

Preface

PRACTICAL THEORIES: STEM AND MODERN EDUCATION

Perhaps no more powerful concept seems to represent today's world than the Internet's tearing down of the borders of the nation-state. Even beyond the ability to engage in international commerce, images, and texts from within, otherwise-secretive regimes threaten tyranny, erase difference, and strive to unite us in common humanity. It is, then, only fitting that cutting-edge, modern, technologically savvy education thrives on tearing down disciplinary boundaries to see common goals and a greater purpose via individual strategies. Interdisciplinarity, the banner term for this revision of education, is often defined as the integration of existing disciplinary perspectives, sometimes combining disciplines, other times critiquing or transcending the disciplines, or both. It has many connotations, distinguishing a variety of goals and contexts. The differences are dramatically evident in disputes over what constitutes real or genuine interdisciplinarity (Klein, 2010). Although arguments over "authenticity" often run afoul of conceptual terminology, it might be best to begin with a focus on the obvious before moving into nuance. Interdisciplinary research and interdisciplinary studies integrate content, methods, concepts, and theories from two or more disciplines or bodies of specialized knowledge in order to advance fundamental understanding, answer questions, address complex issues and broad themes, and solve problems that are too broad for a single approach (National Academies, 2004).

Given the immediacy of such a definition, it becomes apparent that, in practice, different types of interdisciplinary teaching can be identified: informed disciplinarity, synthetic interdisciplinarity, transdisciplinarity, and conceptual interdisciplinarity (Lattuca, 2001). In informed disciplinarity educators focus primarily on a single discipline but incorporate other disciplines to illuminate course content. Synthetic interdisciplinarity educators combine theories, concepts, and perhaps even research methods from different disciplines, but the contributing disciplines remain clearly identifiable. In contrast, transdisciplinarity mutes the disciplinary sources of theories and methods, applying them across disciplines so that they are no longer associated

with a single discipline or field. That is, the disciplines are not the focus of this type of course; the transdisciplinary theory is. Finally, conceptual interdisciplinarity includes disciplinary perspectives, but does not have a disciplinary focus (Lattuca, Voigt, & Fath, 2004).

An interdisciplinary course, such as “Weird Science: Interpreting and Redefining Humanity,” is an example of the possibility of merging the different types of interdisciplinary teaching; in this case, a Hegelian synthesis of disciplines, interdisciplinarity, and conceptual interdisciplinarity. This course, one of my own design, introduces students to a spectrum of literature in the sciences, technology, and engineering through an interdisciplinary exploration of the enduring question: What does it mean to be human? Through this exploration, students are familiarized with concepts in the natural and social sciences, technology, and engineering highlighting complementary perspectives. For example, students are introduced to the anatomy and physiology of the cell while reading nonfiction literature designed to appeal to the imagination. The broad question of what it means to be human is filtered through diverse topics that include racial constructions of humanness, philosophy, genetics, robotics, the ethics of transplantation, and the bioethics of euthanasia, quantum mechanics, simulations, and virtual worlds. Students question how different disciplines define concepts of the self and disrupt or disturb seemingly stable identities. The course focuses first “On Being Human” and then “On Being Human Virtually.” Perhaps really multidisciplinary overall, this interdisciplinary course combines the natural and social sciences.

This classroom application of interdisciplinary theory requires, though, a clear sense of praxis. Practical approaches to interdisciplinary studies include constructivist theory, which places the student at the center of learning, constructing meaning in the classroom. This theory contends that learning takes as its starting point the knowledge, attitudes, and interests students bring to education; and learning results from the interaction between these characteristics and experiences in such a way that learners construct their own understanding, from the inside (Howe & Berv, 2000). Problem-Based Learning (PBL) is a related approach. In the PBL model, students engage complex, challenging problems and collaboratively work toward their solutions. PBL supports students in their attempts to connect disciplinary knowledge to real-world problems. Student motivation to solve a problem becomes the motivation to learn.

In any examination of the praxis of classroom activities, it becomes obvious that supportive learning environments are essential in helping undergraduates, especially underrepresented students, in the sciences and mathematics. In addition, any examination of classroom activities will suggest that peer interaction is an integral, even vital part of the learning experience. Peer-Assisted Learning (PAL) is a student-centered instructional model wherein students actively learn in a small

group, facilitated by a peer leader. Since mathematics is the gatekeeper of many science and engineering disciplines, PAL mathematics workshops are designed to provide an academic support system with a peer leader to assist as a role model and facilitator. The goal of the PAL mathematics workshops is to build a community that maintains a safe setting for students to question and challenge concepts, to integrate various problem-solving strategies, and to communicate ideas while working collaboratively on mathematical modules with interdisciplinary themes.

There is a need for both student and teacher preparation programs. Socio-reflection is the ability to reflect upon an experience among peers or classmates. Reflective practices among student-teachers in teacher preparation programs are an important aspect of the process. These practical theories must be combined with online learning and technologies, as well as research that uses mixed-method analyses, the use of both qualitative and quantitative methods toward analyzing and eliciting data to evaluate learning outcomes.

Our growing realization of the importance of reflection and preparation in teaching is another facet of learning's significance in real-world applications. It is no longer a question simply whether interdisciplinarity promotes learning. Interdisciplinary learning is a vital strategy for engaging the increasingly complex challenges we face today, and the equally complex solutions will coalesce around STEM, dealing with issues ranging from such medical dilemmas as drug-resistant bacteria to global climate change. Solutions to these challenges will require a workforce armed with a skill set that engenders technological sophistication and interdisciplinary thinking. The diverse workforce necessary for these challenges requires a radically re-envisioned mathematics and science education so as to provide a foundational STEM education for the challenges of a transnational, global future (Lansiquot, Blake, Liou-Mark, & Dreyfuss, 2011).

The goal of this book is to help create a nation of problem solvers based on case studies of successful users of interdisciplinary studies geared toward underrepresented students in science, technology, engineering, and mathematics. Graduate students and pre-service teachers interested in learning best practices for the profession may also benefit from the cases. Education policymakers and persons interested in innovative interdisciplinary studies can use the book as a reference. Finally, as a guide for researchers and professionals in STEM fields, the selected cases may improve learning outcomes for their students.

In the first case study, Marlene Hidalgo, in her chapter titled "Interdisciplinary Learning from a Student's Perspective," describes her experience as a student in an interdisciplinary course. She reviewed the literature on the perspectives of various disciplines and participated in lectures led by professors of different disciplines to explore the idea of what it means to be human. She discusses the challenges and solutions in integrating disparate perspectives to both write her final term paper

and build a visual representation of the future human in an online virtual world. Aside from a few minor weaknesses, she notes, the course format offered uniquely rewarding experiences.

Cecelia Wright Brown and Kevin A. Peters offer teachers' perspectives in Chapter 2: "STEM Academic Enrichment and Professional Development Programs for K-12 Urban Students and Teachers." The authors provide information on exemplary professional development programs for STEM teachers that can be replicated in urban school districts; STEM academic enrichment programs that support increased knowledge of STEM content, pedagogy, and research; and offer strategies for engaging pre-college students in urban school districts to pursue STEM research and careers. Wright Brown and Peters highlight their research on STEM student-oriented programs (i.e., Women In Science and Engineering [WISE], Undergraduate Computer and Mathematics Academy [UCMA], and Mathematics-Science-Engineering Fairs), and teacher-oriented programs, namely, Project-Based Learning (PBL), linking Algebra and Biology, and content-based Mathematics Professional Development.

Learning communities are a way to facilitate interdisciplinary studies for students. Bernedette Kelley and Lisa McClelland, in their "STEM Learning Communities: An Interdisciplinary Approach to Teaching and Learning," aptly define learning communities as a group of people who are actively engaged in learning together with an interdisciplinary framework. This third chapter engages student perceptions and misconceptions about careers and the connections to course curricula. The authors point out that these communities show improved retention rates, increased student learning and achievement, increased faculty engagement, and fewer feelings of isolation. In their case, learning communities bridge the gap between faculty and students, which proved to be a tool for student retention in STEM majors.

In Chapter 4, "Reengineering an Introductory Computer Education Course for Undergraduate Students," Farhat (Meena) J. Lakhavani and April Rupp provide a summary of Computing@Carnegie Mellon (C@CM), which is a required course for all incoming undergraduate students. The goal of this new course was to address the diversity in students' preexisting knowledge and skills, increase flexibility to better accommodate student-scheduling constraints, and reduce resource consumption while changing the content and its learning outcomes. This course provided an opportunity for the diverse body of students to work in the Open Learning Initiative (OLI), combining the results of learning research with the affordances of technology to improve learning. This online learning environment combines intelligent tutoring systems, virtual laboratories, simulations, and frequent opportunities for assessment and feedback to create and deliver dynamic, flexible, and responsive Web-based instruction. OLI provided students flexibility and choices for learning spaces and styles. The success of this course allowed the college to reduce reliance on the computer labs, thus providing an opportunity for other academic initiatives on campus to utilize these spaces.

In Chapter 5, “Communication, Culture, and Technology: Learning Strategies for the Unteachable,” Ray Gallon explores the challenges of teaching Content Strategy and Information Architecture, which are caused by disciplinary methodology’s lack of guidance in uncovering the hidden source of quality. The solution is to provide the cultural, epistemological, structural, and strategic principles behind these disciplines in classroom sessions, employing traditional lecture methods plus interactive exercises. All practical, hands-on experience comes through group research projects where students are expected to apply the principles that have been discussed in class. He recommends classroom methodology adjustments to make material more interactive and to bring it into line with the informational environment students live in every day.

Melissa L. Burgess’s experiences in Chapter 6’s “Using Second Life to Support Student Teachers’ Socio-Reflective Practice: A Mixed-Method Analysis” serve as an example of an innovative approach to the reflective practices among student teachers in teacher preparation programs. Burgess presents a socio-reflective approach in the multi-user virtual environment called *Second Life* whereby student teachers can collaboratively share their reflections during their field experiences. Student-teacher reflective practices are usually individual assignments within teacher-preparation curricula; however, as demonstrated in this case study, collaborative reflection using virtual platforms such as *Second Life*, not only provides a social venue for online learning, it also serves as an approach that models and supports collaborative learning, learning that is reflective of our global society.

Innovative approaches to fieldwork are explored in Chapter 7: “Virtual Interdisciplinary Experiences for Teachers of Writing: Considerations for Implementation.” Christine Rosalia and Laura Baecher explore teacher education within a comparative case study. The studied initiatives connected teacher candidates with English language learners, across disciplinary boundaries and settings, via online communication. Through careful consideration of each project’s affordances and constraints, technology as an interdisciplinary collaborative tool may be better understood.

In Chapter 8, “Energizing Interdisciplinarity: Addressing Army Energy Use through Curricular Reform at West Point,” Bruce Keith defines interdisciplinarity as the integration and synthesis of ideas and methods from two or more disciplines. He introduces the Net Zero initiative goal, an interdisciplinary curriculum capable of engaging students with knowledge and applications of energy systems, which can potentially impact both local and global environments. He believes it has the potential to transfer capacity beyond West Point and the Army to the United States in its efforts to become increasingly more energy independent.

The next chapters focus on interdisciplinary projects and studies within STEM disciplines at New York City College of Technology (City Tech) of the City University of New York (CUNY). In “Theories in Practice: A Focus on STEM at City

Tech” Sean MacDonald, Olufemi Sodeinde, and Andleeb Zameer, members of the Interdisciplinary Curriculum Committee at City Tech, a stakeholder in the development of an interdisciplinary approach to teaching courses, preview the following chapters on interdisciplinary studies in STEM disciplines by City Tech administrators and faculty from different departments who collaborated with one another, and with educators from other institutions. In “Enhancing Diversity in STEM Interdisciplinary Learning,” Reginald A. Blake and Janet Liou-Mark describe interdisciplinary approaches designed to increase participation by underrepresented minorities in STEM disciplines. Cinda P. Scott, Bonne August, and Costanza Eggers-Piérrola, in “All Hands on Deck: Using Case Studies to Support Institutional Change,” address interdisciplinary collaboration on lab content, and include the perspectives of faculty and students on the issue of the state of the labs. Furthermore, in “Integrated Projects and the Development of Interdisciplinary Problem-Solving Strategies” by Paul C. King, “Development of Interdisciplinary Problem-Solving Strategies through Games and Computer Simulations” by Candido Cabo and Reneta D. Lansiquot, and “Integration of Civic Engagement Pedagogies in the STEM Disciplines” by Gwen Cohen Brown and Laina Karthikeyan, the authors present the results of their studies applying interdisciplinary approaches to teaching STEM courses, which show that students perform better in interdisciplinary courses as they develop an awareness of the connection between key concepts and their real-world applications.

Education has always been focused on where the need is greatest. The case studies in this book, written by trendsetters in interdisciplinary research, and utilizing best-practice techniques in conducting interdisciplinary research, illustrate methods of applying interdisciplinary research process to a variety of problems. More interdisciplinary studies focused on improving outcomes in STEM still needs to be done. This book strives to engage the twin spirits of interdisciplinarity and best practices in order to lay the groundwork for STEM evolutions in the reader and other institutions. Only through the acknowledgment of constant innovation and learning will modern education keep pace with today’s world.

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