Meta Disciplines: Systems, Design, and Computing

Jianxi Luo
Data-Driven Innovation Lab
Singapore University of Technology and Design
luo@sutd.edu.sg

Abstract

This paper defines and discusses the meta disciplines and their institutional implementations at a university. The meta disciplines refer to such fields of study as systems, design, and computing, which focus on meta theories and methodologies that may empower research and education across many if not all traditional disciplines such as engineering, architecture, medicine, business, and government. I consider three experiments at MIT to build intra-organizational units of meta disciplines, including the Engineering Systems Division, Schwarzman College of Computing, and Morningside Academy for Design. Their organizational design increases the dimensionality of knowledge to be learnt and created throughout MIT. The development and use of meta theories and methodologies may empower learning and exploitation in traditional disciplines while also fostering their interactions for emergence and innovation. Despite these benefits, meta disciplines by nature can be difficult to develop and sustain.

Keywords: Meta disciplines, Systems, Design, Computing, MIT

1 Introduction

Our world is faced with many growingly complex and uncertain "wicked problems" (Rittel and Webber, 1973) such as COVID and climate change. As we enter the fourth industry revolution, the fusion of the cyber, physical, and biological worlds induces new societal challenges to ethics, equity, and human values in the prevalence of ubiquitous computing and artificial intelligence (Schwab, 2017). Such wicked and new challenges involve intertwined technological, social, economic, and political factors that co-evolve and stakeholders with heterogeneous views and dynamic interactions.

Such emergent challenges would require continual design and experimentation of novel solutions, which are social-technical, systematic, and evolvable (de Weck et al, 2012). The complexity and uncertainty we face may have reached the level that human intelligence alone would be unable to effectively understand the intricate problems and come up with systematic solutions. Meanwhile, artificial intelligence (AI) beyond singularity (Kurzweil, 2006) may offer new capabilities to augment design creativity and AI-driven innovation to address those complex challenges (Luo, 2022).

These suggest the necessity and importance of design, systems and computing in engineering education, research, and innovation. Engineers of the future, regardless of disciplines, may benefit from mastering design, systems, and computational thinking and applying them to problem solving and innovation in their fields of practice. We anticipate engineers who are leaders to design and experiment with the aid of artificial intelligence for human-centred social-technical system-based solutions to complex challenges and for innovations that drive civilization toward a sustainable future.

Design, systems, and computing themselves appear to be specific fields to study, while they are also ubiquitous in and essential for many if not all fields of study. Herein, we call them meta disciplines. The theories and methods developed in the meta fields, such as design thinking techniques, models of system dynamics, and artificial neural networks, can empower education, research, and practice across many if not all traditional disciplines such as engineering, architecture, medicine, business, and government. In turn, the development of meta theories and methodologies may benefit from drawing upon, synthesizing, and unifying the observations, understanding, and methodologies in different fields. The relations and interactions of meta and traditional disciplines are depicted in Figure 1.

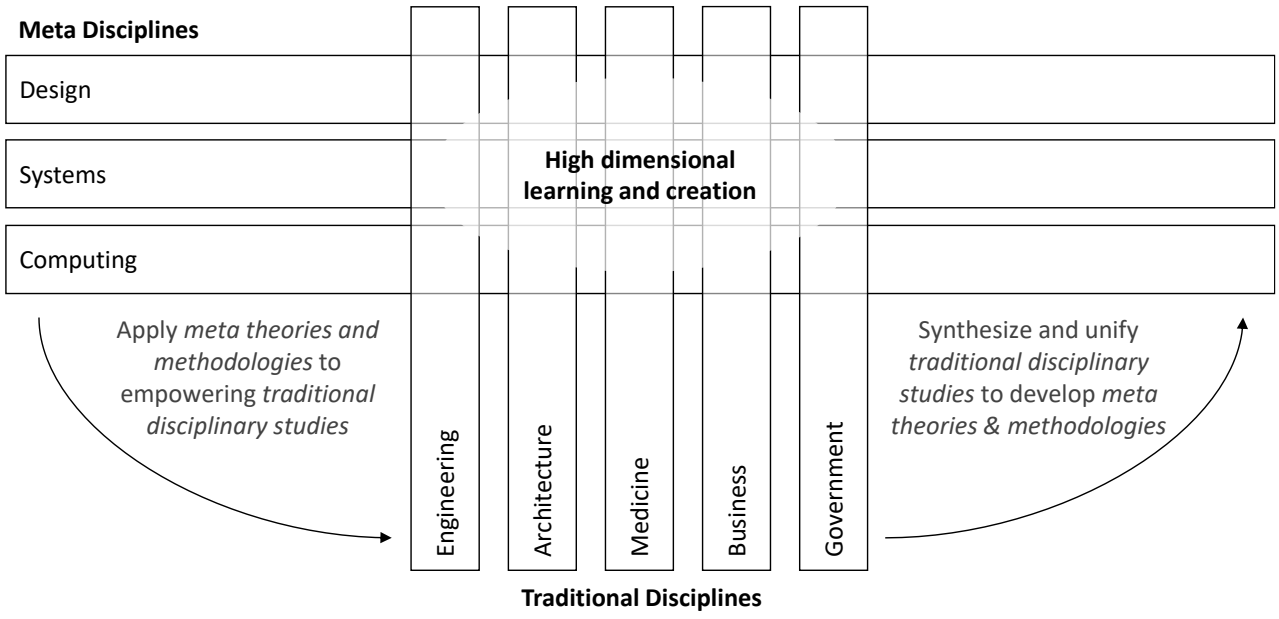

Figure 1: Relations and interactions between meta and traditional disciplines

Despite the high-order values of the metal disciplines for traditional disciplines, it remains ambiguous how to embed meta disciplines in the organizational structure of a university for them to empower traditional disciplines while advancing themselves at the same time. In this paper, we analyze three experiments at MIT to build intra-organizational units (see below) on meta disciplines, including

1) Engineering Systems Division (ESD)
2) Schwarzman College of Computing (SCC)
3) Morningside Academy for Design (MAD)

We briefly review the missions and operational models of the three organizational unites, analyze their commonalities and differences, and assess their challenges and prospects. It is important to note that, we do not consider them as golden standards but experiments of a university for organizational learning, transformation, and evolution.

2 Meta Disciplines at MIT

2.1 Engineering Systems Division (ESD)

ESD was founded in 1998 to focus on the engineering of complex systems and broaden engineering education (Roos, 1999). ESD addresses the societal and industrial needs for new theories underlying many socio-technical systems, such as global manufacturing, multi-modal transportation, and sustainable energy, and unified methodologies for designing and managing them against growing complexity, emergence, and uncertainty. ESD hosted a PhD program in Engineering Systems and several master programs, e.g., System Design and Management, Technology and Policy Program. About 50 faculty members were associated with ESD through dual or joint appointments with traditional departments or schools. In 2011, ESD was the third largest graduate program in the School of Engineering and gained the right to hire ESD-only faculty. In 2015, MIT launched the Institute for Data, Systems and Society (IDSS) to integrate ESD and the Laboratory for information and Decision Systems (LIDS) and focus more on data science for social-technical systems analytics, design, and management (de Weck, 2016).

2.2 Stephen A. Schwarzman College of Computing (SCC)

SCC was founded in 2018 with a mission to not only strengthen computer science, AI and computing-related fields but also discover the power and develop the applications of computing in every field of study, while also ensuring the future of computing is shaped by insights from other disciplines. The college is named after The Blackstone Group chairman Stephen A. Schwarzman, who donated $350 million of the college's $1.1 billion funding commitment. The college is an institute-wide academic unit that works alongside MIT's five Schools, with a focused home for computer science and AI education and research. It plans to host 50 new faculty positions, including 25 in computer science, AI and decision making located within the college as core faculty and 25 shared with other departments. It aims to educate students in every discipline to be "bilingual," and able to responsibly use and develop computing technologies to help design and make a better world.

2.3 Morningside Academy for Design (MAD)

MAD was founded in 2022 as a hub to transform learning, research, innovation, and entrepreneurship by integrating design methodologies into MIT courses and curricula (Ochsendorf and Yang, 2022). It is started with a $100 million gift from the Morningside Foundation. MIT

considers design a disciplined practice to augment creativity in and across different disciplines and to take “creative, humanistic thinking to society’s biggest challenges.” It is recently kicked off with launching the program of Design Fellows, who work with faculty and researchers to interweave design with different fields to create solutions to societal challenges. Moving forward, MAD aims to bring together a diverse community of researchers and designers from all five schools at MIT, via design projects, in-residence and public programming. MAD was built upon the successes and lessons learnt from the operations of SUTD-MIT International Design Center (2010-2020) and many existing “design plus programs” at MIT, e.g., design + engineering, design + management, design + health.

3 Analysis and Synthesis of MIT’s Experiments on Meta Disciplines

ESD, SCC and MAD share several characteristics in common. First, they are built around a respective meta discipline with unified theories and methodologies that can be used in diverse disciplines or fields. They differ from such interdisciplinary centers as Future Energy Center or Media Lab at MIT which bring together knowledge and methodologies from different disciplines for innovation but do focus on a meta discipline. Second, they cut across all five schools at MIT (Figure 2) by engaging faculty, researchers and students from different departments and traditional disciplines through dual or joint appointments and integrated multidisciplinary projects or programs. They all offer education and research programs.

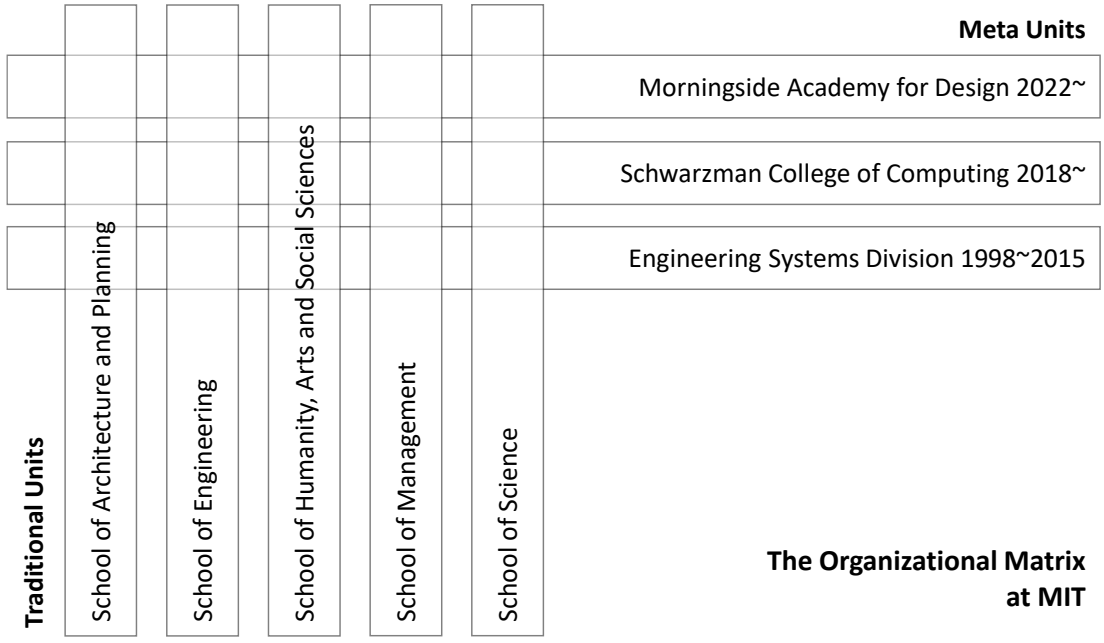

Figure 2: Meta disciplines at MIT

These three meta units at MIT differ in several ways. First, their naming differs as a division, college, and academy. SCC and ESD can hire tenure-track faculty while MAD at this point cannot. Second,

ESD, SCC and MAD are driven by different faculties at the founding stage, e.g., Civil and Environmental Engineering for ESD, Electrical Engineering and Computer Science for SCC, Architecture and Planning for MAD, respectively. Third, their initial funding conditions differ. ESD pooled resources from existent initiatives and programs, whereas SCC and MAD were started with generous endorsement funds from external donors to build new programs.

MIT's intra-organizational design to embed systems, computing and design in the university structure appears to have increased the dimensionality of knowledge to be learnt, created, and shared throughout MIT and beyond. As depicted in Figure 2, they transform MIT into a matrix structure. The knowledge and methodologies from each meta discipline may empower learning, exploitation and innovation in individual traditional disciplines while fostering the interactions and integration of different disciplines for emergent learning and convergent innovation. Meanwhile, meta knowledge and methodologies can be developed and advanced by synthesizing or unifying observations, practices, and knowledge from various traditional disciplines.

Despite these aimed benefits, it can be difficult to develop and sustain organizational units of meta disciplines in established universities. By nature, such meta units are most likely operationalized via hybrid education and research programs. Traditional faculty who was trained and have succeeded in silos may not be able to perceive the values of high-dimensional learning and may not have the interest nor capacity to manage or get involved in hybrid organizational structures with increased dimensionality and sophistication. It is suggested the development and success of meta units would require strong support from the top leadership of the university, as well as abundant resources.

In this paper, we have only briefly discussed three meta disciplines and three meta organizational units at a single university. There are surely other meta disciplines and additional models of embedding and developing them at a university. Universities with different cultures, legacies and governance mechanisms may innovate and experiment different models for developing different meta disciplines and units for increasing dimensionality of learning and creation of knowledge and technologies that can address future needs.

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