Introduction: Pedagogies at the Intersection of Disciplines

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Practice-based educators in the fields of interactive media and computational design are rarely challenged to reflect on their teaching pedagogies and students' learning within an academic, rather than institutional, context. The common formats within which artistic work and design creations gain conceptual and discursive dimensions are artist and curatorial statements, grant proposals, forum and blog posts, or articles produced as academic practice-based research. Where the foci of such writing are necessarily set on the productions themselves, pragmatic or aesthetic concerns, theory building, engaging the general community, or audience communication among others, teaching practices are not often of professional interest with respect to publication and research activity. On rare occasions, practice-based education and studio teaching have been studied philosophically or ethnographically by a handful of scholars such as Donald Schön (1983) or Nigel Cross (2006). However, the kinds of tacit and discursive learning essential to new media and design processes have yet to be comprehensively discussed in light of reflection on current pedagogies. The present anthology addresses this gap in the literature by initiating a new scholarly discussion in the fields of computational creativity.

Today's creators of interactive media "switch hardware and software tools like colors of paint."[1] As fascinating as such fast "switches" are, they also pose fundamental pedagogical and practical problems in tertiary education. How do we design effective inter-, multi-, cross-, and transdisciplinary pedagogy and curricula? In this volume, we bring together essays on pedagogies that produce the so-called *unicorns* – graduates who can code *and* create. Here, the intertwining of (what many consider mutually exclusive) expressive sensitivities and computational skills plays an essential role

[1] To cite an interview with Matt Cottam in Joshua J. Noble's *Programming Interactivity*, 2nd edn. (Beijing; Sebastopol, CA: O'Reilly, 2012).

in media and design education. This calls forth a new kind of undergraduate curriculum which adds to the already existing pedagogical challenges such as (1) maintaining a balance between breadth and depth of skills and knowledge; (2) developing fluency in coding along with advanced technological creativity; and (3) establishing the role of logic and numeracy in visually dominated media.

A multiplicity of technical skillsets – animation, graphic design, electronics, computer vision, web development, sound design, 3D printing, and algorithmic thinking among many others – contributes to an equally diverse set of professional fields, such as user experience design, virtual worlds, web applications, project management, creative directing practices, game programming, storytelling, industrial design, communication design, and beyond. This rich combination of skillsets and possible roles is profoundly cross-pollinating and thus triggers continuous shifts in professional contexts. Within this contextual framework, this anthology asks: what does it mean to teach students for computational creativity?

Almost all of the current publications in the subject area of "creative coding" feature showcases and compendiums of art and design works integrating computational or "new media" processes. However, finding texts that address pedagogy, curriculum, and educators' professional development in the richly diverse fields of computation and creative making is challenging, because teaching and learning are considered to be marginal to the prevailing discourses. In our courses, we have faced this problem on numerous occasions. Whether in the process of applying for teaching grants, or in moments of need for sources in the literature that explore relevant teaching practices, or during office hours when students come with the simple question "What should I do?," we have come to realize the scarcity of works that deal with the pedagogies of computational media and design from practical and interdisciplinary perspectives. Thus, the purpose of *Teaching Computational Creativity* is to identify specific conceptual frameworks, lines of inquiry, methods and strategies for teaching and to

1. provide an opportunity for educators to reflect in an academic context on their teaching practices, as opposed to their research and creation interests more typical of academic publications.
2. support an answer to the question: how do we define and explicate areas intersected by a multitude of platforms that cut across design, media, fine art, and informatic practices?

An impetus that contributes to this gap in the literature is the increasing diversification of disciplines and their epistemes, key concepts,

methodologies, and skillsets which combine in the new hybrid practices. Additionally, the barriers to nontechnical specialists have been substantially revised, and individuals with diverse scholarly backgrounds can play key roles on multidisciplinary teams, especially with regards to the setting of technical systems within human contexts. The history of usability could be said to have begun with Frederick Taylor's *Scientific Management* (1911), which introduced processes of rigorous measurement in the work setting, and later led to developments such as operations research – the forming of large interdisciplinary teams assembled for complex technological systems design during World War II – and evolved into a conception of "human–machine coupling." With the growing integration of computers in the workplace, these empirical approaches developed into human factors research and the elaboration of new cognitive and psychometric approaches in the disciplines of human–computer interaction (HCI). The idea of giving voice to the ordinary user in an everyday setting has a history dating back at least to the 1990s with researchers such as Jakob Nielsen (1995) who proposed 10 usability heuristics for user interface design. It was with the development of the World Wide Web that user studies began to integrate more qualitative and interpretive research designs grounded in ethnography or phenomenology, for instance. We can see that it is a relatively recent development that nontechnical specialists have been included as potentially integral to interactive media and design teams.

After suffering a series of failures and development of progressively user-unfriendly software products, Silicon Valley has come to realize the importance of the humanities as an input for innovation. As much as we need engineering or scientific knowledge to practically build new technologies, nontechnical and socially oriented thinking is vital to the creation of user-centered, sustainable, and future-envisioning interactive technologies. As one headline has it, "'Useless' liberal arts degrees have become Tech's hottest ticket" (Anders, 2015), where the article goes on to explore how graduates from arts and humanities backgrounds have become a force for creative innovation in the tech sector of the economy. Whether from philosophy, theater, literature, history, or art backgrounds, nontechs working in the tech business "provide users with extra bits of surprise and delight" (Anders, 2015, para 2). Today the development of interactive technologies includes sociocultural dimensions which the so-called "third-wave" of HCI has termed "the phenomenological matrix" (Harrison, Tatar, and Sengers, 2007). Observing these powerful shifts, we are in a position to notice how domains previously reserved to computer scientists and engineers have opened up to prioritize innovation in the fullest range of human contexts.

This diversification of practice, however, comes at a certain price – such as deciding what media and design skills *not* to cover in the curriculum any longer – and involves a series of challenges which can be summed up in the question: what do we teach to whom, with which methods, and to what effect?

Despite the rapid growth of new media and design programs in recent years, there is no comprehensive exploration of the pedagogical aspects of the richly diverse fields of computation and creative making. These new interdisciplinary programs often face definitional issues, strategically piecing together unique school names such as "interactive arts and technology"[2] or "design media arts,"[3] or perhaps distinguishing units such as "film, video, new media, and animation" from "art and technology" or "architecture, interior architecture, and designed objects"[4] in the same institution. These disciplinary separations, however, sometimes provoke forum questions such as "What is the difference between Carnegie Mellon University's Interaction Design and HCI Master's degrees?"[5] Scott Snibbe, one of the creators of Adobe's 2D animation and visual effects software, After Effects, addresses the disappearance of clear-cut boundaries in the following terms:

> If one's job can be clearly defined, then it's likely it can be immediately outsourced to Pakistan or India via oDesk, eLance, etc. To be a first world creative worker, one needs to be a synthesizer of information and fields. I read this great blog post by AJ Kessler, that was titled "If You Can Easily Describe What You Do, You're Fucked." He said, "The people that will thrive are the ones who can figure out what needs to be done next and why." So, it's good that you can't explain the meaning of your program – you're on the right track to creating people who can think on the fly and fill holes that don't exist yet.

Technological developments and intersections proceed at a pace indifferent to academic curricula or administrative unit names. As Ray Kurzweil (2011) has famously noted, our intuitions are local and linear but technology moves at an exponential rate and on a global scale. To address these complexities through the lens of pedagogy, this anthology engages with the

[2] Simon Fraser University.
[3] UCLA.
[4] School of the Art Institute of Chicago.
[5] www.quora.com/What-is-the-difference-between-CMUs-Interaction-Design-and-HCI-Masters-degrees

definitional problems of the field, and the complex interactions generated by the abundance of platforms and their interrelations.

Existing scholarship has conceptualized various aspects of interactive media and design's theoretical and practical foundations ranging from simple applications, processes, codes, and technical specifications to social impacts, working practices, and expressive potentialities (see, e.g., Bogost, 2007; Kwastek, 2013; Miller, 2008; Reas and Fry, 2007). In addition to the relatively obvious practical production skillsets, interactive technologies are also exemplary in relation to art and visualization practices (see Ferster, 2013; Popper, 2007). There are often clear scholastic divides in the management of digital cross-pollination. In the scarcity of works that deal with the pedagogy of interactive technologies, we can sense a strong separation between perspectives of: (1) technicality as expressed in computation, coding practices, and hardware configuration on one side and (2) digital humanities represented by a theoretical rhetoric "distant and apart from the work people have done and are doing" (Keramidas, 2012, para 2). This collection challenges these divides in the way that all applied practical activity – in this case, teaching – undermines detached theoretic positions which "battle" each other on abstract planes of mere argument. We can note, from our more integrative stance, that both digital humanities and HCI are currently articulated as being in their "third waves" (Berry, 2011; Bødker, 2015). Perhaps, a fourth wave will soon emerge which dispenses with the current divisions between human interpretations (digital humanities) and uses (HCI).

The authors here defy Charles Percy Snow's classic distinction between the "two cultures," or the culture of technoscience and the culture of the humanities. This hallowed division is to a great extent still instituted in the organization of our universities into faculties that segregate the study of literature and art from the study of science and engineering, for instance. Yet the worlds of interactive media and design combine elements of both cultures intimately and inextricably. The design of apps or interfaces for devices such as smartphones can itself be an interface between aesthetic considerations, narrative design, and computer code. Given the hybridity of practices involved in computational media and design, today's creators need to be as "agile" in their thinking as in their software development. Creative computation calls for participation in what has variously been called "the third culture" (Brockman, 1995), or what Buchanan called "a new liberal art of technological culture" or an "epistemology of design" (Loh, Chai, Wong, and Hong, 2015, p. 2) based on abductive reasoning that is distinct from the methodologies and ways of thinking in the arts and

sciences (Cross, 2001). Karl Popper's notion of "World 3" (1978, p. 144) is also relevant:

> By world 3 I mean the world of the products of the human mind, such as languages; tales and stories and religious myths; scientific conjectures or theories, and mathematical constructions; songs and symphonies; paintings and sculptures. But also aeroplanes and airports and other feats of engineering.

Computational creativity does not cross disciplines merely for the sake of it, but because these hybrid practices require "the ability to synthesize knowledge from a variety of sources" (Loh et al., 2015, p. 3) and thus are perhaps better understood as transdisciplinary rather than interdisciplinary. In the disciplinary model proposed by Moore and Lottridge (2010), (1) *multidisciplinarity* is the coming together of multiple disciplines around a common problem, remaining intact, autonomous, and eventually "going their separate ways"; (2) *interdisciplinarity* is two or more disciplines coming together to forge a new discipline, as in biology and chemistry forming the field of biochemistry, or mechatronics, which is an interdiscipline formed out of electrical, mechanical, and software engineering; and (3) *transdisciplinarity* is the coming together of multiple disciplines to define a new generative context for the production of new problems and knowledge. It is clear from the chapters gathered here that the curricular space being explored and defined is this third model of "generative transdisciplinarity" which Moore and Lottridge define as "dynamic, flexible, transient, generative, reflexive and social" (p. 2738), and thus "transdisciplinary" is also the name of our last part of this book.

Moore and Lottridge argue that in the university setting, with its departmental formations around disciplinary lines and its career reward systems based on traditions that define what counts as legitimacy in knowledge production, transdisciplinarity proves the most challenging to institute while at the same time promising the greatest possibilities for innovation. They take up several brief case studies that link to the notion of 3rd Wave HCI as examples of new innovative research that has as one of its institutional features the contribution of humanities and social science lenses brought to bear on the development of new technologies. In their view, disciplined transdisciplinarity fundamentally involves collaboration and teamwork. Also, these new transdisciplinary academic units have to institutionally and professionally negotiate the validity of their research methods and perspectives relative to the more traditional disciplines.

Additionally, the chapters transgress the division between high and low culture that separates "art" from useful everyday objects. The creative

intuitions and skills involved in artistic activity are also required in the design of our networked material environment today. The academic specialties that treat the different aspects of interactive media and design must come together in the mind and practice of the student. They are not assimilated into a single discipline but become differentiated resources at the command of skilled creators or teams who are proficient in coding skills as a new overlay onto the traditional requirements of art, media, design, and informatic knowledge. The relations between disciplines in the new practical work take the form of new connections between different levels of the object or system. For example, the designer has an aesthetic or practical intuition (or both) which must function as lines of code in a program, go through design process stages of variation, revision, iteration, and testing, and ultimately be instantiated in a robust artifact either as a working prototype or finished piece of technology operating in real environments which are also human contexts and subject to differing interpretations and uses. Constant conceptual movement oscillating across the boundaries between disciplines is required, integrated with the acts of making.

All of the chapters presented engage with the pedagogical techniques and principles for acclimating students to these diverse domains of knowledge and skills that can be described as neither science nor art, neither high nor low, neither culture nor commerce, but potentially mixing all at any time. This new organization of technical and cultural production at this point in its development needs a firmer conceptualization of its pedagogical practices, which is the need that this volume addresses.

Teaching Computational Creativity includes international contributions from educator–practitioners who are developing a new "scholarship of teaching and learning" (SoTL) in the fields of code-based media and design. Rather than attempt only a general framework for conceptualizing today's skillset demands[6] or "competencies"[7] to use the contemporary parlance, this collection incorporates and interconnects a mix of practical and theoretical perspectives and approaches to provide a multidimensional understanding of what matters for the disciplinary complexity of today's computational media and design curricula. We have aimed to reflect the diversity in contemporary teaching practices rather than create an artificial

[6] For example, narrowly defined professional training based on notions of current industry demands or "hot" labor market skills.
[7] http://edglossary.org/competency-based-learning/

sense of particular "schools of thought" somehow more or less dominant or important across differing contexts. Despite this diversity in perspectives, the collection is far from "eclectic" as the reader will note many recurring themes throughout the chapters which create a surprising sense of unity given the range of topics and technologies broached, enough unity in fact to allow us to propose a curricular synthesis in the Afterword.

As educators, our motive for developing *Teaching Computational Creativity* is pedagogic, as we teach courses on code-based design, audio-visual production and postproduction, installation, performance, narrative, media and cultural theory, information design and communication design among others. To date, no book-length academic works have discussed and analyzed the problems of pedagogy within this "multi-field" in ways that are comprehensive, practical, holistic, and directly transferable to the classroom. There are no established models for unifying curricular concepts across the involved disciplines. Thus, this anthology seeks to provide practical guidelines to educators in the disciplines of computational media and design, and to initiate new and relevant discussions. Accordingly, the anthology contains six parts, each of which explores a significant pedagogical theme acknowledging not only the heterogeneity of the fields but also many teaching and learning perspectives accompanying creative coding and computational media. Following the chapters, we present interviews with noted artists and designers who have significant professional practices and who provide an opportunity to step out of academia into the industry and contemporary studio practice as a position from which to reflect back into the educational context.

NEW FOUNDATIONS

Computational media have no distinct point of origin and as such merge within themselves a plethora of perspectives, skills, and paradigms. As much as the fields of creative coding, design, and interactive media have benefited from nontechnical, socially oriented knowledge, computational skills have now become foundational in art education. Joining the traditional notions of "2D, 3D and 4D" as a requisite skillset for any creative field, programming knowledge is beginning to be considered as a form of literacy necessary for contemporary societies and creative practice. Coding theory now joins graphic design, photography, and even art history (e.g., in the form of computer art history) as an essential formal grounding for new practitioners. Procedural logic and numeracy, traditionally not emphasized in studio education, take on new roles as in the visual modeling of organic

motion and other natural phenomena in Processing, a popular coding environment used in art and design pedagogy (Greenberg, 2007, pp. xxii–xxiii).

In the first chapter, Ryan M. Patton and Luke Meeken survey the introduction of preservice art educators to programmable media, where programmable media is defined as both an expressive art form and a curricular tool. The authors present a curriculum that frames digital art and interactive design concepts through image manipulation, web design, video production, game design, and physical computing assignments. The implementation of metaphorical processes from traditional media practice inflects art education students' ability to make conceptual linkages between game design mechanics and nondigital artworks. Patton and Meeken make recommendations for curricular and policy changes to the teaching of technology in K-12 classrooms and in teacher preparation programs, providing a roadmap for the multiplicity of technological platforms used in new media art education.

Introducing coding is further discussed in Chapter 2, where Andrew Hieronymi provides a first-person case-study account. Hieronymi investigates the learning dynamics that take place during the creation of expressive interactive experiences such as digital games, interfaces, art installations, and mobile applications. Despite students' passion for interactive media, they are often intimidated by the steep learning curve of acquiring programming literacy. In his chapter, Hieronymi describes the methods he implements to assist students in overcoming these challenges and supports his strategies by looking at the work of three of his students.

CODE AS MEDIUM

Code is a text, but of a specific kind – a text that produces causal chains in machines rather than intertextual effects of encultured associations. Ina Greenberg humorously notes that "When I tell people I write code as my main artistic medium, they smile politely and quickly change the subject" (2007, p. xxii). Greenberg's observation suggests that the interpretive traditions associated with the "text" propagated by literary studies have missed code as a medium of creativity and artistic expression.

Chapter 3, written by Channel TWo, conceptualizes code as an organic medium of a pervasive, invisible material that drives our contemporary-mediated environment. From the electricity flowing through landscapes, to the models of environmental collapse, code is pervasive in our realities and is no longer marginal to mainstream art worlds, or to popular media such as cinema and games. Channel TWo argue that despite some students' resistances

to coding, contemporary art and design practices cannot dispense with it, and discuss their teaching of "slow coding" as an instructional strategy.

In Chapter 4, Brad Tober examines another critical aspect of treating code as a medium – the democratization of design production. He argues that at the forefront of this phenomenon stands the contemporary maker movement which promises to extend the means of code-based fabrication to nearly everyone. Such democratization however prompts a questioning of the role of those who had previously (and exclusively) engaged in design production. If nondesigners enter the design sphere, then what are the new roles for professional designers? Tober's chapter positions an argument for developing design curricula that are "entirely code-based." Code-relevant principles and activities inform the entirety of the design processes students are exposed to. Design and code share core structural features that enable the use of code as a medium for both teaching and executing design.

PHYSICAL{LY} COMPUTING

Contrary to the widespread beliefs in the "immateriality" of the digital, practitioners are well aware of its materiality and regularly exploit it, whether in the form of embodied performances or in the circuit-based analogs of the body, namely the hardware connecting sensors and actuators to microprocessors. Physical computing presents a somatic and even visceral dimension to a medium that is generally conceptualized as lacking in physical properties, being entirely informatic in an almost disembodied sense (for a detailed discussion, see, e.g., Sanchez-Vives and Slater, 2005). Recognizing the somatic potential of computing subverts the definitional hold of "computation" as a sequence of calculative, logical, and generally mathematical procedures. Understanding this physical dimension initiates attentiveness not only to the embodied conditions of human users, but also to dispositions in relation to our increasingly informatic material contexts.

The complex relationship between computing and situated bodies is the subject of Chapter 5. Luiza Novaes and Joao de Sa Bonelli present a teaching initiative of Interaction Design and Physical Computing that is currently under development at Pontifícia Universidade Católica do Rio de Janeiro in Brazil. The relationship between the theory of design and its practice is considered in light of the seminal works of Donald Schön, Herbert Simon, and Nigel Cross. Today designers are not simply users of digital interactive systems, but are an integral part of interface development teams responsible for the mediation between computer systems and their human users.