In *Asia/America Scholars of the 21st century*, Chapter 11

Lucky to Be Alive: Ming Ming Chiu's Persistent, Creative Path via Computer Science, Education, and Statistics

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Growing up at the border between rival gangs warring over heroin, Ming Ming CHIU was lucky to survive and test into an elite middle/high school of gifted students and teachers. While his carelessness denied him first prize in every academic subject, his imperfection freed him to explore diverse, unusual projects. Fittingly, he studied artificial intelligence in college. There, his friend and he worked together effectively on the insanely difficult assignment of creating a word processor, sparking his lifelong interest in collaboration. To pay his tuition, Ming taught. Without proper teacher training though, he made many mistakes. Notably, a student returned to jail rather than remain in Ming's class, fueling his desire to understand how people learn. His research reflects these interests; he invented a statistical tool to analyze conversations, an artificial intelligence program to apply it, and another statistical tool to model how multiple songs, ideas, etc. spread through a population. Using these tools, he showed how (a) to detect sexual predators based on their online messages, (b) to detect corruption in the music industry, (c) both rich and poor students learn less in less equal schools or countries, and (d) China and Qatar can improve their school systems.

At the precarious border between Chinatown and Little Italy in New York City, Ming Ming Chiu (please call him Ming), a poor, small boy (the shortest in his class) grew up surrounded by John Gotti's Mafia, the Ghost Shadows, and the Flying Dragons. In sixth grade, Ming was walking along Mott Street when three Ghost Shadows gang members approached him. One grabbed his jacket and told him to walk over to a doorway. Ming politely said, "No, thank you," pushed the gang member away, and ran through oncoming cars onto Canal Street. He zig-zagged for several more blocks, boarded an uptown train, and was relieved to see the doors close with no gang members in sight. His childhood would include several more violent incidents. One day, his best friend disappeared; to avoid being recruited into the Flying Dragons, his best friend's entire family moved away. Another friend was killed in a heroin war between the Ghost Shadows and the Flying Dragons. His schoolmate was gang-raped in her apartment building. Daily newspaper stories about murders flowed from his dad at the dinner table, always ending with a plea to "Be careful." Fear was always nearby.

In this world, curiosity was dangerous, but Ming was curious about everything. As an infant, he put anything nearby into his mouth and unlocked gates, once crawling out on to a main road. Luckily for him, his parents fished out bones and toys from his throat, and a quick-thinking teenager tossed his bike onto the road to stop oncoming cars. His parents repeatedly told Ming these stories to deter his curiosity and keep him safe.

Learning

School was an oasis for Ming. He felt safe, and his teachers welcomed his curiosity. For example, his teachers often ended a lesson by asking if their students had any questions, which he interpreted broadly. After a lesson about sunlight, he asked, "If light can't escape a black hole, how do we know it's there?" While his classmates rolled their eyes, his teachers always tried to answer his questions. Encouraged by his teachers' responsiveness, Ming excelled in school academically.

But not in his parents' eyes. Ming was careless and, hence, rarely perfect (many 98s and 99s), so his parents criticized him for not studying hard enough. Perhaps if he were wiser, he would have understood that his parents knew little about the United States or its schools and

only wanted him to do his best. In China, his mom and dad completed fourth grade and sixth grade, respectively, and they spoke little English. As early as the first grade, Ming began to interpret English and U.S. culture for them. The contradiction of his parents' criticism versus his interpretation responsibilities and his teacher's praise led him as an eight-year-old to trust his own judgment over that of his parents. At that time, his family wanted to buy a refrigerator, so he read the relevant *Consumer Reports* article and guided his parents toward his targeted model. Relying only on his own judgment however, he also tackled many unnecessary challenges and made many errors, such as turning white underwear pink by washing it with a red t-shirt in a hot wash cycle.

Through a little cleverness and a lot of luck, he survived his childhood (being born on the 7th day of the 11th month didn't hurt). By passing a test for gifted students, he entered Hunter College High School. His wonderful teachers asked him to write a new constitution for the United States, use imaginary numbers to solve electricity problems, and design art murals for three mathematics classroom walls. He was proud of his winning third-place design, four reflected diamonds, and of how he and his friends carefully painted it on the third wall. Moreover, he enjoyed his varied discussions with his new friends, ranging from justifiable conditions for suicide to a classified ad in the school newspaper, "Oral sex prevents tooth decay."

While he appreciated his talented teachers and schoolmates, he adored his free train pass. After surviving his childhood—while embracing adult-like responsibilities—Ming felt emboldened to explore the metropolis (with appropriate defensive tactics such as walk fast, hide money, don't stare, and so on). His train pass let him traverse the city from the burning cars in Harlem to the glorious sopranos at Lincoln Center (only $2 for the Wednesday afternoon back row!). As his parents would not have approved, Ming and his sister self-imposed an 8 pm curfew to ensure that they returned home well before their parents did at 10:30 pm.

Ming thrived academically at Hunter, but he was still careless. Competing against gifted students, his imperfect tests, essays, and projects were costly; he never had the highest score in any course. Despite graduating near the top of his class, he won only one honorable mention in chemistry in six years. While initially disappointing, it also freed him to explore unusual projects without worrying about grades. Some were successful, such as explaining the possible paths of stellar evolution on a poster. Others were not, such as a story about a walking wall: Ming loves to tell how he managed to get a failing grade on this paper.

After high school, Ming continued his exploration of diverse topics. At Columbia University, he took an "Introduction to Computer Programming" course, which included assignments ranging from creating electronic address books to simulating lines at a supermarket. Enamored of the seemingly limitless possibilities in this new and growing field, Ming majored in Computer Science.

In the next semester, however, the second computer course "Software Design" was taught by the worst teacher Ming ever had. This professor not only lectured by reading from the textbook but also assigned an insanely difficult problem, namely create a word processor (like MS Word). When his classmates complained, the professor let them work in pairs, but only six students did so (including Ming; he was afraid of failing). No one created a word processor, but the three pairs created primitive line editors that had some functions and they each received an A+. Ming and his partner, Diana, shared ideas, but more importantly, they lifted one another's spirits, especially when they were anxious about the impossibility of completing the assignment. Knowing that they were committed to doing this together enabled them to continue making progress. This experience highlighted the value of collaboration for Ming and sparked his ongoing research on how people work together.

Of all his computer science courses, Ming liked his "Artificial Intelligence" course best. For the final project, he created a Chinese checkers computer program that incorporated all his relevant knowledge, strategies, and tactics. Unlike Ming, the Chinese checkers program did not make any mistakes, so he lost every game he played against it.

Teaching

To pay for his college tuition, Ming tutored and taught at an alternative education program encompassing adult literacy, teenage apprenticeships and half-way house programs between jail and parole. Many elderly Blacks had attended inadequate schools as children and thus did not learn to read, so they embraced his guidance as he tutored them; they were, by far, his most enthusiastic students. When teacher aides, assistant teachers, or teachers were absent, he substituted for them, and was eventually promoted to teacher. Without proper teacher training though, Ming made many mistakes. He especially remembers a 20-year-old halfway house student who only read at a second-grade level. As the alternative education program only had middle school and high school educational materials, Ming tried various ideas, including reading aloud, borrowing children's books, and drawing sentence diagrams. However, his student did not learn much through any of these methods, became frustrated, and eventually left the program. Ming failed, and his student suffered. Later, to comfort novice teachers who were having difficulties, Ming would tell them this story, concluding that "no matter how badly you feel about your teaching, none of your students would rather go to jail than be in your class."

This failure drives Ming's constant teaching experimentation with different students, content, methods, and media. His students encompass every level: underprivileged preschoolers, gifted elementary school students, teenage Vietnamese gang members, Ivy League undergraduates, pre-service and in-service teachers, and mainland Chinese Ph.D. students. Ming has taught reading, writing, mathematics, geology, electrical circuits, computer science, education, psychology, and statistics. Adapting his teaching to the local culture, his tool kit includes mini-lectures, demonstrations, quiet reflection, student pairing-and-sharing, group problem solving, role-play, whole-class discussion, and videotape analysis. Moreover, his teaching media include traditional face-to-face classrooms, distance instruction via video cameras, Google Docs discussions, online courses, and hybrids of these. Overall, he generally fosters student analyses of their classroom activities to understand key ideas such as algebraic representation, and to develop important skills such as seeing and understanding others' perspectives. By having students collaborate and openly discuss their work, he aims to foster a community of learners. Working together, they are motivated to improve their understanding from multiple viewpoints (e.g., student and teacher), recognize more difficulties, and develop suitable adaptations to improve their learning (and teaching for pre-service and in-service teachers).

Post-Graduate Research

Ming's teaching failures fueled his interest in understanding how people learn and how teachers can foster their learning, so he earned a Master's in Education at Harvard. Combining computer science and education, he created an algebra learning environment based on the metaphor of a pair of twins each holding different boxes and coins to represent the same quantity on each side of an equation despite different variables and numbers.

In his Ph.D. program at the University of California at Berkeley, he continued his education studies under the guidance of Dr. Andy diSessa (advisor), Dr. George Lakoff, Dr. Alan Schoenfeld, and Dr. Rogers Hall. Although diSessa's expertise was in computational thinking and science learning, he encouraged his students to pursue their own interests, which ranged from gender identity to learning how to dive. Regardless of the topic, diSessa painted each of his students' papers red with criticisms and suggestions, pushing his students to consider their assumptions, other alternatives, and implications. Likewise, Lakoff's, Schoenfeld's, and

Hall's respective areas of expertise in metaphors, mathematics education, and representation practices changed Ming's understanding of his dissertation topic, how students collaborate to solve mathematics problems using talk and metaphors during classroom lessons.

Ming benefited from not only his professors' voluminous feedback, but also from simple luck. In the Berkeley library, he saw a counseling journal article on a table. Curious, he looked at the open page and saw a multi-dimensional scheme for patients' stories (Stiles, 1978). Immediately recognizing the value of multiple dimensions, he eventually created a three-dimensional scheme (*evaluation* [agree, disagree, ignore], *knowledge* [new, old, unrelated], *invitation to participate* [question, command, statement]), which captures 27 different types of talk (27 = 3 x 3 x 3). Also, he saw that statistically analyzing turns of talk, rather than individuals, yields much larger sample sizes for statistical analyses (e.g., 500 turns vs. 2 students). Although he wanted to use statistics to model students' talk in his Ph.D. dissertation, the statistical method did not exist yet, so he settled for a qualitative dissertation.

Analyzing Talk with Statistics

After graduating with his doctorate, Ming won a McDonnell Foundation post-doctoral fellowship at the University of California at Los Angeles (UCLA) under the formal and informal mentoring of Drs. Kris Gutiérrez and Noreen Webb. There, he spent most of his time talking with them and other scholars in linguistics and statistics about how to statistically analyze conversations. They told him about eight analytic difficulties, which he had to address before publishing his work. His early attempts failed, resulting in 16 consecutive manuscript rejections.

Fortunately, as a graduate student, he had published a separate study on geometry intuitions in a top mathematics education journal (Chiu, 1996), which persuaded The Chinese University of Hong Kong to hire him as an assistant professor. There, he had lunch with his Harvard econometrician friend, Dr. Lawrence Khoo, who had also moved to Hong Kong. Lunch at the Ritz-Carlton turned into dinner as they discussed the statistics issues and identified additional analytic challenges. After working together for five years, they invented "Dynamic Multilevel Analysis" (DMA, Chiu & Khoo, 2005a), which Ming further improved to become "Statistical Discourse Analysis" (SDA, Chiu & Lehmann-Willenbrock, 2016).

SDA identifies pivotal moments, tests complex hypotheses, and applies to small samples. SDA statistically identifies the critical moments in a conversation that radically change the interactions among speakers (e.g., insights, insults, topic shifts). SDA also simultaneously tests multiple hypotheses about factors at various levels that affect attributes of a speaker's talk across time; for example, after a disagreement by a girl in a mixed racial group at the beginning of a discussion, is the next speaker more likely to express a new idea than otherwise? Furthermore, SDA tests whether specific actions or sequences of them are related to broader outcomes. For example, are groups with disagreements followed by new ideas (*disagree* $\rightarrow$ *new idea* sequence) more likely than other groups to solve an algebra problem?

As SDA is computationally intensive, Ming designed an artificial intelligence program *Statistician* to run it. He hired research assistant, statistician, and computer programmer Yik Ting Choi to incorporate almost everything Ming knows about statistics into SDA. *Statistician* runs analyses and interprets the results. If the results meet the a priori satisfaction criteria, it produces a table suitable for a manuscript. If the results do not, *Statistician* re-writes itself to run further analyses until it meets the satisfaction criteria.

SDA can statistically address many research questions about talk, and *Statistician* can run analyses quickly; hence, Ming sought co-authors who might benefit from SDA and his other statistics skills (110 co-authors on publications so far). Ming has applied SDA to complex models of sequences of thinking and social processes by individuals and groups, ranging from preschoolers to adults in various countries. When pairs of U.S. preschoolers talk about books, their behaviors affect one another's subsequent behaviors (e.g., *agree* $\rightarrow$ *inference*; *specify*

reading purpose → express story information) (see Christ, Chiu, & Wang, 2014). Among triads of Dutch third-grade students writing reports, sequences of *planning*, *low-level thinking*, or *evaluations* raised the likelihood of subsequent *high-level thinking* (Molenaar & Chiu, 2014). Canadian university student teams designing lessons online often engaged in the following sequence of thinking: *opinion → elaborate → theorize* (Chiu & Fujita, 2014).

Beyond students, Ming used SDA to analyze teachers and technicians. When a female U.S. teacher teaches a lesson and reflects on it, she often follows this sequence: *problem exploration → teaching adaptation → problem resolution* (Hayden & Chiu, 2015). After a professor *shares personal experiences* or *asks for critical thinking* or a classmate *recalls facts* or *thinks critically thinking*, a U.S. in-service teacher is more likely to *recall facts* and *think critically* (Arya, Christ, & Chiu, 2014). During U.S. teachers' discussions of a video of their work, the following factors increase the *generation* or *application of teaching suggestions*: a *video of instruction* (rather than assessment), *sharing a teaching problem* (rather than a solution), and specific conversation turn attributes (type of *pedagogy*, aspects of *subject matter*, *sources of knowledge*) (see Arya, Christ, & Chiu, 2015). Among German technicians solving problems during team meetings, *solution-focused behaviors* and *past emotional positivity* increase subsequent *emotional positivity* but *problem-focused behavior* decreases it (Lehmann-Willenbrock, Chiu, Lei, & Kauffeld, in press). As suggested by these studies, SDA analyses of conversations or sequences of thinking can increase our understanding of them and thereby encourage desirable behaviors/sequences and deter harmful ones.

Corruption, Big Data, and Sexual Predators

Along the way, Ming discovered many collaborators who required different statistical analyses, so he invented new statistical methods and applied them to complex data sets. For example, between singing karaoke songs in Tokyo, Ming and his new friend Joeri Mol discussed how to detect corruption in the music industry. When record companies bribe radio stations to play specific songs (payola songs), their airplay and sales patterns differ from those of other songs. To detect this difference, Ming invented another statistical method, "Multilevel Diffusion Analysis" (MDA), which models how multiple songs, ideas, etc. spread through a population (Rossman, Chiu, & Mol, 2008).

As Ming's skills in statistics improved, he began analyzing larger and more complex data sets. He downloaded free, large-scale international data on the learning outcomes of half a million students in 65 countries, including the Program for International Student Assessment (PISA) and Progress in International Reading Literacy Study (PIRLS). Motivated by his experience of living in poverty as a child, he theorized that both rich and poor students in less equal schools (e.g., unequal educational resources) and in less equal countries (e.g., unequal family income) learn less overall. Using the PISA data, he empirically showed that these students indeed had lower reading, mathematics, and science test scores (Chiu & Khoo, 2005b). He further analyzed the PISA data to show evidence of micro-economic mechanisms of inequality, specifically fewer resources and inefficient allocation (also known as *economic rent* and *diminishing marginal returns*, respectively).

Using the PIRLS data, Ming showed that grouping similar students together within classrooms (*tracking*) or within schools (*streaming*) yield opposite effects on learning outcomes (Chiu, Chow & Joh, in press). As streaming enables teachers to *customize their instruction* for similar students in an entire school, reading test scores are higher in school systems with more streaming. In contrast, teachers do not necessarily prepare multiple lesson plans to suit students in different sections of the same course, and reading test scores are lower in tracked classes. Indeed, mixing high- and low-achieving students together can increase opportunities for the former to *help* the latter, which might help both learn (helpers re-organize their knowledge and help recipients receive information). Meanwhile, mixing privileged and underprivileged students

supports their learning from one another's *diverse* experiences. Also, greater differences in classmates' attitudes toward reading help students recognize their positive and negative consequences (*contrasting cases*) and pursue positive attitudes to learn more. Together, these results can help principals design arrangements of students into classrooms to improve their overall learning at little cost.

Recently, Ming has begun examining the complex data of text messages to detect online sexual predators and thereby reduce crime. According to the Federal Bureau of Investigations, 750,000 adults seek sex with youths daily (Rodas, 2014), but less than 10% are arrested (U.S. Department of Justice, 2017). To address this problem, Ming invented a new way to detect how these predators attract children (*grooming*). For example, a predator targets unhappy children with few friends and poor family relationships by talking about their own unhappy experiences and encouraging them to reciprocate. By doing so, the predator engenders sufficient trust in his victims to meet with him. Ming invented a way to detect this grooming by combining automatic computer analyses of words in messages (*computational linguistics*) with SDA and *Statistician* (Chiu, Seigfried-Spelling & Ringenberg, in press).

Leadership and Service

Ming joined the University at Buffalo's Department of Learning and Instruction as a professor, and later became its associate chair. There, he helped foster a culture of collaboration via birthday parties, flash research panels, best idea prizes, Google Docs discussions, and so on. In addition to building a stronger collaboration infrastructure (faculty expertise databases, one-stop information websites, communication tools, etc.), he cultivated relationships among colleagues to foster a community of scholars, co-authoring 14 publications with 11 faculty and 6 students in 5 years. Overall, his colleagues' average research productivity nearly tripled, rising from 0.5 to 1.4 publications per year from 2008 to 2014.

To raise the academic profile of University at Buffalo, he led its successful application for membership in the *International Society of the Learning Sciences*' Network of Academic Programs in the Learning Sciences (NAPLeS). In 2017, the University at Buffalo's Ph.D. program in Curriculum, Instruction and the Science of Learning (CISL) was one of only 33 programs in NAPLeS world-wide and was ranked as the fifth best online Ph.D. program in the United States (College Values Online, 2017).

Outside the United States, Ming has advised the Qatari and mainland Chinese governments on their education systems. The Qatar Ministry of Education and Higher Education invited Ming to analyze their student data and advise them on their education policy. Ming showed them that Qatari family influences (socio-economic status, parent attitudes, books at home, parent-child activities) on students' reading test scores were much stronger (192%) than those in European countries. Qatari preschoolers' many family resources help them develop greater literacy skills compared to many European preschoolers. However, after four years of school, Qatari students were 20% behind their European counterparts in reading, in part because many Qatari students believed that their teachers did not care about them. As a result, Ming advised Qatari education officials to invest in programs to improve young children's learning and the training of principals and teachers.

Ming currently serves on the Advisory Board for mainland China's Ministry of Education's *National Assessment of Primary and Secondary Schools*. After many meetings over meals, Ming persuaded the Ministry to re-design their overall testing strategy (from annual, isolated data fragments in each province) to an integrated database across provinces and across time linked to government information (e.g., demography, economy) at all levels (student, school, district, province). He also introduced ministry officials to new statistical analyses (multilevel cross-classification and multilevel growth models), and is gently suggesting integration of statistical analyses with computer algorithms to increase precision and efficiency.

Ming was the Charles R. Hicks Professor of Educational Psychology and Research Methodology in the College of Education at Purdue University from 2014 to 2017 and is currently Chair Professor of Analytics and Diversity at The Education University of Hong Kong (EdUHK; chair professors at EdUHK are essentially endowed professors). Supported by 34 grants ($8.7 million), he has disseminated his research through 178 publications (100 journal articles), 3 television broadcasts, 17 radio broadcasts, and 148 news articles in 21 countries. In addition to his research, he also runs Education Film Night, Publication Problem Solving Circles (small groups of faculty who answer one another's research questions), and is creating and merging databases to support data-driven decision-making at EdUHK.

Coda

When Ming nurtured his own students, he followed many of his advisor's practices. He let his students, like me, choose our research goals and tried to accelerate us along our chosen paths. Born in China, I had gone to The Chinese University of Hong Kong (CUHK) to do my Ph.D. and was Ming's first doctoral student.

For my thesis, I studied how people in public online forums in China discussed and solved mathematics problems, especially how they create new ideas to do so. I expected that many people would be using online forums to learn in the future, so I thought this would be an important issue. Specifically, I considered how feelings, displayed personal information (e.g., username, avatar), evaluations, elicitations, and knowledge content affected subsequent responses. It was a broad and challenging topic for me, because there was nothing like it in the literature at the time: no theory of online behaviors and emotions, no way of measuring emotions online, and no analysis of parallel online messages.

When I delineated these problems, Ming smiled confidently and said, "if there is no existing theory or methodology, let's create them." We explicated a new theoretical model of how online behaviors and emotions differ from face-to-face behaviors and emotions. Furthermore, we enhanced dynamic multilevel analysis to analyze online messages. I designed and created a computer program to organize and code online discussion data to reflect the complex tree of relations among messages in parallel streams. I used this methodology to identify critical events that radically changed online interactions and tested whether attributes of recent messages affected the nature of the current message. Our work yielded two journal publications and a press conference to disseminate the study to the public. At the press conference, photographers took our pictures, which appeared in several newspapers in Hong Kong and China.

Photo from Press Conference
Ming Ming Chiu (left) Gaowei Chen (right)

When my mom saw the newspaper photo, she said that was the proudest moment of her life. When my dad called me and told me that, my eyes teared, and a voice from the bottom of my heart said, "Thank you, Ming, for encouraging and supporting me to go forward with courage." After I won the CUHK's best postgraduate research award, Ming encouraged me to search broadly for a job, contacting his friends and acquaintances, including ones at the

University of Pittsburgh and The University of Hong Kong, both of which subsequently hired me. I am now an Assistant Professor in the Faculty of Education at the University of Hong Kong.

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