types and instructional approaches.

The data analyzed in this study represent the first 2 years of a 4-year longitudinal study. Extending the analysis to include data from the 3rd and 4th years would enable the mapping of the integration of learning processes in students over the course of their college careers. This work also has many avenues for continuing lines of research beyond the scope of the WNS and into young adults' postcollege experiences.

Study the salience of contexts and demands. In the course of this study, contexts were intentionally placed in the background in favor of process or meaning making. Although I coded the data for context and considered the often intercontextual nature of integration, I did not analyze by context per se. In order to best address my primary research question, I focused on the students' process for integration over where the integration took place and what prompted or facilitated the integration (i.e., the demands of the experience). In this light, the direction of this project required me to focus on meaning making over context. An investigation of the demands of integrative learning experiences may reveal insights for andragogy and practice to promote integration of learning (Barber & King, 2007).

Consider additional data sources beyond the WNS. One of the strengths of these data is that the semistructured interviews allowed the participants to describe their own experiences and talk about integration of learning in their own words. However, this form of data also has limitations; the student may not have chosen to share an experience about integration of learning or may not have had the verbal skills to effectively describe his or her integration to

the interviewer. Observing class discussions or student organization meetings is one way of searching for integration of learning in action. Reading papers for integrative assignments and designing an interview specifically about integration of learning are additional means. Artifacts that reveal integration of learning, such as student writing or e-portfolio collections, also would be rich sources of data to inform the research on integration as a learning outcome.

Examine links between learning and development. I focused on the overall process of *how* students integrate learning in this article. Although all of the students included in this analysis were traditional-aged first- and second-year college students (18–20 years old), we cannot make the assumption that each student is entering college with a similar level of maturity or meaning making. In fact, the literature on college student development suggests that students enter college with a wide variety of developmental levels. Future studies of integration of learning can benefit from comparing individual students' process of integration with their ways of meaning making. An analysis such as this may shed additional light on the intersections of college student learning and development.

Investigate student characteristics in relation to integration of learning. As the student body enrolled in American higher education continues to diversify, it is imperative to consider the learning experiences of students outside of the majority culture. There is a substantial literature indicating that students respond to course content and college experiences differently, depending on the linguistic, socioeconomic, cultural, and other background experiences they bring to the learning environment (e.g., Abes, Jones, & McEwen, 2007; C. W. Barber, 2010; Kiyama, 2010; Ladson-Billings, 1995; Pizzolato, 2005). The WNS data set is itself quite diverse in terms of race and ethnicity; the subsample analyzed in this article is nearly 20% students of color. Analyzing the data in light of student characteristics such as race, ethnicity, gender, sexual orientation, faith background, privilege, or national origin could uncover important differences in the ways students integrate learning.

Integration of learning is widely becoming recognized as an essential educational outcome for U.S. college and university students in the 21st century (AAC&U, 2004, 2005; King et al., 2007). In conclusion, I return to my proposed definition of integration of learning, itself a result of this grounded theory process, to summarize the key concepts gained from my investigation.

> Integration of learning is the demonstrated ability to connect, apply, and/or synthesize information coherently from disparate contexts and perspectives, and make use of these new insights in multiple contexts. This includes the ability to connect the domain of ideas and philosophies to the everyday experience, from one field of study or discipline to another, from the past to the present, between campus and community life, from one part to the whole, from the abstract to the concrete, among multiple identity roles—and vice versa.

This study provides empirical data on the process of integrating learning for college students in an effort to uncover the *how* of integration of learning, namely the emergent categories of Connection, Application, and Synthesis. In addition, the findings demonstrate that integration of learning is not limited to the classroom, residence hall, or any one specific context. By nature, integration of learning is an intercontextual process. Higher education professionals both inside and outside of the traditional classroom can begin to consider which contexts and experiences may *promote* integration of learning by first understanding the ways in which students connect, apply, and synthesize their complex knowledge, experiences, and identity roles in a wide variety of contexts.

Notes

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[1]Because of the longitudinal nature of the Wabash National Study of Liberal Arts Education, portions of this method section have appeared in prior publications.

[2]All interview participants were asked to choose a pseudonym for themselves.

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