G. Thomas Fox

on becoming edGe-ucated

how uncertainty can link the frontiers of expert inquiry to the education of all

This book presents a novel and refreshing view of education showing how students, at all ages, can gainfully be taken directly to the constantly advancing frontiers of knowledge. The journey presents a profound and critical view of important aspects of educational research and graduate training that brings to life the bond between education and research.

The excitement found in this book includes how edGe-ucating often occurs within the challenges of classroom teaching (and beyond) and how to bring research into educational setting. Passion arises about the new opportunities that could emerge for individuals, cultures, societies, and fields of inquiry if all citizens were working at the frontiers of expert unknowns--with or without schooling.

G Thomas Fox is a professor emeritus from National Louis University, Chicago, Illinois. In his 55 years as an educator, he researched educational policy and practice at national and local levels, including at primary school through university doctoral settings; and for nearly three decades he has guided teachers and adult educators in researching their own professional settings.

ISBN 978-9935-468-31-4

9 789935 468314 >

EDUCATIONAL RESEARCH INSTITUTE

G. THOMAS FOX on becoming edGe-ucated

on becoming edGe-ucated

Professor Fox's deep passion for education is truly impressive. Next is his concern that research be properly harnessed to open the door to new ideas – which demands a critical view of its conduct and potential contribution. Constantly questioning, always open to new ideas and avenues, has guided his development of the idea of edGe-ucation which has accompanied his journey through the various corridors of the educational edifices in the US, the UK and even Iceland, as well as teaching both children and post-graduate educators. In his book, *on becoming edGe-ucated*, he explains thoroughly and with various examples the concept "edGe-ucation" and how it differs from "education" as often practised in schools. The book is enlightening and provocative, but also a pleasant and important read for the development of both education and educational research.

> Ólafur J. Proppé, former Rector of the Iceland University of Education; Jón Torfi Jónasson, former Dean of the School of Education, University of Iceland.

As fully engaging and radical as Thomas Kuhn's iconoclastic On the Structure of Scientific Revolutions, G. Thomas Fox's ideas about education, based on more than 50 years of experience, are nothing short of earth-shattering. Like Kuhn, Fox offers a paradigmatic shift in our thinking, urging us to look more deeply at the nature of knowledge and how we acquire it. The result: a truly revolutionary, as well as much-needed, 21st-century vision of education.

> W. Nikola-Lisa, professor emeritus, and author of multiple books, including *From Lectern to Laboratory: How Science and Technology Changed the Face of America's Colleges* and the Christopher Award winning *How We Are Smart: A Multicultural Look at the Theory of Multiple Intelligences*.

In addition to giving fascinating insight from an unorthodox career, Tom Fox's wonderful book validates the complex and difficult work of good teachers – those who wish to prepare their students for the changing and challenging world of today – and at the same time indicates new directions for teacher preparation.

> Dr. Sue Hansen, Consultant to Action Research Leadership Institute, Chicago Foundation for Education.

G. Thomas Fox

on becoming edGe-ucated

how uncertainty can link
the frontiers of expert inquiry
to the education of all

Editor:
Ólafur J. Proppé

Editorial team:
Jón Torfi Jónasson, Teresa Ritterhoff

EDUCATIONAL RESEARCH INSTITUTE

Published by the University of Iceland Institute of Education 2023

Cover art: Anna Jóelsdóttir
Cover art photography: Vigfús Birgisson
Design: Jón Proppé

Printed by: Prentmiðlun

ISBN 879-9935-468-31-4

The latent learning potential of the world population has been grossly underestimated as a result of prevailing mind-sets that limit the design of interventions.

David Cavallo, 2000

The greatest obstacle to discovery is not ignorance, it is the illusion of knowledge.

Daniel Boorstin, 1983

Science is the belief in the ignorance of experts.

Richard P. Feynman, 2015

Table of contents

Introduction

When I was guiding teachers on doing their own research within their classrooms, I seldom referred them to my research because I wanted them to focus on, share, and discuss each other's work, not mine. But with one group, I did. This group of 16 teachers were sharing the difficulties and hard work that reviewing the literature on their specific research topic was requiring, and they were wondering if it was worth all the trouble. I told them that the time they were putting in and the troubles they were encountering meant that they were engaged in serious inquiry. They were not only collecting data on their own; they were analyzing examples of similar work and lessons learned from other researchers in order to become better informed about what their data and experience might be telling them.

I then brought up my own current problem doing the same part of my research that they were. I described how I was looking for past experiences of, and educational connections to, bringing untrained individuals to work at the edges of expert inquiry. One of my main problems, I told them, was my inability to come up with a word for what I was looking for and what it was that I was trying to analyze.

"How about edge-ucating?" a teacher immediately blurted. Her suggestion stuck. The only changes I have made over time have been with different spellings where, eventually, the word became "edGe-ucating" with the hope that the capital "G" may help people emphasize the word "edge" when pronouncing the word.

You will find stories in this book about inexperienced newcomers who have been edGe-ucated as young as 7 years old, and others as remote from Western educational contexts as Thai villagers, including village elders with less than a year of formal schooling.

Unlike my teaching, much of this book is about me – both as narrator and participant.

I am an educator, and have been for 55 years. I taught children who were 10 to 12 years old for over seven years. I researched educational aims and actions in institutional settings from grade school through university, including the professional education of teachers for over two decades. I taught teachers and other adults how to do field research in order to help them work better with their professional challenges for nearly three decades. I did this work in three different countries: the United States, England, and Iceland. So, I am not only old; I have

been unusually lucky in the variety of educational work I have been hired to do.

Somewhere along the line, I began to encounter examples from a variety of settings – mostly outside of education – where untrained individuals were working at, and extending the edges of complex fields of inquiry. At the beginning, most of these situations were reported as unique, oneoff occurrences. But the variety of what I found pushed me further into trying to understand if what had been accomplished could become an intentional action like educating, that is, as a set of processes where one guides another to new skills and understandings. In the case of edGe-ucating, that would mean leading the non-expert to help reach and extend the edges of expert knowledge.

What made edGe-ucating different from educating was that edGe-ucating focused on what experts in an area of inquiry did not know, not on what they knew. It was the "ignorance of experts" (a phrase coined by the physicist, Richard Feynman) that was highlighted in edGe-ucating, along with the potential of non-experts to bring new perspectives that may help solve the experts' problem.

EdGe-ucating, then, twists around the educational assumption of expertise and ignorance. Expertise becomes not one end of a continuum and ignorance at the other end. Rather, ignorance is located at both ends – as is expertise. EdGe-ucating assumes that not only can the untrained be guided to understand some of the more complex, difficult, and unsolved problems facing an expert inquirer, but that the non-expert's added perspectives may also provide solutions to an expert's unsolved problem.

The twist that edGe-ucating brought to educating did not surprise me. As many educators who focus on what their students know, I often realized that my students – young and old – could have more insight into any field I was teaching than I – or my resources – did.

Over the years, I started to point out not only that edGe-ucating could be valuable to the individuals being edGe-ucated, but why individual accomplishments in becoming edGe-ucated could also be useful to their social, cultural, and civic environments, as well as to the inquiry field in which the edGe-ucating occurs. I have sometimes tried to convince educators that edGeucating could become a significant feature of learning in schools.

It may not be surprising that I have been less than successful in encouraging my fellow educators to try, or even consider, edGe-ucating.

So, in this book I decided to do something new for me. The aim would be to link my educational experiences to the possibility that all humans can learn at and contribute to the edges of expert knowledge.

That is not exactly how I began to write this book, however. After retiring from being a university professor of education eight years ago at the age of 78, moving to Iceland with my Icelandic wife, and trying to learn the language, not very successfully, I considered writing two books. One book would be about what I knew about edGe-ucating, the other would be a memoir. But I quickly realized that at my age I probably would not complete two books – and not only because of my age. Although I had written a number of articles, chapters, research reports, and a few book manuscripts, I had never published a book of my own. So, I decided I would try to combine my two book ideas into one, for general readers, not knowing if that could be done.

The organization of this book roughly follows the three stages of my professional life: teaching children, researching educational contexts, and teaching teachers how to research a particular feature of their own classroom that they felt needed to be resolved. I tell stories of my experiences at each stage that now provide me evidence that many of my successes at teaching, researching education, or even teaching teachers to research often fell short of edGe-ucating – except at times, edGe-ucating me.

All the stories in this book exemplify one or more of four themes embedded within my educational experience. One theme is that educating is filled with intellectual challenge, with much of this challenge going beyond guiding students to learn what is known. For example, a primary challenge in educating is created not by the processes of educating being so complex or difficult to understand. Instead, a primary challenge is that success in educating is universally unpredictable. One is never certain what a student, or a group of students, will do with a particular message or educative action before the educating occurs, while the educating is occurring, or even after the educating has been completed. Regardless of what one is aiming to stimulate another mind to be engaged in, what those minds will do with that expectation is never certain. This feature in the work of an educator brings the ubiquitous need to accept failure, and to consistently problem solve, which means throwing away what you thought would work, and create something better. I can safely say that nearly all educators recognize this unpredictability from their own experience.

A second theme is that expert frontiers in the sciences and all fields of inquiry are generally more capable of being understood and engaged in by non-experts than is currently acknowledged by most non-experts as well as by (too) many experts. As complex as a field of inquiry may be, its unknowns are far more capable of being dealt with than the educational experiences of the experts who have got-

ten to those edges suggest. Although only a few have recognized the existence of our general human intellectual capacity to deal with expert edges, there are many examples from a variety of settings, circumstances, and areas of understanding that demonstrate the efficacy of this theme.

The third theme is that those who educate in classrooms and those who perform formal inquiries around the edges of what is known in their respective fields have more in common than either the inquiry professions or the education professions have yet realized or imagined. The practices of both, for example, share the need for close observation, the application of strategic problemsolving talents, an active intellectual creativity with a wide-ranging curiosity, along with the humility to accept failure and continue to resolve, regardless. This theme, too, has seldom been entertained, either by educators or by expert scientists and inquirers. The stories included here may suggest another way of thinking about inquiry by both sets of professionals.

These three themes have become clearer to me through my 55 years of teaching early adolescents, of researching educational intentions and practices, and of teaching teachers to research.

The fourth theme, however, is one that I did not fully recognize until I was analyzing the three themes while writing this book. That theme is the central role that uncertainty can play as a professional characteristic that connects those educating with those performing expert inquiry at the edges of the known. A commonly shared recognition of the importance of uncertainty in the intentional actions of both expert inquiry and education may make it easier to connect these two professions than either profession has acknowledged.

Although all four themes have come through the stories making up the chapters of this book, this fourth theme will require considerably more attention, understanding, and practical action than I have supplied if the potential in edGe-ucating is to be realized. That is why the final chapters of this book discuss these four themes further, as I share what I have learned about edGe-ucating and educating from writing my stories. You will find, for example, that I have added endnotes for those final chapters for readers who may want to pursue further some aspects of what I have learned about edGe-ucating and educating.

You may wonder about the way I continue to use the word "becoming" throughout the book. I use "becoming" as an action verb, where the action is a process of change towards an attribute that is often aimed for, but never quite reached. It is used as in the phrase, "I am becoming tolerant," or "wise," or "educated." "Becoming" represents a process, in my case lasting decades as I searched

to understand what "edGe-ucate" could mean as an intentional educational action, including occasional advances along with more common setbacks. It is a word full of an implied admission that I am not there yet, neither in action nor, even, in fully understanding where I have been heading. "Becoming" is also a word that can be filled with special meaning for educators (for example, Carl Rogers used it in 1966), perhaps because most educators' long-term hopes refer to what students can accomplish with what they have done once they have left the educator.

Becoming, then, is an active process of growing into a more resourceful self or group of selves, a self or selves with greater realization of what is possible for us as humans to accomplish – individually and in groups. In addition, there is considerable importance to my using the word "becoming" while being edGe-ucated because failure is such a necessary feature within the processes of becoming.

As I now consider my becoming edGe-ucated in writing this book, what I realize is that this book aims to pique new interests in educating as an intellectual enterprise worth the struggle. That is not a simple goal. More of us valuing the mysteries and potential in taking educational actions means more may also entertain, imagine, and pursue how edGe-ucating could be better accomplished for all. If this book has helped to edGe-ucate, then it has encouraged a reader to begin to wonder if she could include herself in edGe-ucating as she considers widening her engagement with new intellectual challenges.

A more modest hope is that the stories contained within may be fun to read and to contemplate as a form of one human's engagement with the challenges of educating, including the mistakes and the imagined possibilities.

One
college at Princeton

why math?

At 17, in my last year of high school, I decided I would focus on math in college. It wasn't my first choice. In my early teens, I wanted to be a cartoonist. I drew cartoon figures constantly, mostly trying to catch action in sports I played, football, basketball, baseball, tennis. When I looked into becoming a cartoonist, however, I found that the profession included years of drawing someone else's creations. Not for me. By 16, I thought seriously of becoming an architect. I had been drawing house designs for a few years, concentrating on unusual shapes with floor plans and much glass. But then I discovered that the architecture profession also had years of drawing details of what a master architect had designed. Nope.

In my last two years of high school math, our teacher – she was tough, funny, focused, and close to retirement – occasionally gave us problems that had not yet been solved by mathematicians. One unsolved problem I worked on for months was to construct a simple formula for computing factorials, which are successive numbers multiplied by each other, starting with 1. The factorial for 3, for example, is 1×2×3 or 6, for 4 it is 1×2×3×4 or 24, for 5 it's 120, for 10 it is 3,628,800. For about a year, especially on sports team bus trips, I tried to come up with a formula for computing all factorials without having to multiply all the digits. I never succeeded, but think I did get to a partial solution for numbers less than 20. Don't remember more, but being forced to use only my mind appealed to me. When I heard that mathematicians often made breakthroughs in their twenties, that sold me.

College applications required I state a major, and so theoretical mathematics it was. When visiting the University of Iowa, for example, football coaches there suggested I talk with a mathematics professor. He told me, "Kid, if you want to do theoretical math, don't come here; we do probabilities." I turned down Iowa's full athletic scholarship, and took a partial scholarship to Princeton, along with promised hourly work. At Princeton I knew I could find out what theoretical math was, and if I could do it.

silence as praise

My first math class at Princeton was beginning calculus. (High school students now can laugh, but this was 1955.) Professor Steenrod taught our class of aspiring mathematicians, engineers, or scientists, about 25 of us. He was a full professor and had written many books and papers on algebraic topics, including a commonly used text on college calculus (which he didn't use). We knew we were in expert mathematical hands. Generally, our homework was to solve a few new problems, and in class we were called up individually to the blackboard to write our solutions.

Early in the fall, I was called, went up, wrote my solution, and returned to my seat to wait for his judgement. Professor Steenrod looked at the board for some time, then stared down at the floor. Silence. Then at the blackboard. Then at the floor. Then out the window. Then back to the blackboard. The other students were now looking at me, and I didn't know where to look. Finally, Professor Steenrod looked up at us students, shook his head and said, "I have never seen a proof like this," long pause, "but I cannot prove it wrong. Now, can someone else give us a different solution?"

At the time, I took this as ultimate praise, a sign that I was in the right place. My friends in the class, a few football players going into engineering, weren't so sure. They thought I should treat this as an error.

I never did find out why my solution was unique. Or just how Professor Steenrod so silently checked over my solution. Perhaps I was onto something without knowing it? He never said, then or later. I still have no idea whether I did something near an edge of math or not.

lots of courses

physics

You may think that math would have helped me in introductory physics, but it didn't. I was lucky to have a professor, John Wheeler, who was a giant in fields of theoretical physics such as gravity, relativity, and curved space. His lectures were pitched with excitement, enthusiasm, and insights into the invisibly small and the immeasurably large features of our shared universe, with a variety of stories, photos, videos, and physical examples. With intense passion, he occasionally described current debates about the unknowns, especially those in relativity, a topic in which he was a world leader (Einstein had died at Princeton the year be-

fore). Fascinating, exciting. But the emphasis in the exams was not on unknowns, it was practical problem solving, applying laws such as those of thermodynamics. Not my strength. Almost flunked. I loved the course, and much of the attraction of the edges of theoretical physics stayed with me. I wish the course had included work for us to do on the edges that Professor Wheeler was wrestling with at that time. After Princeton, I did get a chance to work in a theoretical physics laboratory, and contributed data from observations, but left feeling I could have done more.

literature and art

Literature and art courses fascinated me in different but related ways. Literature was verbal, while art was not only visual but highly verbal in the lecture hall. Lectures in both were passionately expressed, stimulating my mind with new possibilities of word, sight, and life.

In the beginning literature class, we were reading Faulkner and our instructor asked if anyone was shocked when the main character had sex with the family cow. Silence. Until I admitted softly, "Yes, I was shocked!" Adding, "after all, I'm from the dairy state of Wisconsin." After the loud laughter from the class subsided, our instructor asked, "Well, did anyone think this scene was funny?" Again, nothing, until I blurted, "Oh yes! I was laughing out loud when I read it." I learned something about human emotions from those two admittances, and their relationship to good writing, but not enough to do well on the tests. I also learned something about my sophisticated classmates.

I was struck even harder by the modern poetry we were reading later: cummings, Pound, Elliott, Moore, Crane, and especially – for me – Yeats. I remember writing an essay about how the sounds of specific letters could provide unique meaning to modern poetry. The "m" sound, for example, was peaceful, comforting, relaxing. The "t" sound, though, was explosive, troubling, destructive. (As I write this, I realize both those sounds are in my name.) My instructor thought that was rubbish, of course, and it showed in my paper's grade. But he also offered me nearly two months of private writing lessons because, he told me, I seemed to have thoughts that could use more practice being expressed. I appreciated his confidence, and his challenges. It was my first brush with becoming edGe-ucated in language.

I wonder, though, if maybe my foolish thoughts were near some of the borders of what modern poetry was trying to confront: the clash between what our minds do and what poetry and literature are guessing they do. Might there be

frontiers of insight, borders of understanding in the arts, to which beginners in the analyses of the arts may contribute?

philosophy of science

I loved the philosophy of science as it was then being pursued through the distinction between inductive and deductive rules of logic. I appreciated the power of deductive logic, so distinctive in mathematics. But I also knew, through experience, that deduction always left large parts of reality, and truth, behind. So, engaging with inductive logic was an attractive challenge to me, along with, I must admit, the idea of no logic at all. Perhaps combinations of all three could lead me to ways of understanding that I had never considered.

Although I did better in the philosophy of science than I did in science, I didn't have a clue of what the purpose was, of what the frontiers of the philosophy of science were, of what the unanswered questions were, or of where I could be in that enterprise. Another reason I didn't give the philosophy of science consideration as something I could do was that I thought I needed much more knowledge of science than I evidently was able to muster. It didn't seem right that someone not good at science could be good at the philosophy of science. I know better now.

history

I hated history. In high school it was all story and memory, and not very juicy story. But my increasing interest in poetry, in literature, and in the arts led me to take a history course in Europe of the 12th century. It was a small class, about 10, all fourth-year history majors except me, taught by a professor whose specialty was this period. We read original documents from those times, (in translation if necessary), and their analyses. The focus on everyday life in this century fascinated me, including the collective community work required to build Gothic cathedrals, the conditions that led to initiating universities, the needs for reimagining spiritual thought and practice, the social events that led to altering economic and political aims, the encountering and valuing of cultural clash, the creation of theatre for all, and the raising of nascent natural science.

Almost all these creative enterprises of the 12th century were stimulated, at least in part, by new discoveries of ancient Greek and the more current Arabic thought that was being encountered. The 12th century was a period of intense transition – much like ours in the late 1950s, our professor often said.

I tried to keep up with the class as an inexperienced neophyte in the practice

of history, and by the time of the final exam, I felt I was starting to feel comfortable. Perhaps I could pass the exam if I studied hard the night before.

Instead, that night I decided to go to a Bergman movie, *The Seventh Seal*. Not sure why; a lark, perhaps, or to place me deeper into those times. Or both. I knew the movie centered on death, religion, war, and love in the 12th century. For that hour and a half, I became so emotionally immersed that I was still in the 12th century the following morning, and did quite well on the final exam. Probably better than if I had studied. I remember being unusually comfortable as I performed the descriptive analyses that we were being asked for to demonstrate our understandings of the complexities and the interconnections of the cultural changes and challenges of that time.

Recently I discovered that around the same time I was taking this course, there was a similar history course being held at Harvard where, over several years, students researched the everyday lives of common people living in a single medieval French village. The students' collective work was then published in a book as an historical breakthrough, and became a best seller. Unlike us, those students were working at the edges of medieval history.

audits galore

In my third year of college, I also realized that I could enrol to "audit" a course, which meant that, even without the prerequisites, I could attend the lectures and sometimes the discussion sessions without taking the exams or getting a grade. This seemed unusually attractive to me, so for my last two years at Princeton I took advantage of auditing a variety of courses to expand my experiences in coming to know. I needed the intellectual excitement of new ideas, new formal languages, new possible connections of meanings, and new ways of questioning that were being created, discussed, and questioned. I was never asked what I thought I could add to any of these course subjects from the experiences I was gaining. Too bad. I probably was more capable of connecting these learning experiences to new, previously unconnected thought than I appreciated then. Or that I am capable of doing now.

mostly wrong but great

In the last semester of my second year, the eight of us who had identified ourselves as math majors were put into a small class of our own. On the first day, our young professor told us that this, our last course in calculus, was going to be taught from a "topological" perspective. He added that we would find out

what this meant as we worked with him. He was impeccably dressed, extremely confident, and creatively articulate. None of these characteristics were held by other math professors I had seen around the math building, instead favoring rumpled shirts, coats, and slacks, an occasional lack of a sock, and a shyness produced, perhaps, by constantly being within the mind. I had once seen Professor Steenrod walk into a tree. Our young professor's verbal acuity proved especially important as we entered into the symbolic spaces of topology and their algebraic configurations of curved dimensional geometry. Numbers weren't important; imaginative shapes and their relationships were. He exuded a passion for this work, along with its potential to us, as we applied a new symbolic language that expressed a variety of spatial relationships.

In addition to the nature of the professor, what I remember most from that class is the final exam. Most final exams were three hours long. This one had 5 problems. I don't remember the problems, but I do remember the return of my exam's hand-size "blue book." As I paged through my solutions to the problems, along with the red marks that accompanied them, I became more and more horrified! I had gotten three out of the five answers wrong! When I got to my answer to the final question (wrong), I was, understandably, extremely worried about my grade. On the page following my final answer were his comments to my work, and then my grade. The grade was 96 out of a 100, second best in class, preceded by comments about how much he appreciated my processes for arriving at the solutions, processes that were unique, creative, and well done. Thus, my grade was for my creation of mathematical processes, not for the poor arithmetic I had applied to arrive at my 3 incorrect final answers.

The unforgettable lesson learned was that mathematics was not about correct answers, but about the processes created to arrive at solutions. This was by far the most enduring insight into mathematics that I have ever had. I never forgot that lesson, and I never forgot the professor's name: John Nash. Only decades later did I discover that he had become famous as a Nobel Prize winner for inventing economic game theory, also a winner of the Field Prize in mathematics, and as the subject of a popular movie, *A Beautiful Mind*. The movie celebrated his accomplishments as a uniquely gifted mathematician who was also schizophrenic. At Princeton, all I knew was that I was told that he couldn't become my "major professor" as I had requested for my last two years in math, because, "He no longer is working here."

I have always known that I was blessed to have had John Nash as my introduction to topology and to contemporary theoretical mathematics. But what I

have never known is what made the processes I had created in that test to be so unique as to be rewarded with a high grade, despite the incorrect answers. Was I approaching some frontier of mathematical process? Yes or no, it would have been edGe-ucational if I had been told.

single wing football

American football is a strange team sport with 11 men on a side, each dressed with too much hard plastic padding over the shoulders, a harder helmet with a steel cage to protect the face (invented after my time playing), a great deal of running at each other, even more hitting once one got there, and then frequent meetings to plan the next move. My Icelandic wife says it is just a poor excuse for men to touch each other. To me, football was a central part of my life from the day I was born. My father was a college football star, captain, All-American, and, just after leaving college (and gaining a son), a football coach at the University of Wisconsin, where he worked for the first ten years of my life. Football was probably – no certainly – the reason I was accepted to Princeton with some financial assistance.

On the first day of football practice at Princeton (about two weeks before classes started), we were told the varsity team was looking for a center in the single wing, and I thought, how hard is it to throw a football 3 yards through your legs? I decided to give it a try. Although I made the freshman first team, I was a terrible center. Among other things, a center needs to be very strong in the upper body, and the strongest part of me were my legs and my quick reactions going forward. In the second year, I was put on the junior varsity team, practicing the other team's plays for the varsity to prepare for their next week´s game. The junior varsity team played some games of their own, and I even enjoyed the practices pretending to be the "other team." By my fourth year at Princeton, I remained on the junior varsity but now was playing quarterback as we helped the varsity practice for their games, and tailback in the single wing in our junior varsity games. Tailback (like quarterback) is the one who usually gets the football (passed from the center) and runs with the ball or passes it to others. I was also the punter, kicker of points and kickoffs, and captain of the junior varsity team. It was the summer before my fourth year that changed my view of myself as a football player.

Because I was fast, big for those times, strong in my legs, and didn´t wear my glasses playing, I had always blocked for others in organized football. That summer before my last year in college, I was sent to a reserve army training camp at Fort Sill, Oklahoma, along with many other young men from a variety of

colleges in the U.S. who likewise had entered ROTC (Reserve Army Training Corps) when they started college. Among these were football players from well-known football colleges, places like Alabama, Texas, LSU, and Oklahoma. When we could, we practiced together and worked out together. I was surprised to realize that I was the fastest and best athlete of the bunch, knew more football, and was one of the leaders of the group. I knew I could have played on their teams, something I hadn't thought for a long time. I returned to Princeton for early fall football practice with a different attitude about myself, and the desire to become a tailback.

My last and best game as a junior varsity player at Princeton was a loss to the Army junior varsity, which ended with us a few yards from making the winning touchdown. It was after that game that I was called up to the varsity, played tailback in the 4 remaining games, and was awarded a Princeton letter as a member of the varsity team.

The last thing that altered my view of myself as a football player occurred after the football season ended. All Princeton football varsity members were asked to fill out a questionnaire. One question was, who do you think would be the most likely teammate to be a successful professional football player? A majority of my teammates said it was me. Was I closer to the edges of excellence than I, or my coaches, had thought? Maybe it was a joke.

theoretical math for all

All third-year students at Princeton had to write a research paper in their major. I was never told what this meant for mathematics, but I thought it meant we were expected to do some original work in some area of contemporary mathematics. I was on my own in deciding what my topic would be, and I wanted it that way. I spent months in the math library looking into a variety of possible mathematical topics to tackle in a new way. Nothing seemed exciting enough to create something new, or that I understood enough to try. I began to worry about the deadline along with my talents in mathematics. Then I found a thin book with a topic that fascinated me: dimension theory, an area in algebraic topology that dealt with the definitions of the dimension of a space, including the specific spatial characteristics of these spaces, and the possible relationships that could occur between spaces of differing dimensions, starting with a space of zero dimensions (a point or many points), and then a space of one dimension (a line or many lines), or a space of two dimensions (a surface or many surfaces), and going to as many dimensions of a space as you wanted.

What fascinated me was that I felt that these esoteric discussions and proofs in topology were not only accessible to me, but they were potentially accessible to anyone. They didn't require much previous knowledge of topics like algebra or geometry to understand the questions raised or the essence of the proofs, only spatial intuition along with elementary notations of inside and outside or whether a space were open or closed. What I would try to do in my paper was to take this contemporary field of theoretical mathematics and try to make it understandable to nonmathematicians. This took me many weeks, and I turned it in just before the deadline. I got a good grade, but few comments, whether good or bad. Clearly, I had addressed a topic of little interest to my Princeton mathematics professors.

That summer, I shared my paper with a friend from high school who was a philosophy major and was not familiar with – or interested in – contemporary mathematics. He told me he did try reading it, but found it not easy going, although interesting in a strange way. That reinforced my view that I had found a challenge that I hadn't yet solved. It was the beginning of me edGeucating myself.

a revolutionary's refusal

I had heard that a Cuban Castro would be speaking at Princeton. I knew a bit about the Cuban revolution that had been going on with the Castros' small band of revolutionaries still hiding somewhere in the mountains. Although their on-going battles with Batista's army had captured some news interest, I knew I knew little, since events in Cuba had held my unique interest from childhood. My father had often told us a story about playing in a football bowl game in Havana in January, 1937, a story that always included how he and his teammates heard constant machine gun fire from just outside the stadium as they were playing the game. One doesn't forget a detail like that.

I found an empty chair near the back of a large room full of students and faculty who, like me, were interested in learning more about this revolution occurring not far off the tip of Florida. Raul Castro – Fidel's brother – spoke more like a banker than a revolutionary politician. He referred to Cuba's need for military resources, the difficulties the Castro band were having in their back-and-forth battles with the Batista army, the extraordinary needs of ordinary Cuban people, their lack of democracy and human rights, the extent of extreme poverty, ruled by mafia crime, and their common need for independence, freedom and free speech. Regardless of presentation style, I was struck deeply by the human immorality I was hearing, and the need for change.

After Mr. Castro's talk, I waited for the crowd to move out. Then, when he finally started up the aisle, I moved out blocking his way and said, "I want to join your army." He stared at me, saw I was serious, and with a sneer, responded, "I came here for money; if you have no money, you're no use to me." And pushed past me with his handlers.

That message was no different than most messages I had been receiving at Princeton. Will power may be something, but money was everything. Even in a revolution. I not only felt like a fool, I knew I was a fool. Although Castro's general rule was also foolish, this was clearly a terrible decision of mine. Some steps into the unknown are nothing more than stupid, and I certainly have made lots of those. Sometimes, our attempts at edGe-ucating ourselves are mistaken, maybe even dangerously so. Lucky me that Raul Castro didn't appreciate my offer.

mostly right but foolish

No surprise: in my last year at Princeton, I began to think about what I could do with my continued fascination with contemporary theoretical mathematics. What did surprise me, however, was that I had little idea what I could do, as I continued to try to judge my own talents in mathematics while also considering possible work. Going on to graduate school and eventually becoming a math professor was a clear possibility, but it was appealing to me less and less. My performance was not that special, but even more important to my decision making, being a math professor didn't speak to me; in fact, universities didn't in general. So, I wrestled with the one question I felt I had to solve alone: What could I do with theoretical mathematics if I were not to be a math professor?

Slowly, I began to hit upon a possible solution that completely surprised me. Perhaps I could teach contemporary theoretical mathematics to young children! I knew the theoretical math that had engaged me at Princeton had required almost none of the fourteen years of mathematics that I had learned up to my second year in college. Any child's everyday experience with space would probably be enough to understand and apply the minimal language and symbols used to work with the curved spaces of topology. Furthermore, I felt that basic rules of logic were something children applied from an early age. I knew from my third-year paper that it would be a challenge to try, but a challenge for me more than for the children. I also recognized that this was an idea that no mathematician at Princeton would consider important, and that appealed to me as well.

I clearly remember the weekend when I made the decision to teach contemporary theoretical math to children. It was the Thanksgiving holiday weekend

with my favorite aunt and uncle, a bit over an hour train ride away. They were favorite relatives because of their extensive reading and deep interest in ideas: his interest in arguing with experts in university disciplines while he had no more than an 8th grade schooling, her openness to culture like arts and opera along with her new Jaguar XKE, and their common fascination with jazz and sports car racing – all of which they shared with me. Both worked, were childless, and seemed genuinely interested in what I said as we conversed over their daily martini ritual. That weekend remains clear in my mind probably because I couldn't get to sleep on the couch, instead talking with myself about the exciting idea of teaching children contemporary mathematics. Not sleeping was new, but more unusual, for me, was that I didn't share the decision with them.

A few weeks later, I returned home for Christmas, wanting to talk to my father about my decision. He had been sceptical of other choices of mine, for example going to Princeton and not Iowa. I appreciated that his concerns were for my continued welfare and knew the criteria he used were always a viable alternative to mine. I wanted to inform him of my decision, but I also needed to test my new certainty against another I trusted. Talking with Dad might accomplish that. We sat on the couch one evening and soon were passionately arguing and explaining ourselves as clearly as we could for over two hours. Neither of us was surprised at what was being said by the other, but we listened, unconvinced. As we argued, I must admit, I grew ever prouder of my decision as I expressed new reasons for this decision, coming, for example, from being the oldest of seven. Definitely I was going to see what I could do to encourage children to become involved in contemporary theoretical mathematics.

In January, soon after returning to Princeton, I found an announcement that a preparatory day school was interviewing for a math teacher for 5th and 6th graders (10 to 12 years old). I signed up to talk with the Head of School. He seemed excited about my background and with my ideas for teaching contemporary math, adding that I could also teach gym to these ages, and help coach the high school football team. Within a few weeks, I was offered the job. Then came the biggest challenge.

out for good

I thought if I taught for a year or two, I could find out more about what it meant to try teaching children contemporary theoretical math. But I was also in the Reserve Officer Training Corps (ROTC), committed to two years of active duty in the army once I graduated. After all, the Army not only trained and educated

me to be an officer, they had also paid me a bit of money the last two years. I was expecting that this obligation could be waived for a year or two if I applied for it. I went to the ROTC offices with my formal request, telling them how important it was for me to teach children fresh from my Princeton years of contemporary theoretical mathematics before performing my two years of army duty. The army said, "Absolutely Not. After graduation, you will be called into the army. Period. There will be no postponement, no alternative schedule, and little wait." As I got up to leave, shocked to the core, I asked one last question, what if I don't graduate? Their reply was, "Then you wouldn't be called into the army. You have to graduate before your duties begin."

My dilemma became dark. Graduate, go into the army, don't begin teaching for at least two years; not graduate and not go into the army. But would I be allowed to teach if I didn´t graduate?

It was a crazy dilemma with serious consequences. I mulled over it for days, and then called the School Head. I hesitantly pursued the possibility of teaching there without a degree, telling him why. He thought about it, and then said OK, he would take me without a degree for a year and we would see. I packed up and left. College at Princeton was over. I could complete college after trying to teach young children contemporary theoretical math.

I expected that I could do well teaching young children contemporary theoretical math, and I had an intuition that no one else had tried it. I was also certain that this aim of mine was something that Princeton could not help me achieve, prepare me for, or strategize with me to accomplish.

I now know I was wrong. Princeton, and all institutions of higher education throughout the world, can be intimately involved in acknowledging, encouraging, and ensuring that women and men of all ages and from all backgrounds can become better edGe-ucated through their help. Universities can edGe-ucate others. But only if these institutions and their fields of inquiry feel a need and a want to fill that need.

Two

beginning to teach kids

teaching contemporary theoretical math

I had no preparation in teaching children, and had held no conversation with mathematicians on how to introduce contemporary theoretical mathematics to anyone, including the young. Still, I felt a need to try; probably because no one else had, as far as I knew. I did know that no mathematician at Princeton thought that teaching contemporary theoretical mathematics to children was interesting or valuable. Since there were no education courses at Princeton, I had only my imagination to rely on, plus my interest and limited creative talents in contemporary theoretical math.

Another primary answer to the question of why I wanted to teach children is that, as the oldest of seven, I had developed a deep respect for the private minds of the young. By 10 years old, I had experienced three brothers and three sisters from birth, and had realized throughout my childhood just how independent, unique, creative, and talented individuals are from the moment they are born.

Thus, I considered myself lucky to have been hired to teach mathematics to students 10 to 12 years old, in a preparatory school for boys. In terms of contemporary theoretical mathematics, I prepared by focusing on concepts that had engaged me at Princeton, and planned on taking about 6 weeks from the students' normal arithmetic studies to do so.

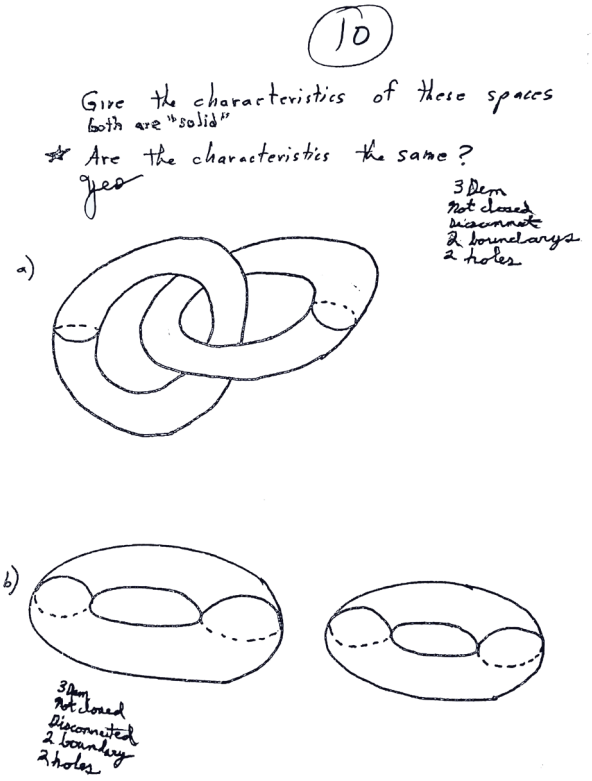
I chose to focus on topology. Topology is often described as "rubber geometry," meaning that it deals with spaces that can curve, bend, switch around, have holes, connect to other spaces, and have borders where a particular space stops. These curved, twisted, often limited spaces also have specific dimensions, from zero, one, two, three, four to any number.

Importantly, what allows a space to curve is being placed into a new space at least one dimension higher. An example is a page of paper, representing a two-dimensional space, bending within a 3-dimensional space with one edge of the paper coming back to attach to the opposite edge, to form a tube. In topology, such a space would be described as a two-dimensional space, connected, with two

boundaries (at either end) and a single hole. What would that space look like, if it had no boundaries? (Answer: the surface of a donut, with the two ends of the tube connecting, leaving no boundaries.)

My plan was to introduce the terminology, language, and concepts of topological dimension theory to students, and provide them exercises for applying this language to describe topological characteristics of a variety of curved spaces, from one to four dimensions.

For seven years I taught topological dimension theory to children from 10 to 12 years old, five of those years in a grade school for all children. I have kept a range of samples from the grade school children´s work from this course on topological dimension theory, and, as I look at their work now, I am impressed with how well they did. Today, I would not do as well as any of the children did 50 years ago. Below is an answer to a question from an exam, with 10 being the highest grade for this question.



In fact, the classes always did much better on topological dimension theory than they did with fractions, or proportion, or long division. The children also worked differently on topological dimension theory than they did on arithmetic. They were more intellectually engaged, asking questions, going beyond the examples, making up their own spaces, talking to others about the possibilities of new spaces, and arguing with the terminology if they felt it was missing some important potential characteristic of a space.

Furthermore, I learned that students who did well at theoretical contemporary mathematics were often not the students who had done well in the arithmetical math that they had had in their previous six years of schooling. Many who had difficulties with arithmetic were terrific at topology; some who were always near the top in arithmetic were not so in topology. Topological dimension theory required different intellectual talents and skills than arithmetic.

My course on topological dimension theory was not at an edge of contemporary mathematics at that time. It did, however, lead the children to understand and use some of the terminology, language, and approaches to problems that were being used by those working at the frontiers of contemporary mathematics in the 1960's, when I was teaching school. "Knot theory," for example, a field of topology that focuses on what configurations a one-dimensional space could take to be tied or not tied in three dimensions (my last math course at Princeton), was significant to the efficient designs of computer wiring and was at an edge of contemporary mathematics at that time. Although we never got to "knot theory," it used similar terminology and approaches to the ones the children were using.

I never thought then of having young students work at an edge of expert mathematical understanding. I do now. What I did do, without knowing it, was have the children take a first step towards getting edGe-ucated, as they began to use some of the terms and problem-solving approaches that were near the frontiers of what I had done in contemporary mathematics as a math major at Princeton University.

In my first year teaching children, I was also asked by the school head to teach contemporary theoretical mathematics to the secondary school's math teachers. He thought contemporary work in their field might interest them and be professionally enlightening. Sure, I said, I will teach them the same course I am teaching the children. That turned out to be a serious challenge for me – and for the teachers!

The high school level math teachers resisted the new terminology and found the spatial imagination difficult, along with the emphasis on the visual in solv-

ing problems. "This may be contemporary mathematics," they admitted, "and it's useless to us," they continued, "we'll never have to teach this."

Sixty years later they are still right. That may change. Information technology can easily support edGe-ucating students, anywhere, and at any age, to get to the contemporary frontiers of nearly every field of inquiry - including mathematics.

As my belief in the flexibility and power of children's minds was confirmed, a final lesson the children taught me was how they placed topological dimension theory into their classroom education. Every year, a few weeks after the children had been working on topological dimension theory, I would get this question from a student: "Hey, Mr. Fox, I was wondering: when are we going to have math again?"

teaching from educational edges

I was often close to frontiers in education while teaching children, but without knowing it. There are two important features to this admission: one is that I was, at times, dealing with the edges of educating children, where experts were uncertain about how children learn, or how to get them to learn. The second admission is that I seldom knew I was near an edge that expert educators were working on. "Modern math," for example, was becoming an educational edge around the same time I began teaching topological dimension theory to children. But it wasn't until later that I discovered that expert mathematical educators were promoting the idea of teaching Boolean algebra to young children. Boolean algebra is a piece of contemporary mathematical language that did not come nearly as close to a contemporary mathematical edge as topological dimension theory. It was, however, considered a prerequisite for learning contemporary mathematics, and was taught as such -with much public backlash.

Being at an educational edge, but ignorant of experts' educational thought (and they of mine) did not make me unique as a teacher then; nor would it now. Almost all teachers who try something new are working at an edge of education without any links to the edges of educational thought and research. Furthermore, the practicalities of teaching classes of students leave all teachers on their own educational edges. Because of differing group dynamics and with nearly every learner learning something unique from each activity, every class is different. Few general rules based on insights from research can solve a local educational problem without further analysis and adaptation by a teacher or group of teachers. So, naturally enough, as I tried some ideas of my own, I may often have been around edges of educational thought. Just as likely, I may also have been off the

edges of good practice. Most of the stories from my experiences of teaching children occur at edges where some educational experts were considering how to understand and deal with the challenges. But I didn't know that they were, and they didn't know, or probably care, that I was.

emotion and learning

In my first year of teaching math to 10-to 12-year-olds, I was also their gym teacher. We started with soccer (a big sport in our region) and then basketball, but by mid-winter I had noticed bullying on the fields and courts, as well as halls, cafeteria and classrooms. I had had some training in boxing when I was about their age, and boxed some at Princeton (losing my last one and a half front teeth). If I taught boxing, I wondered, might the bullying change?

I got permission from the school head and from the parents for teaching boxing in the winter quarter, with the parents promising to supply the mouth guards and the school the gloves (no head protector, this was 1960).

To prepare, I went to the head coach of a very successful university boxing team, and he gave me pointers about teaching boxing, emphasizing footwork, balance, and defensive moves, along with the left jab, including the flick of the wrist which supplies the real sting, the right cross and the uppercut. And lastly, the left hook which took the most practice.

In the gym, most students listened and practiced, some with extreme focus; a few didn´t listen at all. You can probably guess who did which. Wyndham was one who listened intently. He was tall and lanky, lived as the only male and only child with his mother, two aunts and grandmother. In sports he had been inattentive at best; in the classroom imaginative and quiet.

We worked on the basics of boxing for many weeks. Wyndham listened closely to the defensive moves, practicing them with his arms, gloves and movements of his head and upper body, along with his feet. He practiced the jab with the flick of his wrist, he worked on his right cross and uppercut. He also displayed an unexpected agility at shifting his weight for the left hook. Throughout the same time, B, the largest bully in the class, listened not at all, throwing only wide, rounding punches, and not practicing defensive moves in any way.

The class ended in a tournament with three weight classes, both Wyndham and B being in the heaviest group. B lost in his first match, clearly so. He was being hit with jabs at will and missing with his wild punches. No contest. Wyndham won all his matches, including the championship, keeping his chin close to his shoulder, moving his feet, flicking his jab, throwing right crosses when the

opponent dropped his guard, and the occasional left hook. By the last bout, he didn't seem surprised at all that he won, and neither did his classmates.

I remember this in some detail because one doesn't often see such dramatic change in a student. What I learned, and what was near an edge of educational thought at that time, was how significant deep emotions, such as fear, can be to learning. I knew motivation was being referred to by educational experts, but most often only in the abstract and demonstrated with money or some other tangible reward. In Wyndham I had seen an example of fear driving his need to learn, eventually to the extent that the fear was replaced by a realistic confidence in himself.

Existential fear can lead to learning, quickly and surely. Military trainers have probably understood that for thousands of years. Civilian educators, not so much. As we all know, there are plenty of existential fears in children today, starting with climate change, international warfare with nuclear threat, and the prevalence of firearms, for example. If we were to address children's fears through educating, many new edges of expert understanding would need to be addressed, with most of those edges having little certainty. EdGe-ucating may help.

open discourse and a new decision

Within my first year of teaching children at a preparatory school, I naturally came up against a variety of edges of educating. Although I had no academic preparation, I did have the benefit of conversations with my experienced colleagues as we discussed our challenges of teaching children and youth, the varied ways in which views could be formed about children's educational needs, and how their learning in school could be deeply affected by non-controllable social and economic contexts.

My colleagues' openness to me was genuine. The head football coach, for example, with more than twice the years of coaching that I had in life, treated me as an equal. He asked me for my opinions, often over a gallon of ice-cream, and we worked with my suggestions as we did with his, making decisions together. After our first game, we had noticed that our best ball carrier was often missing the spot where he was supposed to be going. We couldn't figure it out, as the boy was unusually gifted, quick, and focused. So, it wasn't attentiveness or brightness that seemed to cause the problem. I thought it may be his hearing. Since we used an ordered numbering system to identify where he was to go, I suggested we ask him to listen to and then repeat some of the code numbers we gave him. We discovered that he inverted and regularly rearranged the numbers, a form of dys-

lexia, although we did not have that term. After we changed to a system of color coding, there was no problem.

The art teacher and I often talked about modern art and where our various interests came from. He later asked me if I could take over a sculpture course he was scheduled to teach for spring semester when he had also scheduled a break from teaching. Although I had had no training or experience in art or education, he suggested that I could focus on my interests in space, dimension, curvature and shape, which he knew were special interests of mine. The class went well.

I was fortunate that I received that kind of collegial respect and communication within my first professional encounters with educational edges. I quickly learned that uncertainties were everywhere in teaching, and that that meant one often had to try something that they had never before thought of trying. It was an attitude to educating that I carried with me from that point forward. And, over my years of teaching, I continued to learn how important collegial conversation and respect were to me as a teacher of children, and how lucky I was to be in educational settings with open discourse.

As I considered my next steps in teaching, however, I decided that I needed to change my teaching environment. I had begun to desire to teach all subjects, not only math. Although I had learned that I could teach the math I had met at Princeton to young kids, my intellectual interests, curiosity, and readings at night had increased into many other inquiry areas. Reading about history, anthropology, archeology, and sciences like biology, microbiology and astronomy, for example, had become fascinating to me, along with philosophy. The best place for me to continue to pursue and integrate many of those new interests, while teaching the ages I found so enjoyable, would be in a school that served all children. In the U.S., that meant a public grade school. I also knew that that meant I would be working in an educational setting that included more females than males, unlike the all-male settings I had been in for the past six years. That change seemed natural to me.

out with textbooks

Before the children arrived on my first day of teaching all subjects to my first public school 6th grade class – at Odana Grade School in Madison, Wisconsin – I placed a student's math, history, science, geography, and reading textbooks on each desk. After all the students had sat at their chosen desks, peering around their books, I told them to pick up all their textbooks and follow me. We formed a line as I slowly led them, arms full, along the school hallways to the storage

room, opened the door and pointed to where they could place their textbooks. Once all their books were placed in tall stacks, we walked out, I closed the door, and we returned to our classroom, empty handed. I then told them what we had just done, and why.

We had removed single sources of information, some poorly informed, all dull. My purpose, I said, is that this year I want us to find better information from other kinds of sources, especially library books, and from people experienced in these subjects, and, as much as possible, on topics that interest us in these subjects. I told them that they now had the responsibility of not only learning, but of finding information to learn in each subject. And then, I added hopefully, you can share that with the rest of us.

I had given thought to what I was doing. I had transferred to an education major at the University of Wisconsin-Madison, receiving my bachelor's degree and teacher certification. I had heard criticisms of classroom textbooks and read about active learning, learning by doing. But I had never heard an expert refer to taking nearly all textbooks away from students (spelling was the only one I kept), and I knew little of what to expect, including how the students would respond. I could talk to the students a bit about how doing history was different from learning history, and that doing science was different from learning science. I learned such ideas from some of my history and science classes, not from my educational ones. Some of my critical education classes, however, referred to the variety of informative resources that students could choose, rather than being forced to read the limited choices in textbooks. That was talk, not experience. As a teacher, I was uncertain about how this approach might work with 10- to 12-year-old children. I'm not sure critical educational experts knew that then, either. Or now.

The first rule I gave the students was that they had to get a public library card, and show it to me by the end of the week. I worked with the school librarian and our modest library, but soon discovered that I would be spending much time in public libraries myself, often leaving with boxes totalling more than 50 books for the class each time I visited. Unfortunately, I also learned that it would cost me a relative fortune for overdue books. I won't list more consequences here – some positive – from taking away the students' textbooks, but a few may arise as I describe processes and outcomes that may have resulted from this move to have the children learn more about how to learn independently without textbooks. And hopefully enjoy that kind of learning. Some activities led the students to a few edges of knowledge as well as leading me to edges of educating.

what is matter in the very, very small?

When I taught 6th grade, 6th grade science was primarily focused on matter: for example, atoms and molecules. I thought it would be helpful to begin such abstract topics by seeing what the students thought about matter themselves. To begin, I brought in a bunch of stuff: paper, glass, sticks, stones, plastic, gum, matter of many different kinds, and in private gave them each a different piece. I told them to break up their piece into as tiny a bit as they could. The students then put a tiny bit of their matter on a small piece of paper under clear scotch tape, with their names on the back. We placed all the tiny bits of matter on a table, gave each piece of paper a number, and then tried to guess what each tiny bit of matter was. Was number 1 a piece of a stick, a piece of glass, or a piece of grass, for example. We wrote down our answers for all the tiny specks, and then we turned over the pieces of paper, one at a time, with each student then stating what their tiny bit was made of. We all were nearly always wrong.

"What does this mean?" I asked. "Does this mean that the smaller matter gets, the more everything is the same?" Some said "Yes, definitely they're the same. They look the same." Some said, "No, absolutely not. You can't make glass from small pieces of grass! Or sticks from small pieces of stone!" An animated argument began about what the consequences would be for either answer, noting, for example, that characteristics like color, smell, and texture seemed to go away the smaller you got with matter. Maybe even taste. The argument was still going strong when we ended for the day.

The students' homework for that night and the rest of the week was to bring any matter that they could find into our classroom. Sticks, stones, sand, grass, cardboard, glass, paper, plastic, dirt, be as creative as you can, I said. I had to say "No" to the question, "Can I bring my baby brother?" The students' desks were placed around the walls of the classroom, leaving space for the matter they collected. In a few days we had a pile of junk on the floor as high as the children's shoulders and taking up the space of a few desks.

"We are now going to have a discussion on what matter is," I said. "We will start with the question, What do you think matter is? Define matter."

The discussion had a few rules. First, students had to use their own arguments and reasons for what they believed matter was and why it was like that. No books or other sources could be used for support. Second, students had to use the pile of matter to demonstrate the points they were making; just telling us was not enough. Third, students were expected to respond to others' ideas, not just have ideas of their own. That meant listening closely to other students, asking ques-

tions if something were not clear to you, and also responding to what was said and to state whether you agree or disagree, and why. Fourth – and very important – was that everyone can change their minds. In fact, the point of this matter discussion is to think for yourself, to listen to others' views, and at times change your own view when that seems better than what you had thought.

I also wanted every student to be an active discussant, with two other roles needing to be filled: a moderator and a recorder. The moderator would be a different student each day. It was their duty to call on those who wanted to speak, maybe call on some who hadn't spoken yet, and keep the discussion on topic and in order. The recorder was my role. As recorder, I needed to take down what was said, type it up, and share it at different times for everyone to read, respond to, and perhaps disagree with what was said, including disagreeing with one's own statements. As recorder, I had to be silent.

The following is from a section of one class's discussion on the question, How does matter stick together? The discussion was started by a student who filled a bowl with water, and then wondered why the water fills the bowl, but the bowl is not filling the room. There followed a reference to a previous discussion on everything having holes.

Marybeth: if matter is mostly holes, then the bowl is shaped like a honeycomb

Lynn: it is not holes, but space with things in it

Joann: can space be broken into pieces?

L**ynn:** no, there is nothing to be broken up

Phil: (with two glasses of water) particles of water can squish in between space in other water

Sara: (with same two glasses) maybe at first water does, then after that, it can't and water will rise

Randy: magnets stick together, so lots of matter might stick together in the same way

Mike: matter sticks together by the space

Tom: if space is between particles, then how do they stick together? If Randy were right, the bowl would not be a specific shape, just a blob stuck together

Joann: matter is floating free in a particular arrangement

Lynn: (holding vinegar bottle with a bit of vinegar in it) if everything

were in a group, then you couldn't smell the vinegar, but you can smell it, so it is not entirely in a group together; so there is not always close groups of matter

Janet: vinegar is a kind of gas, but there is some sticking together, the liquid sticking at the bottom

Donna: (has someone smell a tongue depressor, then sticks it in the vinegar bottle, not touching the vinegar, then has him smell it again): why does the smell stick to the tongue depressor?

Paul: (taking metal can and pan moving them together, then away from each other) the metal pan and can don't stick together, you can touch them but they don't stick together

Lynn: all little particles can move around, but they are not completely free

Joann: some of the pieces of the vinegar floated around and onto the tongue depressor

Tom: (holding the tongue depressor) and into the wood, it seeped in

Janet: some matter sticks

Tom and Paul: this penetrates

Patty: floating around particles that happen to gather is the bunch of matter, I mean that is what makes up glass or labels or ink or metal or smell

Bill: why can't the can come apart itself?

Paul: why don't you stick to the wall if you stand against it?

Janet: why does tape stick?

Paul: you can pull it off

Peggy: what does "little pieces of matter" mean?

Phil: if Patty is right about matter, then you don't touch the ground when you walk or stand

The discussion continued, referring to heating as a kind of magnetism, sticking some things together.

The students discussed matter by raising questions and giving answers to five questions I asked about how matter acted in the very very small, and why. For each question, their answers, demonstrations, questions, and explanations usually continued for about two days, an hour or two each day. The large pile of stuff stayed in the middle of the classroom until the matter discussion ended, about two weeks later.

The discussions were always interesting to the students (and to me), with a variety of students stating, questioning, demonstrating, and interacting with what they believed or reasoned, and why. Often the students who seemed most comfortable and engaged in demonstrating what they thought, and why, were those who hadn't been "good in school." Nearly everyone, however, seemed good at questioning themselves and others. Are listening to others' ideas, and explaining and demonstrating one's own ideas separate intellectual talents from articulating what one has read? Maybe, but I'm not sure many professional educators were asking that question then. Or now.

My experience from five different classes with students explaining and discussing matter impressed me with their collective reasoning skills as they connected observation with logical explanation. It also seemed to pave the way for all students to engage more fully with the atom and molecule metaphors that they met soon after. No student seemed overwhelmed. I also learned how important it was for the students to hear themselves and to hear other students attempt to explain phenomena that required explanations of the unseen. I became convinced that this activity was useful to them before continuing to much more complex views held by expert inquirers. The questions that they asked, and the open ways in which they expressed themselves as they discussed what was known about how atoms, protons, neutrons, electrons, and molecules behaved, for example, were detailed and filled with wonder. As are those scientists who work with these phenomena.

One consistent educational edge in understanding children's minds over the years has been to identify children's capacities for dealing with complex thought and reasoning. These matter discussions suggest to me that 10- to 12-year old children are definitely capable of dealing with the complexities of trying to understand phenomena that cannot be seen directly. At the time, I didn´t know who I could contact to discuss these realizations about the importance of children grappling with their own forms of observation and logic before encountering and trying to understand expert theoretical models. I am still not sure, but I am certain that the issue is a significant challenge for educators, and, especially, for edGe-ucators.

stimulating questions through models

To help us learn about atoms and molecules, the students made a large model of the carbon atom. Models are nothing new to teaching and learning, but I wanted something more from models than the display of information. In particular, what

I wanted was models that could stimulate student thought, encourage questions, elicit wonder, and maybe disbelief. I wanted models that could encourage students to go beyond the physical presence of what was being studied to possible new connections that were not being made by their sources.

The point of the model of the carbon atom, for example, was not only to see the relationship between protons and neutrons clumped together in the nucleus, and electrons moving around the nucleus at different levels, but also to induce wonder at the immense empty space involved, the constant movement in the structures of atoms, and the necessary strength of invisible forces. Accompanying the aim to stimulate intellectual engagement through modelling, was my feeling that size could be useful, and that having students build the model could be significant to stimulating their thoughts about related topics. Although planning and building models in the classroom took time, I felt the challenge in the building process might be especially effective in helping the content retain a place in their long-term memory as well as immediately engaging them with the ideas immersed within the model. If the models were something the students had to bump into, to move around and constantly encounter, I thought that might induce a sense of wonder at what was there, perhaps bring a surprise along with some irritation, including the mystery inherent in what the model they built was trying to say.

The nucleus of the carbon atom was made of 12 pieces of crumpled up colored tissue paper, one color for the six protons, one for the six neutrons. These were smashed together and held up by a clear string hung from the ceiling in the middle of the room, above the desks a bit above a child's head height. For the six electrons, we used six tiny black beads, two placed in a circular path about three desks out from the nucleus, and four in a much wider orbit around the nucleus nearer the walls of the room. The electrons were likewise held in place by a clear string through each bead that was hung from the ceiling. We referred often to the horrible scale for our atom, and its actual scale, along with our inability to show the movement of the electrons or the pulsing of the nucleus.

Did the combination of discussing matter and large-scale modelling help? One year, I asked a school parent, a physics professor, if he could come to talk to the class about his specialty, sub-atomic particles. For over an hour and a half he discussed with the students the current theories and conundrums of sub-atomic physicists, punctuated by animated student questions and comments about the existence of particles smaller than atoms, a topic we had never covered in class. On his way out the door, the university professor came up to me and said, "I've

never had such interesting discourse with my graduate students as I have just had with your students here!" "Welcome to 11-year-olds!" I said.

I was hoping for similar questioning and thought when we were studying the Early Middle Ages in Europe, which is why we made the classroom into Chartres Cathedral. The students built an eight-foot version of the cathedral's stained-glass rose window with the stained-glass pieces made from brightly colored, transparent, cellophane paper, and the form of the window and the lead between glass pieces being black mortar board.

The entrance to the classroom became a near eight-foot high, three-foot deep portal covered with statues of saints made from medical cast-wrapping. Four wide columns were suggested by rough cord attached to wooden forms placed on the floor and ceiling, fluted similarly to the columns in Chartres Cathedral. A tall flying buttress was built and placed near the side wall of the room, and a chandelier of candles hung from the ceiling. Instead of the day or two that the carbon atom took us to build, making the room into Chartres Cathedral took closer to two weeks, a good part of every day. In addition to reading more about the middle-ages within the cathedral, we sometimes turned off the lights and listened to Gregorian chant, writing down our thoughts.

Not all models we built filled the classroom. Students made molecules out of colored gumdrops, a different color for each specific atom and held together with the number of toothpicks equal to the number of electrons being shared between atoms. When teaching the human body in fifth grade, students built a skeleton sitting in a desk of its own by the door of the classroom, to which were gradually added a heart, veins, arteries, a nervous system, and internal organs. (The first day we put up the skeleton, called "Clarence," I forgot to inform the janitor, and that night, he told me, it nearly gave him a heart attack.) In history what became the portal to Chartres Cathedral had been used earlier as the gate to ancient Babylon, and after that it was the entrance to a Greek amphitheater where we put on Greek plays and debates. This structure was about eight feet high, ten feet wide and nearly three feet thick, designed and built by students.

I never talked with experts on educational thought and learning about designing, building, and living in models that could encourage student reflection around specific triumphs of human enterprise. If I had, perhaps together we could have developed more insight into the nature of learning, especially by early adolescents. Perhaps educational experts could have tested out more complete sets of approaches to encourage deep learning that went beyond the limited pur-

poses of school learning, then or now. In the future, perhaps we can also consider how models would aid us in edGe-ucating.

poetry as condensed thought

I didn't focus on poetry until the early spring, well after we had been writing for clarity and reading for information and insight. We began this new enterprise by reading and discussing a range of modern poetry. I emphasized modern poets' creative uses of space between words, lines, and phrases, with only occasional rhyme, often a focus on everyday actions, feelings, and words. In my first year teaching 6th graders all subjects in Odana grade school, after some days of reading and talking about specific poems by modern poets, I brought in pots of dead or dying plants, put them around the room, and asked the students to write about what they saw, felt, or thought about when they looked at these dead and dying plants.

As the students began, Ahmet just couldn't stop talking with his neighbors. No shushing worked, so I sent him out the room with his desk, into the narrow hallway to face the brick wall and write his poetry. That was not my best moment of teaching, and it does demonstrate some of my many limitations as a teacher. But a miracle happened.

About an hour and a half later, after students had finished writing, I called Ahmet back in the classroom, and each student read their poetry to the class. Ahmet read two poems. Ahmet´s first poem was about staring at the rough, red bricks in front of him, wondering if there was anything more interesting than the repetition of those bricks. After describing details of the bricks and mortar, he went on, "Who could say if all the galaxies in the universe were more fascinating than this brick wall?" Ahmet's second poem was about himself. "I'm like the two ends on a stick," he began, "with the ends never touching." The class and I were stunned. Ahmet's two poems were like no other.

I never again brought in dead flowers, or anything else to stimulate the children to write poetry. Instead, I gave each student a small notebook, and real time to write, like a full afternoon. And I encouraged them to find a quiet place where they could think and write their thoughts. This could include a spot within our classroom, for example, or some other quiet space within the school, or on the grounds around the school. Or, even, home. I stopped calling what the students wrote "poetry," and instead we called them "condensed thoughts." After each day that they wrote their condensed thoughts, I typed them up, made copies for all,

and we would read them together later, and then discuss them, one at a time. Below are a few.

Robin's poem

Words
They come in haunting, shredding apart my mind,
they rip and jab
not having any mercy.
  Where do they come from?
  Probably they've sputtered
  out of lips, unable to keep them
  silent. They pierce the air with
their sharp sound.
Leaving wounds, unable to ever
  be repaired.
We allow them to rule us
they give us no choice
  and yet

  we use them
  we find them
we make their existence doomed.

Dave's poem

drowning in thought
spinning tingling sensation to form
a whirlpool of thoughts as though
all were secrets of the universe
bound tight inside my
mind, struggling, trying to rip
loose and I my mind holding everything
but locked without the key
and my mind stretching, reaching out across
the vast distances of space and I
hear nothing, see nothing yet my mind

hears everything, sees everything and my
thoughts taking over my body and
nothing or anyone exists except my
thoughts and they're thinking their
way through my mind
expanding understanding more,
knowing less.

Ann's poem

fuzzymindsBLURRYooozingrunningwater
drumsbeatingpoundingnervesstarttogallop
cracklingshatteringbonesstomachflyshigh
fuzzymindsBLURRY,futurecomesarushingworld
comestoanendatrapbeingsetstormseemstogather
barbellseemstodropslowlytogetsquishedfuzzyminds
BLURRY,whichwaytoturnwhatpathtofollowminds
rainingthoughtsfuzzymindsBLURRY,ideaspop
inquestionspopoutsunstartstoshinefuzzyBLURRIES
gone.

Jay's poem

norAud nda norAud
nikamg em
os zidzy I dlucon't
erad ym now gohtuths.
sA I eritd nda eritd ot greain
ym nimd wrloging ni ainp.
nigog
lilw I erve greain ti?
    Owh sownk?!

Julie's poem

the tall blades
of grass seem

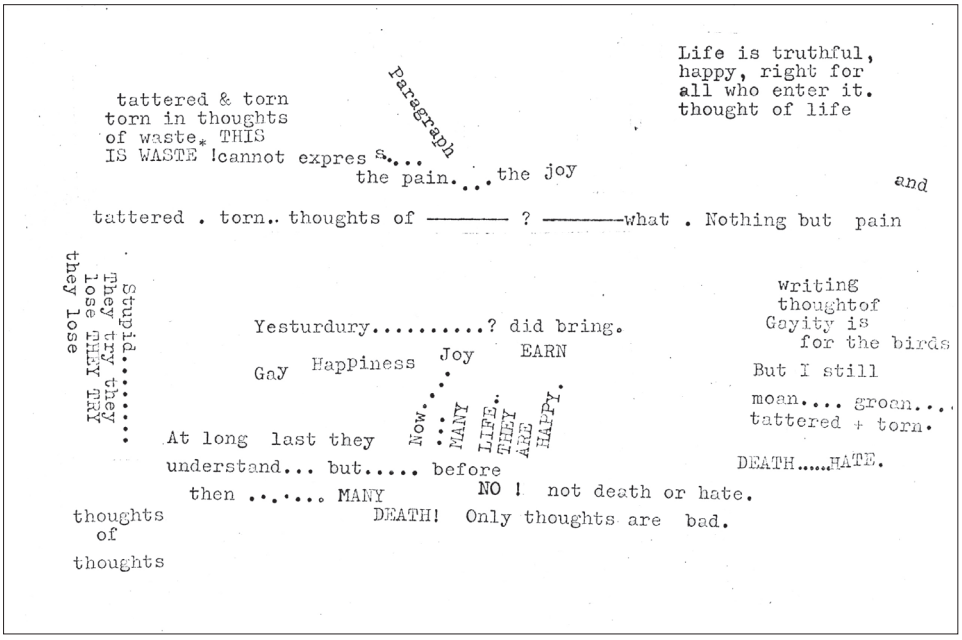
like little people
waving to me
in the breeze.

JoAnne's poem

"Yes, I understand, Mrs. X, of
course, I know you
want an appointment
very
soon, but we are simply
booked solid through
November. We've been
working around the
clock trying to keep
up with the demand.
With so many people
being born these days
it's easy to understand
why so many people
want to die. But
as I told you
before, Mrs. X,
we've been trying
to get the deaths
up. I'm sorry, Mrs. X,
but the earliest date we
have available is
Dec. 3. Will you
Take that? All right,
Mrs. X. Good-bye."

When we started writing "condensed thoughts," Marybeth told us all, "This is the dumbest thing I ever heard. Words are fine for saying 'get off my foot,' or 'pass the salt,' but words can't express thoughts!" The next week, we happened to go to a variety of university laboratories to get a look at science being done, and to hear scientists describe their work. One lab we visited was a biology lab experiment-

ing on a variety of dogs, cats, and rats. Below is one side of three pages, back-to-back, of Marybeth's private thoughts written the next day, typed as best I could from how she had spread her written words across a page.



On one afternoon set for writing condensed thoughts, Bill decided that he needed the quiet of home, so taking his pencil and small pad of paper, home he went. Within a short time, however, he reported he had to go outside, his mother was making too much noise cleaning the house. But in the next yard a neighbor was mowing. Bill couldn't concentrate. Perhaps the university, a short bus ride away, would give him inspiration, since much was happening there (this was the late 1960s). Getting off the bus, he walked for some time through the university grounds, occasionally sitting and writing his thoughts. He continued beyond the university up the street to the State Capitol building, where he stopped to write some more. Before he knew it, he was well beyond the State Capitol in an area he had never been, not sure where he was.

He began looking around for a bus stop when a police car braked in front of him. Two policemen jumped out and yelled, "Sonny, what are you doing?" Holding up his pencil and small pad of paper, Bill replied, "I'm thinking."

"Thinking?" shouted the cops incredulously, "You're supposed to be in school!"

I had a feeling that the children's poetry was special and unique. Towards the end of my last year of teaching public grade school, I put many of the children's condensed thoughts into a book length collection. I sent the manuscript to a well-known publisher of the arts in our state. He responded by saying, "I can't publish this, the children's poems are too good; they need a wider readership than I can give. But," he went on, "I have talked with a publisher friend of mine in New York who is interested." The publisher of World Publishing Company and I arranged a time to meet in New York.

I flew to New York expecting a brief conversation. We talked for an entire afternoon, starting with the poetry and who the children were (lower middle to middle class, Midwestern). Then he began grilling me about how I taught all subjects, not just poetry. After four hours of intense discussion about the children, the children's writing, and me and my teaching, he said he wanted to publish the work, but only if I added more about me and my teaching. I was deeply disappointed; I wanted this book to be the students' work, not mine. Although two literary publishers seemed to have agreed that the students' poetry had gone beyond a literary edge, their poetry was never published.

To listen to the minds of a variety of 10- to 12-year-olds speaking through their poetry is to be at an edge of understanding who children are, and what they are dealing with. I was certain that children of this age taking time to listen to and express their thought was worth their school time as they took risks in writing and sharing. They also discussed each others' work, often reading aloud a classmate's thoughts with differing inflections, expressing competing meanings taken from the written words, and occasionally remarking on how interesting a thought could be when read backwards. Mostly they reflected together upon how a classmate's expressed thoughts captured feelings that they were having.

If this were a step in edGe-ucating, however, the students needed more expertise in identifying the value of their literary work than I could give. Unfortunately, I never thought of looking for someone who could help them take that step. For example, I never thought of asking expert poets to help them prepare and publish their work. The students were clearly ready.

Three
kids continuing to teach me

constructing as learning

As I taught, I realized that coming up with new ideas on how to encourage students to learn was dependent not only upon me and my imagination or insight, it was also dependent upon how well I could observe and listen to them about how they learned. The point was to create situations where that could be done in a natural way.

One situation, I began to realize, was when the students were building something together. In addition to the Chartres Cathedral or a carbon atom, the Gate of Babylon or private thoughts, there were movies, debates, plays, and science experiments, for example. As I found opportunities for students to construct something outside themselves, I began to ask myself why this seemed so important to them, and to their education. Why did these actions seem to matter in stimulating their capacities to analyze and to learn? As they became more generally successful in handling complexities of new concepts, they also became successful in group production, forming genuine feelings of personal and group accomplishment as they interacted and interchanged leadership depending upon their talents.

I began to call these activities of production, "constructions," and to focus on what it meant for students to construct something that stood outside themselves. They were making something public related to their learning, something external which most educators (and others) consider primarily internal.

Too often, I thought, learning is considered private and contained only in singular minds. Such an attitude seemed inaccurate to what young minds were often doing, especially when they are trying to grasp complex concepts and/or production. To me, the word "construction" meant that the students were being challenged to make something meaningful outside of themselves that they could literally stand away from, something they could analyze, critique, discuss, revise, and encounter with others as well as with themselves.

What was especially important, I felt, was that these intellectual and physical activities could be accomplished with a focus outside of who they were. In-

stead of discussing and analyzing concepts that were internalized and personal, with individual doubts and uncertainties, or potential failings of the private self, they could focus on something "out there." What they had constructed could be thought about, could be analyzed and discussed with others, without it being considered only in one's head.

I had had some background as a construction worker and as a commercial painter working in large buildings like hospitals and airplane hangers. I knew what it was to work on something outside of yourself, to stand back and analyze that work without the judgment being about you.

To me, this attitude could be considered a significant feature of learning, especially learning something complex and ambiguous with a variety of possible connections.

When learning something new and complex, it helped to take that information out of your mind, so that you could consider it, play with it, go beyond it without any reference to your own smarts or capabilities or talents. Once new complexities were out there, they weren't you anymore. In fact, they weren't permanent, they could be improved upon, added to, critiqued and revised. By you. And often helped by others doing the same.

I built my idea of "construction" slowly. As I taught, I watched how the students responded to new complex concepts and to their own and others' ideas. I wanted to find a better way to articulate how children learned complex concepts, tried out new connections to build upon, and at the same time took on these new concepts as something that they could transform and improve by themselves, including with others. I began to write down my thoughts about construction in my last few years of teaching children. By the time I left grade school teaching, I had written a short essay on why placing complex concepts outside of oneself and into the public sphere was important to learning, especially for children. I titled it "Construction," but never shared it with anyone. It never got to an expert edge of education.

Later I discovered that around the same time I was writing about "construction," the same word had been applied by progressive educators to mean something quite different about learning. To those educators, "construction" referred to all meaningful learning that occurred internally and uniquely within an individual. The word referred to a private process of making one's own unique meanings from experience. Although construction can imply the building of a concrete object, to these educators "construction" referred to a private process of thinking, of making meaning, and of learning within one's own mind.

When I heard this version of "construction," I rather liked the idea of referring to learning as the building of private meaning; it represented how a group of students could create multiple meanings from a single classroom learning experience. Unfortunately for me, however, it conflicted directly with my view of "construction" in learning. The professional educators' view not only emphasized the private nature of learning; it often held strongly to the distinction between the imperfect relationship of what could be constructed in an individual's head and what was supposed to be constructed.

My own view of "construction," on the other hand, emphasized a public display, not only for learning, but for creating understanding through critiquing and improving upon complex ideas, often dynamically with others. And it emphasized that all these intellectual processes could be better accomplished by considering an object outside of the mind that could then be shared and altered in a public way. My view of "construction" was not a view that could be contained within a progressive definition of "construction."

Although I had written some essays about my ideas, I knew that the experts' definition would overshadow and prevail over mine. (I tried a bit to promote my view of "construction" as a graduate student, but didn't take it any further.) More than twenty years later, an educational thinker, Seymour Papert, created a view of construction similar to the one I had envisioned as a teacher but without, as far as I can tell, much success in changing how most professional educators still speak of "construction."

The following subsections describe some approaches to classroom learning that I called "construction activities." I still think my idea – now our idea, if we include Papert and his followers – of the public nature of "construction" in learning more successfully captures how children can learn complex concepts. Since I haven't yet argued it with progressive educators throughout the world, however, it isn't at the edge of educational understanding or debate. It still rests outside of that educational edge. Nevertheless, the view of "construction" proposed by Papert and myself may be helpful to designing processes for edGe-ucating going forward. And, at least for me, that proposition came from observing and listening to my students.

making movies

I had become interested in the potential of making film when I was in the U.S. army in Germany, following my first year of teaching at Odana grade school. In Germany, I bought a very good 8 mm movie camera, splicer, and projector to

see what I could capture of my experiences traveling through Europe in the early 1960s. Before returning to teaching, I thought seriously about how students could use film in the classroom, but I didn't want students filming students. Too much inevitable silliness that I didn't know how to deal with. Animated film, however, had always interested me as a child, and I thought that the children could perform all the roles required to make animated film by being the script writers, directors, and illustrators. In my following four years of teaching public grade school, each class made at least one movie during the school year.

One student-created animated movie that stands out in my mind is actually three films a class made, all at the same time. We were studying ancient Mid-East cultures: Egyptians, Mesopotamians, and Hebrews. Naturally, one fascinating topic for the students were the differing religious views, and the stories that guided those views.

Previously, the students had each done some cutting and splicing of my old films from Europe, synchronized with music. So, they had a grasp of cutting, splicing, and editing film, along with working with a tape recorder to sync film and sound. As a "math guy," I was especially pleased with how confident they became at working with the ratios of frame and time, with 16 frames per second. They had to apply that ratio to work out the number of frames for the time they had allotted for each scene of their animation. Ratio was always tough for most children to learn, but, as it turned out, not in making movies. They all did it, no problem. If you multiply 16 frames per second by 60, by the way, you will realize a minute's worth of animated 8mm film required 960 frames. A lot of work!

We formed three groups, Egyptian, Mesopotamian, and Hebrew, with each group responsible for making an animated film of a story from that culture that emphasized the relationship between the almighty and humans. One decision that each group had to make, for example, was how to represent the Gods or god in their film; another was what would represent men and women? Gathered in three different corners of the room, each group impressed me with the immediate range of possibilities that were presented and discussed. Clearly the task was not beyond any child. Eventually, each group came up with a solution that they felt was fair to their culture's view of the relationship of gods, or God, to humans.

The Egyptian group said they knew what Egyptian gods looked like, there were many images of them in drawings they had seen. All they had to do was make these images two-dimensional, similar to the ancient Egyptian drawings. They decided they would do this as mortarboard cutouts, covered with brightly colored reflective aluminum to highlight their unworldly aspects. Humans in the

Egyptian story would be marbles, easily moved around, but hardly distinct from one another. Their story was about Isis.

The Mesopotamian group chose large three-dimensional doll-like human shapes for the gods, with Gilgamesh, two-thirds man and one-third god, for example, being a strong-armed armored figure. Humans were sticklike figures made of pipe-cleaners in different colors. Their story was about Gilgamesh, an epic figure who interacted both with gods and with humans.

The Hebrew group chose humans to be made from 3-dimensional solid wooden shapes, not colored, that we had in the classroom to study mathematical properties of solids. Thus, each human in the Hebrew story had a unique form. The singular Hebrew God was a booming voice with colored lights flashing as He talked. Their story was about Moses and the 10 commandments.

I was bowled over by each group's portrayal of God and man, the dual portrayals capturing the relationship between the deities and the humans in their respective stories. What made the combination of their choices especially striking to me was that each group's decision was made independent of the other two groups. I doubt if professional film animators could have done much better in depicting the relative relationships of deity to humanity in those three ancient cultures.

A different year's class decided to make an animated movie of the ancient story of Gilgamesh, having been impressed with Gilgamesh's movements between the world of the gods and the world of humans. The students decided that telling the story of Gilgamesh needed two screens, one above for the heaven of the gods, one below for the earth and humanity. That required two movies, two projectors, both timed well enough to allow for simultaneous movements from one to the other, along with one tape recorder. Somehow, they pulled it off, with multiple showings to other classes, although never quite perfectly synchronized between sound and image. Their ideas exceeded their skill set. And certainly mine. But, once again, I was impressed with the students' understanding of the complex story, their thematic portrayal, and the meanings behind their intent and efforts. If the students had worked with guidance from someone with genuine professional film understandings, we can only guess at what they could have accomplished and produced.

Movies are difficult to make, and they take time. Especially animated film. Along with visual imagination, animation takes considerable planning, a focus on the details of moment-by-moment movement, moving forms frame by frame, and a variety of skills necessary to work within a group having a common goal. I

found that 11-year-olds can take on all the challenging tasks of making animated movies, from beginning to end, including the difficulties of synchronizing audio to visual (with no technical capacity for putting sound on 8mm film at that time). Not only were all students capable of completing the construction of an animated movie; in the process they became more knowledgeable on topics like ancient religions than many of the resources we had on hand. In addition, they became much better analyzers and critics of filming and editing that they saw on television and in movie theatres. With more knowledgeable guidance than I could give, I have no doubt that they could have reached closer to the edges of professional filming. As we know, children are doing that now, usually outside of their schools.

debating as ancient Greeks

Studying ancient Greece in 6th grade was always fun. There is so much that can be considered: democracy, architecture, philosophy, science, history, theatre, unique battles, and the everyday life of those living in ancient Greece. Not everything could be covered, of course, not even by 11-yearolds. Each year, however, every student became either a Greek thinker or an expert on some basic areas for understanding ancient Greek culture. The thinkers included Aristotle, Plato, Socrates, Pythagoras, Homer, Euclid, Aesop, Pericles, Archimedes, Herodotus, Diogenes, a Spartan, Euripides, and Hippocrates. The cultural topics included themes like city states, architecture, religion, epics, or battles such as Thermopylae. All students learned the Greek alphabet (applied to English sounds, like in writing their names) and some basic history including everyday life. Each student also performed in an ancient Greek play, and wrote an illustrated Aesop fable of their own (including in Greek lettering along with the English). Most of the information and details of ancient Greek culture were shared by student experts who got their information from a variety of resources.

Each year eight to ten students chose an ancient Greek person to "become." After learning as much as they could find about their individual, the Greek thinkers debated about questions such as what they thought about the gods, or knowledge, or power, or democracy, or what was a good life. These debates on a particular issue were performed daily, publicly in the classroom, usually for an hour or more. For the week of debates, the rest of the class were the audience, listening, taking notes, and, as ancient Greek citizens, asking questions for more clarity from the individual Greek thinkers in front of them.

The final exam included every student writing a Greek dialogue. Questions for their dialogues were centered on a few current issues of the day, like what

could be done to improve the life of the poor, or about the increasing use of drugs, or about what they thought of hippies. The students had to choose one of the questions and write a dialogue using at least four of the ancient Greek thinkers who had been in on the debates. I did not record the debates, but did keep the written dialogues. Below is part of Christine's dialogue created around the question, How can we best understand the problem of the very poor in our big cities?

Archimedes: The cause of this problem is that they are not educated, send them to schools, educate them, then they should learn a useful trade, we coulduse some fine businessmen and inventors.

Pythagoras: If they went to school, it still wouldn't help them, their numbers are arranged so that they are fated to be poor, so let them stay that way. You can't change their numbers.

Spartan: This number business is nonsense. They should steal more. It's stupid to sit there and starve. Anybody who is born weak or can't steal should be killed. Why live with somebody who can't steal?

Diogenes: Stop this bickering! What are you so worried about? A person doesn't have to have chairs, a fine house and banquets every night to be a good person, I live myself in a barrel.

Archimedes: These people need a change, they need good teach- -

Pythagoras: Don't you understand that they can't change no matter what, their numbers are arranged so that they are poor!

Spartan: Have you given people numbers?

Pythagoras: Yes

Archimedes: What are they?

Pythagoras: Well, that's mine. If you really want to know, come to my school.

Diogenes: Why talk about your numbers if we don't even know what they are! (fight, bicker fight, bicker)

Pythagoras: Let's get back to the subject. All right, it's true you don't have to be rich to be a good man, Diogenes – -

Archimedes: But how could anybody raise children in a barrel, are you going to get a bigger barrel or many bar- -

Diogenes: I didn't say you had to live in a barrel. I'm a citizen of the world! I can live anywhere I please! By saying I live in a barrel I meant that you don't have to have a lot of things to be a good man.

Archimedes: Perhaps you don't know, but there are some very hot places and cold places in the world!

Pythagoras: And if you don't have a decent house in extreme climates, you'll be in for a surprise.

Diogenes: Archimedes, cave people lived in the cold. And Pythagoras, I didn't say you couldn't have a good house, but many people who are rich aren't happy.

Pythagoras: Well, just because you are poor doesn't mean you are happy, either.

Diogenes: I agree.

Spartan: Quit talking about living in a barrel! The problem is here and now.

Archimedes: Yes, I agree. The answer is a good decent education so that they can earn their food, and not steal it.

Pythagoras: Well, there aren't enough good teachers.

Spartan: If I lived in such poor conditions as there can be in cities, I would march out against the rich men. Why do they just sit there and let the rich men put them into debt? They should march out against them, burn houses and conquer them!

Diogenes: I believe that there is no honest man. And as it looks, I am right for here people are stealing, the rich are taking advantage of the poor and all sorts of things like this are happening!

Spartan: But marching against the rich is the only way they can do it.

Archimedes: Yes, Spartan, but after you conquer the rich, they'll take revenge and you'll be no better off than you started!

Citizen: I think we have your points of view pretty well, now I have a question.

To me, the students' written debates reach the edges of 11-year-old children's understanding as well as of what we consider their education should include. Children clearly know what dialogue is, they know what argument is, and by 11 years old they can apply and argue with thought, logic, and analysis. When it comes to philosophy, and understanding the nature of argument, they are not the neophytes that we seem to assume from the way we approach education. How often have we allowed children opportunities to display their philosophical sophistication in school? Has academic philosophy ever been considered a useful tool for children to apply? Would academic philosophers enjoy working closely with 11-year-old students? From my experiences listening to 11-year-old students work with the conflicting ideas held by ancient Greeks, both in the circumstances of ancient Greece and of our times, I am convinced that students of that age could deal creatively with the edges of current philosophy.

Unfortunately, I did not capitalize on what the students were demonstrating to me. It didn't occur to me that there could be opportunities to bring in experts in ancient Greek thought, for example, or in modern philosophy to work with the students. They showed that they were close to being ready to engage with the edges of academic philosophy of their time. They just needed more expert guidance than I could give - along with intellectual respect, of course.

designing one's own science experiments

Near the end of the school year, I wanted to reward the students for the science they had been learning by experimenting on their own. More than that, I wanted them to get experience in doing science by asking and answering their own questions. I knew that they would enjoy being in charge of asking and trying to answer their own questions. It also seemed a no-brainer to do this near the end of the school year, when I felt I knew enough about each student to trust their individual decisions as they worked them out.

We had read and discussed what science experiments were over the course of the year, and I gave them a few days to consider what area they might be interested in exploring on their own. Many decided to question how heat worked, some questioning what burning did or how flames worked. Liquids were an interesting area for others, knowing, for example, that water boiled to steam, but then wanting to test how steam behaved and why. For others, bubbles were especially interesting to investigate more closely.

I bought small alcohol burners with thick wicks, a few beakers and ceramic plates, and stands that could hold the beakers or plates above the burners. Also lots of aluminum foil to protect the wooden topped desks, along with pot holders.

Other topics chosen showed wider interests. One student, for example, decided she wanted to locate the sun's placement in the sky over time, from sunrise to sunset. She had been told that the sun's placement changed over successive days, but she wanted to see that for herself. She thought that if she measured it over some weeks, she might get a better understanding of how the earth revolved and circled around the sun. She became extremely excited by her measurements and with how the results of plotting the locations of the sun over time was helping to make clear to her how the earth moved.

I was surprised when two boys came up to me in the hall at the end of a school day to explain the question they wanted to raise together. It wasn't easy for them to explain in words, so they showed me as we were walking in the hall-

way. "We know speed," they said, walking slow then fast. "And we know that is measured in distance over time. Like miles per hour. But there is something besides just speed. Like you can change your speed." One then walked faster and faster, and the other began to slow down. "We have been wondering," they said, "just what time might have to do with changing speed. We know time is involved, but how?" They stopped, paused, looked at each other and then at me. "We kind of think that changes in speed have to do with time, like speed does, but we don't know how you say that? If you go faster and faster and faster, you can't just use the different speeds. Because the speed is changing all the time." So, their question, they explained to me, was about how one expresses the fact that speeds can change every moment without having to measure each change of speed at every different moment.

I was immediately struck by their insight, especially their interest in how time was involved in change, and how to express the facts of acceleration with constantly changing speeds. I knew enough math to know that they were talking about acceleration, a topic that Newton and Leibnitz had worked on, nearly simultaneously, as both invented calculus. I also knew enough physics to realize that what they were asking was a question related to Galileo's investigation of the relationship between acceleration and gravity.

In my excitement, I wasn't sure just how to respond, but I wanted to encourage them without saying too much. I told them that they were onto a very important question here, and that one word that could help them was that changes of speed were called "acceleration." Like a car accelerates when you put on the gas. I encouraged them to keep asking their question, and I felt that their focus on time, and on the problem itself, was a good one. I don't remember how they ended their inquiry. They did not invent calculus, but if they did encounter calculus later, I am sure they recognized that they had asked the right kind of questions and had tried to answer them in their own ways.

That was success to me. It was exciting to see each student working on their own questions, and trying to see if they could supply more understanding by asking and trying to answer their own questions through experimenting, including thought experiments. That is not enough for edGeucating. But my experiences with 11- and 12-year-old students working on their own questions and trying to solve them through experimentation, observation, measurement, and applying the mind, suggest how ready they were to entertain a variety of current expert approaches that try to understand complex phenomena – in all areas of inquiry, not only in the sciences.

studying the present

In my last year of teaching grade school, I thought it might be a good idea to jump to studying the present as part of our history of humans. In previous years we had never come close to doing this. More importantly, I realized that this group had displayed considerable interest and talent in analyzing themes related to society, culture, and human values. A study of the present seemed a good challenge for them.

I wasn't sure how to go about it, but I wanted it to be an active study, not entirely based on reading others' views. The best I came up with was building our classroom into an imaginary community with housing, businesses, streets, neighborhoods, people of different nationalities, race, backgrounds, social status, talents, and seeing what kind of questions and concerns that they might come up with as they made that community into a complex human enterprise. Although this incomplete idea fascinated me with possibilities, I did not want to pose it to the students. Instead, I gave them the open question, "If we studied the present day, what might we do?"

The class got animated and immediately began to generate ideas about how to study the present day, including going to businesses, work places, public spots, different neighborhoods, talking to a variety of people. As they continued to raise these possibilities, and tried to revise them to accommodate being in school, the students unexpectedly seemed to be coming up with an idea close to the one I had had. We could create an imaginary society in our classroom, with streets and people, communities, businesses, and government. And then we could create ways to show how different interests can change actions and how the variety of people within this imaginary community could interact with each other, or not. The excitement in the room was growing with so many ideas and possibilities coming up that each student had to raise their voice to be heard.

Then, Gayle, a thoughtful and talented student, who on this particular day was sitting near the back of the class, piped up, "This is the dumbest thing I've ever heard! Why do we have to make up an imaginary society when we are in the middle of the present ourselves?" Everyone stopped, some looking back at Gayle, some looking at me, some looking at each other. Silence. I looked at Gayle, embarrassed at my lack of similar insight, and asked, "Do you have an idea for how we can do that?" "Well," she immediately answered, "There are all these kids in our school, why don't we study them?" The class immediately erupted enthusiastically to Gayle's idea, and I knew we had an aim that we could accomplish: to

study the present by studying those in our grade school. I had never thought of that, had never done anything like that myself, but, I thought, I think this class can do it. Quickly, the students decided to give it a try.

"OK, then your assignment tonight," I told the students, "is to write down your ideas about how we can study students in our school. Bring them in tomorrow so we can discuss in more detail how we will do our study."

But after the students left, I realized something. It would not be possible to do any study of the children in the school unless the other teachers would allow us to do that.

I had always had great respect for all the teachers in our school. They were experienced educators, strong independent women of various ages, more experienced and more capable of teaching basics like reading than I. I knew that their students always got their full attention. Furthermore, each teacher had a unique style of teaching, and I always thought that was a big plus for the students. Still, when I presented this idea of a study at a teachers' meeting that afternoon, they surprised me. All agreed to having a student of mine observing a student of theirs in their classroom for a morning or afternoon – with a few conditions. The observer must be as invisible as possible: no talking or disrupting the class. Also, the student being observed should not know they were being observed, and the name of the observed student should never be made public.

The next day I told the students it was a go, but only if the conditions from the teachers were obeyed. If anyone violated these conditions, our study would be called off. Period. We then began discussing their specific ideas on how to study children in their school. Although none of us knew what we were doing, after a couple days of discussion we had a plan. The following became our plan.

Each student would observe two students, from two different grades. No names would be used. The observations of each student would include two half days in the classroom, at least two times on the playground, and two times in their neighborhood. We talked about observing and taking notes, and of how not to be obvious about who they were watching in the classroom, playground or neighborhood, and why that was important. We tried to distribute the observations equally across grade levels and across classrooms. As we prepared to start our study, I wasn't sure whether the observers would manage to be "invisible," or how well they could take notes while observing.

Bob demonstrated that I needn't have worried. Bob had been the bad boy of the school for all seven of his years there (which is why he was put into my classroom). I liked Bob, he was impulsive but quick and if he was really into

something, he was insightful and creative. One boy he chose to study, a second grader, was a neighbor of his who was liked by all the kids and the adults in the school and in his neighborhood. The boy had a reputation of being polite and self-controlled, pleasant to everyone, and Bob told me he wanted to know what that was like.

On that first day of observations, a morning, half the students, including Bob, went out to observe. At 11:30, the end of morning classes, Bob came running down the hallway, yelling, "He is just like me, he is just like me!" Breaking two rules at once, he was also waving pages of paper covered in notes to prove his point. After he came close enough to talk, he added: "He bothers the students next to him, doesn't pay attention to the teacher, yells out answers to questions without being called on. He's just like me!" Bob had five pages of notes to prove it.

Everyone took extensive notes, and as we talked about what to do with these notes and with what they were finding, the students suggested that they needed to get to know those they observed better, more than they could get from observation. "We need to talk to them," they said, "find out more about what they are thinking." We decided these talks would be done in pairs, with a second student being responsible for taking notes of the questions and the answers. As we discussed what talking to the students meant, by the way, I had to let them know that throwing wet paper towels in a student's face was not allowed. And why.

The observation period took two weeks; the interviews, done in a utility room, was about a week more. In considering how to analyze their observations and interview of each student, I suggested that they use their notes to help them choose five words that described their nameless student. For each word they chose, they were to write up why they used that word, referring to the notes they had from their observations and interview. Below is one example from Sharon who describes a 4th grade (10-year-old) girl.

> She acts like she is always being watched, and trying to look good. In talking to me, for example, she tugs at the strings of her hat, pulls up her socks, moves legs all over, pushes her hair out of her forehead, talks fast and pronounces her words distinctly, smiles like she were a goody, and is kind of jumpy in her seat. When she sits at her desk, she kind of admires her ring and plays with it, she acts like she's thinking real hard and grits her teeth, erases every little mistake and throws it away, and writes her words very carefully, talks under her breath like she is thinking real hard, pushes her hair around. She also acts like she is a big help, like when, after writing, she slowly goes

to help her neighbors, like she is a big help! She also seems nervous. I'm not sure why she does this, maybe it's involuntary, but she very frequently licks her lips, pulls at teeth, rubs teeth, bites nails, rubs her nose, talks under her breath, her back is usually towards the person who's talking, puckers her lips. I also tend to think she has a lot of confidence in herself, or just maybe a little conceit! In a way she seems too sure of herself or, at least, knows pretty well what she is doing. In describing herself, she refers to being "quite creative," "good in art," "liking to get up in front of class and talk," and, quite surprising, she answered the question of, How would you rearrange the room? she said, "I would have three boys and me in a small group, with blue carpeting and blue flowers around the desks!"

She's a shy person and many of her thoughts do not show. So I was especially surprised to find out she really paid attention to boys and wanted to be around them. The reason she may do some of the things I've said is because she has a lot of confidence in herself, to keep her going. And if she didn't have that, then she wouldn't be the happy, enthusiastic, and hard working kind of person she is.

The students got together to compare and contrast the individual children described in their respective classroom levels and then shared their findings to the class, grade level by grade level. But many students were dissatisfied. They said they felt that they had more to discuss from what they had learned from these individual children. After discussing what made them uneasy about what they were finding, they decided that each grade level group should get together to design a better school environment for the children they studied.

Their recommendations for improving children's learning environments included such items as special tunnels for reading, time to study by going for a walk, having a glass floor in classrooms to look at ants and bugs and other life below the ground, and an experimental room to try out anything the children wanted. One group suggested more windows and bright lights, mirrors, including "goofy mirrors." Another suggested an amusement park with a merry-go-round; another suggested tall ceilings with high trees spaced throughout the room with tree houses for small groups of students to work together.

Some groups designed furniture, space-bubble chairs for privacy, each a different color, comfortable with a radio that could be turned on to talk to or listen to the teacher, or for music when one is reading, with a desk that could slide up

to write on. (This particular chair was shown through three detailed drawings, with comments.) One group recommended a great big book that a child could walk through and see the story come to life. Another suggested a huge dinosaur model with soft insides to study in, and a tail that could be moved. Desks other than the bubble chair were described, with many file drawers for organizing materials. One suggestion was for a "cube" where you can pick anything you wanted to study, anytime. There were many suggestions for more books, especially adventure books, or books about real life, and many suggestions for more time for student talk, for student creativity, for enjoying themselves like bumper cars or desks that fly around, or mazes with doors that opened if you solved a problem right.

There were a few general suggestions for teaching, like having more work on getting along with others, and more time for exploring and finding things out for themselves.

As you can see, the students let themselves go wild with these recommendations, some more serious than others, but they related everything to what they had recorded about the children from their observations and interviews, and subsequent analysis and discussion.

The students' study of children in their school concluded with making an animated movie titled, "Life with Dick and Jane, and Sally, Spot, Tim, Tom, Puff, Harvey, …" (*Dick and Jane* was the title of all their beginning reading books.) The following are a few scripts from about 40 short animated scenes the students made to express some of the realities in the lives of the students they observed.

1) Dick walks into a classroom and he stutters when he talks, and the whole class laughs at him. He then walks away and he kicks a dog laying on the ground.
2) Bob's hairy thing [Bob designed it] walks into a crowd and they all run away. He walks into another crowd and they run away. All kinds of people who look like him but with different shades of green hair walk up. He walks off.
3) Sweetly, Sally runs up to Jane.
   "Do you want to play a game?"
   Jane shouts, "Get lost ya little punk!"
   Sniffling, Sally says, "But, but …
   "Did you hear me, get lost." Jane walks off.

Sally runs off crying into some bushes and hides. In the bushes, she finds Tim and says sniffling, "Yim, you're the only one who likes me," and hugs Tim.

4) Dick is sitting on the ground, reading a book. Jane comes up and shouts, "HI!!!" Dick jumps in the air and runs down the street and Jane watches him. Then Jane sits down and starts reading Dick's book.

5) Push Dick, push. Push down Harvey. (He does.)
Push Dick, push. Push down Howard. (He does.)
Push Dick, push. Push down Harold. (He does.)
Push Dick, push. Push down Heidi. (He does.)
Push Dick, push. Push down Henry. (He does.)
Push Dick, push. Push down Helen. (He does.)
Push Jane, push. Push down Dick. (She does.)
(Dick cries. Jane cries.)

6) The back of Tom and Dick's heads are showing.
Tom: "How are you today, Dick?"
Dick: "I'm fine, Tom. I'm fine."
(Both turn around and each face is a bunch of scars and scratches.)

7) See mother come with the groceries.
See mother tug and pull at the groceries.
See Dick run to help.
"Nice Dick."
(Mother pats Dick's head. Zoom in on Dick. He stares at camera.)

8) Bob's hairy guy goes into a big crowd. The crowd leaves. He stands alone for awhile. Then Jane comes and they stare at each other, then walk off together.

The animated movie was shown to those individual classes in the school that wanted to see it.

I was proud of what the students had accomplished. They had taken on the challenge of studying children in their school, a challenge they had given themselves, and succeeded. The variety of ways that they had interpreted the responsibilities of completing that challenge were certainly well beyond what I had expected when I suggested we study the present. They had clearly gone beyond my experience and knowledge of how to study the present, and had resolved challenges that I had never tried. The successes of their varied accomplishments were apparent, from observing to interviewing to analyzing their data to recom-

mending changes in schooling to making a movie about childhood that conflicted with their storied reading texts.

To say that the students reached a unique level of analysis and productivity within their classroom efforts was enough for me as their teacher. I felt then, and still do, that they, and I, had accomplished something special in education.

That pride I had as a teacher conflicts with my current judgment as an experienced professional educational researcher. Within fifteen years of having encouraged the students to do their own study, I had become a member of a relatively new international group of qualitative researchers in education who were emphasizing observation, interviews, and analysis of qualitative data, and subsequently presenting their analyses in a variety of forms to international audiences of educational experts and policy makers.

From the perspective of a qualified researcher of human activity in educational settings, I could see the students' insightful creativity, but also the limitations of their studies. Their detailed initial observations were commendable, for example, but their approaches to interviewing were lacking some of the basics. Too many of their questions were able to be answered in single words, and their lack of follow-up questions to interesting answers is a common fault of all researchers. The students hadn't been trained in any basic interview techniques (other than not physically harming the interviewee). They could have been trained easily, if I were me 15 years later. Perhaps if I had gone to some research experts at that time? But the truth is, there were few researchers of education then who were experienced in doing research that primarily used observing and interviewing, or who felt that such skills could be useful for producing new understandings about the practice of education.

Thus, the students were near an edge of educational research practices at the time. It was a shame that I did not think of going to one of the few educational inquirers in 1969 who were developing similar procedures for studying educational settings. If I had, I know that my students could not only have applied the more sophisticated techniques used by those who were breaking educational research boundaries, but they could have added some much needed humility - and talents of their own - to the entire educational research enterprise.

Without knowing it, my students had led themselves, and me, to edges of educational inquiry by, for example, drawing recommendations from their data and creatively reporting their results. I can say now, with professional certainty, that the students at that time went beyond current practices of educational research.

As a teacher, I had put what the students had accomplished into a common category: beyond my expectations and absolutely wonderful. That appreciation, however, is not enough for edGe-ucating. Although the students had shown real talent in designing and performing inquiry – including finding a creative way to communicate what they had learned from their research – with more professional field techniques they could have provided even more insightful data on children's experiences and understandings. With better guidance and more opportunity available, they could have presented their work to a growing international audience of educational researchers and policy makers at that time.

Four
beginning to research education

linking language and thought

Within two weeks of quitting teaching, I had married, gained three step-daughters ages 9, 11, and 14, and entered graduate school. I left teaching with serious questions about my teaching and students' learning, and hoped I could answer some of them through dialogue and research with those at the university. I was also hoping to obtain my doctorate degree as quickly as possible, although I was earning more as a student than as a teacher. My GI Bill check would end in three years, and the girls would soon be entering college.

I learned quickly enough that no professors at the university were interested in my questions about teaching, so for my doctoral research I took on an unanswered question about the links between language and thought. It was a research problem for which I had no training or academic experience; no education professor at the university did, either. That didn't bother me. The problem I was to research had been created by U.S. followers of an educational critic from England who had proposed that children of the poor did poorly on their exams because they spoke a form of English that could not carry sophisticated academic thought. The critic's ideas were being applied in the U.S. to explain similar examination performances for African American students, many of whom spoke a form of Black Dialect as it was called then (now called AfricanAmerican Vernacular English).

A more general theory for the possible links between language and thought had been proposed earlier in the century by an anthropologist who suggested that rules of a spoken language determined the nature of how its speakers thought. My research problem was to design a test of both these related theories to Black Dialect speaking children.

Having grown up white in Madison, Wisconsin, in the 1930s to 50s, I had no experience in Black Dialect, and, with my lack of background in linguistics, clearly this research problem was removed from any educational edges that I had brought with me. Except that my doctorate research could test the accuracy of a

blanket reduction of respect for what a large group of children could learn, a view about children that I implicitly knew was wrong from my teaching experience, and from my life. I also had no background in doing research.

In my first two years, I took courses in child language acquisition, linguistics, speech, philosophy of language, and research methods. I received my Master's Degree after my first year for a review of the literature related to language and thought, which also became a necessary chapter to my doctoral dissertation. In addition to gaining more background in Black Dialect through my readings, I began to have some exposure from my friendships with two African American colleagues in graduate school. In addition to classes, we shared work on a program assisting African American leaders who were developing Black Histories for schools throughout the U.S.

I immediately began to appreciate the complexities of Black Dialect and its variety of ways for expressing sophisticated thought differently from Standard English. I did not try speaking Black Dialect, however, thinking that that could appear pretentious to its speakers.

In addition to expanding my understandings of research and linguistics, I became fascinated by the facts of how all children applied language rules within their first few years of life. Interestingly, the facts conflicted with most theories of learning at the time. Noam Chomsky, a linguist whose work at that time was at the edge, had recently begun to resolve the educational debates around children learning language more naturally and quickly than one would expect by pointing out that the rules of language seemed to be especially embedded in the human brain. (Now Chomsky's work is largely accepted, but with deeper modifications.)

As I began to consider designs for my research, I went to my major professor to share an idea I had on applying topological analysis to the problem rather than statistical analysis. He had no idea what I was talking about. I barely did, either, so I gave up that idea; it would have taken me too long to develop. Thus, statistics it would be, which meant there was no edge to the research process that I would use. Perhaps one bit of creativity appeared in the stories I created for children to hear that described situations with apparent contradictions, like a person being both good and bad or smart and dumb. Black Dialect rules could treat these conditions separately with the Black Dialect construction of the verb "be" which implies a temporary condition. Standard English does not. Thus, I was looking to see whether child speakers of Black Dialect were more ready to apply apparent contradictions to people and events in the stories than child speakers of Standard English only.

The results of my research were not edgy. Generally, there were no great differences between the two sets of children, even though, statistically, Black Dialect students – especially girls – were a bit more ready to use apparent contradictions in the stories. As one of my doctorate committee professors said, my findings were "primarily another nail to put in the coffin" for the theory that Black Dialect was an "unsophisticated language."

My study, however, had one interesting and unexpected result, accompanied by a high degree of statistical significance. When the children, both Standard English speakers and Black Dialect speakers, listened to stories that occurred outside of school, they were much more likely to use apparent contradictions than with situations within school. Someone could be described as being both good and bad out of school, for example, but not in school. In both languages, the context of the story occurring in school or not seemed to determine the likelihood that a child was willing to apply an apparent contradiction. The language itself, not as much.

I noted this result in my discussion, but couldn't explain it. Later, similar research results occurred in a wide variety of linguistic research, and the significance of context to language usage became common knowledge. One could say that an edge occurred in my research, but I did not recognize its importance. Nor did my professors.

Although my doctoral dissertation won a national award, it clearly did nothing to claim a role at theoretical edges of language and thought in education, in linguistics, or in the philosophy of language. One of the award judges taught me an additional lesson at the award ceremony when he leaned over and said, "You know, I never did understand what your study was about." I knew then that I had much to learn about how to report research. Still do.

I can add that my experience as a doctoral student demonstrates how limited research performed in isolation can be. Although doctorate research can be some of the best performed research in education, the more the research is completed as the work of one mind, the more limited it may be as work at the edges of a field. As a student, I had been comfortable performing my research alone, and the work suffered because of that.

Perhaps in nearly all fields, research moving across the edges of knowledge generally benefit from dialogue and reflection with a variety of minds. This can be a lesson for edGe-ucating as well, although seldom followed in research contests for the young, nor in our heightened respect for the "genius" scientist. Removing research from being an autonomous, singular enterprise has been a dif-

ficult lesson for me to apply, too, which may be why I am writing these personal stories to capture meaningful events related to edGe-ucating. I can do this alone.

As you will see in the sections following, my experiences in my first few years of researching began to suggest how expert inquiry can benefit from more dialogue and interaction at the edges of professional intellectual work, including, often, our interaction with neophytes to our respective fields of inquiry.

using graphics to describe instructional complexity

Near the completion of my doctoral dissertation, I became one of three investigators in a national study of what educators meant when they claimed to be "individualizing instruction." In the early 1970s, "individualizing" was a term being used by a range of classroom educators who were aiming their instruction to individuals in a class, rather than to the class as a whole. The term was being applied from elementary school through high school and university, and in a wide variety of subjects. The aim of our study was to arrive at a common and efficient language that could capture how these varied instructional programs operated to educate students at a more individual level. Given the variety of possible strategies involved, and the range of differing student ages, institutional contexts, and subject matters, the study was destined to be an intellectual challenge. And it was.

We began with a "pilot study," with each of us three researchers visiting two classrooms that publicly claimed to have developed a program that "individualized instruction." Some were designed by teachers or university faculty, others by publishing companies. We observed alone, talked to teachers and students about their experiences with the observed program, and wrote summary notes of what we had found. We then got together to share what we had each seen and heard, and to discuss what we considered to be the primary challenges ahead of us in studying individualized instruction within a national range of educational levels and subject matters.

The first thing we agreed on is that we couldn't proceed as we had just done. Many different actions could occur at the same time in each classroom, making observing difficult, and our talks with the teachers and students were all over the board. Furthermore, we realized that writing it all up from our notes would take an inordinate amount of time and effort for each program, potentially be more inaccurate than we were hoping.

We also shared how chaotic each classroom looked to us outsiders. Students were moving around, seemingly at will, and teachers were even more lively, hurrying to aid individuals and small groups of students. We could observe no struc-

ture. Yet, when we talked to the teachers and to the students, all knew what they were doing and exactly where they were within the instructional processes of the program. We were missing that structure. If we were to capture what was occurring in classrooms that were attempting to individualize instruction, we had to come up with something different, something both more efficient and more encompassing, than formal observation and interview.

We had started our visits by asking the teachers and students about some commonly applied instructional features, such as what instructional materials were being used; the size of the groups in which the students were engaged; how often these groups were with a teacher; and the varied rates of progress through the program by the students. This had given us a beginning language that most educators, and students, understood. (We interviewed students separately from teachers.)

When we began to ask about the use of these categories, the small groups, both teacher or student groups, would stop and often correct each other, then revise their answers as they worked out a more accurate answer together.

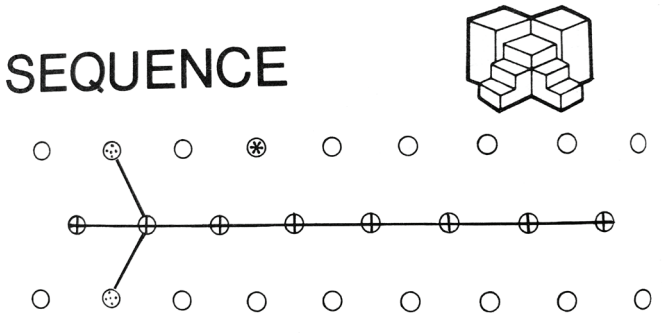
It became clear that we needed a way to stimulate the small groups in deliberating together as they revised and clarified their descriptions of their instructional program.

As we discussed our challenge, an idea came up that we had never considered, or seen. Perhaps they could respond to an immediate graphic portrayal of some general possibilities for how a program feature could operate, and then revise the graphic portrayal to become more accurate as a description of their program. We began to draw some possibilities on the blackboard, such as using bar graphs to capture differing kinds of instructional media being used and how often, or similar graphs for various sizes of student groupings, including how often they were in these groupings and whether they were with the teacher. We soon realized that any use of graphics in a group interview process that applied a final graphic summary would require professional help. From that point on, a small cadre of graphic designers were hired to become our research colleagues.

The graphic designers were involved in all our meetings as we considered how to pictorially capture specific characteristics of instructional features. In the sequencing of instruction, for example, a unit of instruction became a circle. If the sequencing of multiple units were predetermined, that is, each instructional unit were a precursor to the next unit, then a single line of circles was connected. We called that sequence, linear. If a program were linear but with options, the options were shown by occasional connections to circles off the linear path. (See

the figure below.) If a unit could be taken at any time, then there were no lines connecting to that circle.

The circles were colored to show who was making a decision to take a unit: students, teachers, or as designated by the program. Below, with no color, teacher decisions to enter a unit are noted by a star within the circle, student decisions by dots within a circle, and program decisions by lines within a circle.



As can be seen in the figure above, this program is primarily "linear" with one of two options that students could choose to take instead of the second unit. There is also another unit portrayed that can be chosen at any time by the teacher.

The significant feature for interviewing through graphics was that the teachers and the students being interviewed could begin by referring to how a particular graphic did or did not capture what they were experiencing about the sequencing of units of instruction. Through their discourse, and corresponding manipulation of the graphics, they could then develop and eventually agree on their own graphic that would best capture how their program operated within that particular feature. (Color, by the way, is more distinct to the human mind than the dots and lines used here.)

To encourage detailed discourse about how the instruction occurred, an overhead projector was used to manipulate and revise different possibilities for each feature of instruction. In the introduction to the sequencing of units, for example, a field of unconnected circles was shown to represent the units of instruction that were covered in a program. Then, a few prototypes of different approaches to the sequencing of units would be shown and discussed such as linear or linear with options. The interviewees would then choose one graphic to work from and to alter in order to capture more specifically just how the program functioned.

Thus, the portrayal of each program feature was completed only when a particular portrayal of a program feature had been built by the group and agreed upon – including color for who made what decisions.

In practice, this interactive interview process for each category worked well, helped along by a variety of interactions between members of the small groups with corrections and adjustments immediately being applied to the graphic before all group members agreed upon the final graphic for that instructional feature.

Our reliance on graphic description through small group interview became a breakthrough for our collecting of data as the graphics became the prime focus for collecting of complex instructional data. It was an approach to data collection that we had not seen before in educational research. We reported our use of graphics in educational research conferences: at state, national and international levels. I also wrote a chapter for a book (published in England) on how using interviews could be effectively used for educational research. I included how recent research on graphics and the brain could explain why graphics could share details of complex experience better than words alone.

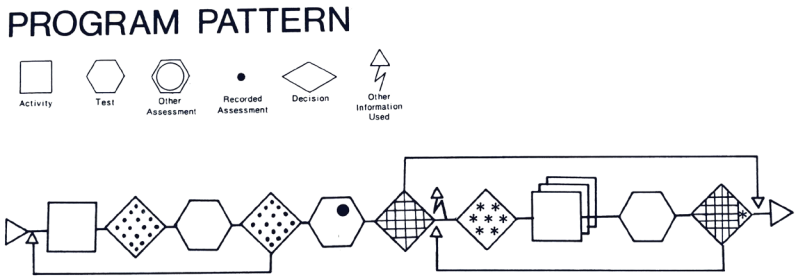
Our small group of educators and graphic designers had created a new approach for future educators to apply when attempting to capture, describe, or design complex educational practices. But, as we continued to use this interview process, we realized we were not yet fully successful in describing the variety of individualized programs that we were meeting.

We had not yet uncovered why so many "individualized" instructional programs could look so chaotic to an observer, yet be so well understood by all its students and teachers.

As we looked over our data, there were always references to a designated sequence of actions being taken and decisions being made within each unit of instruction. The actions included instructional activities, student assessments, and the decisions leading to new instructional actions. Most significantly, the sequence and interaction of these activities were consistently applied within each unit of instruction, and it was that repeated sequence of decision, activity, assessment, and decision that made each individualized program unique.

The graphic designers helped us realize that we could apply a graphic design through symbols that could show the path of activities, assessments, and decisions within each unit of instruction. We called this feature the "Program Pattern." The Program Pattern showed how instructional actions were integrated with the testing and monitoring of student progress, including when decisions were be-

ing made along the way, and who was making them. Below is an example from one program designed by two 5th grade teachers for their school's individualized instruction program in mathematics. As can be seen, symbols were created for an instructional activity, a decision, a test, another kind of assessment, if the assessment were recorded, or if other information was considered for a decision.



In this math program, each unit had a student prospectus of about 15 pages stating the objectives with examples and explanations of how to solve the math problems included in the unit. There were also a variety of practice pre-tests (with answers provided) that students could decide to use. The students could take these practice pre-tests as often as they wanted without their answers being recorded, but, once the student decided to take the actual pre-test, that pre-test score was recorded. Based upon the score (95%) of the recorded pre-test, the program decided the student could skip the unit. If the student did not test out, then the teacher went to further information about the student´s past performances and decided what activities might be useful for the student to learn the material. After the student engaged in a number of activities, the teacher decided when the student could take the concluding exam, and depending upon the results on the final exam (95%), the student either went to the next unit or returned for more instruction.

Everyone seemed to like how this mathematics program worked, especially the students. We didn't quite understand why, until we talked with the students about their Program Pattern.

The students focused on the first few steps, that is, they would look over the prospectus carefully, take the practice exam, see what they got wrong, then get help from older siblings, neighborhood friends, or those in class who had com-

pleted the unit, and return to the practice pre-test. Students repeated these steps for up to three weeks until they could answer every question on the practice pre-test correctly. Only then would they take the formal, recorded pre-test, and test out of the unit so that they "wouldn't have to study." What students appreciated most, they said, was an opportunity "to beat the system."

We completed our Descriptor for Individualized Instruction by testing its capacity to capture the various ways in which "individualized instruction" was practiced at U.S. elementary schools, middle schools, high schools, and university programs.

The primary piece of our research report was a manual on how to use the Descriptor, along with slides that could be made into overheads. Our hope was that the Descriptor could be useful to designers and researchers of individualized instruction, including teachers, as an aid in anticipating and resolving the challenges in designing and putting an individualized program into action.

I must emphasize here that this research study was conducted by three educators with minimal experience with research. It was headed by a professor of mathematics education who also wrote science books for children, along with a recent Ph.D. graduate in the economics of education and myself while I was completing my Ph.D. dissertation. Not only did we have little experience in research, we had none in individualizing instruction. Added to us three, of course, was our small team of graphic artists who had no training in education at all, but were as important to the success of our study as we inquirers. Regardless of our lack of accumulative research experience, or maybe because of it, we contributed to a variety of edges of educational research, adding new findings on how to understand and communicate the designs of complex approaches to teaching. Below are five such edges.

One edge of educational research that we met was how complex educational practices required more creativity in collecting data to describe the teaching and learning processes than most educational researchers had been applying. Our use of graphics was an example of what could be done.

A second edge pointed out by our research was who could design educational innovation. When we worked with practicing teachers who had designed the individualized instruction on their own, the designs were just as or more complex and creative in how they individualized instruction as were those from universities or large educational corporations. Only the teacher designers, for example, consistently considered their programs capable of being improved. When we asked teacher designers what they felt their program might look like in 5 years,

they confidently described specifics of a new, improved program design, based upon their aims and recent experiences with the program that they had designed and put into practice. When we asked university educators or commercial developers the same question, there was an inevitable pause, and then the response, "We have never given that any thought."

A third edge met by our educational research was how necessary it was to listen closely to student views of their experiences with the application of a complex educational design. Students knew exactly how a program was designed to work, and they then spoke honestly and directly about how they were using it. All ages.

A fourth edge highlighted by our educational research, perhaps embarrassingly so because it may be so obvious, was how important it is to collect differing views of how a complex educational program was used in the classroom through deliberations by teams of program participants. Small groups of teachers and of students who were active in the program had to see, hear and revise alternative depictions of the program by other participants before a general conclusion could be reached about how that program was operating in the classroom, and why.

A fifth edge was how the research process we had used, with interviews based upon the immediate analysis of graphics, showed its designers not only how the program was being applied, but also could illuminate how a program could be redesigned to be more effective.

Although we considered our research to be successful in its intent, however, we never gave edGeucating a thought. For example, we formed a company for me to distribute the Descriptor through a variety of local, regional and national educational conferences, but were unsuccessful. In reflection, one of the reasons was that we had not included teachers nor other roles of educators in the inquiry process itself. Sure, we involved them in our data collection, but not in the planning of the Descriptor, nor in our analyses as we redesigned the Descriptor throughout the study. Not only could our study have been improved within the research edges that we encountered, but the eventual use of the Descriptor could have been expanded if we had invited teachers, students, and others to be involved in our research process from day one.

If we had given more thought to our role in edGe-ucating others within our research than our role in educating others after we completed our research, perhaps the edges met by our study may have been developed further, and the promotion of applying the Descriptor may have been considerably more successful.

understanding education through research method

"Can you find anything in here to help us?" As we were completing our research on individualized instruction, I got a call from a federal program, Teacher Corps, asking if I could review their nine years of evaluation research. Teacher Corps had been legislated by Congress ten years earlier, in 1965. The program was similar to the Peace Corps, but aimed at improving the education of minority and poor communities within the United States. During the call, I learned that the program managers were thinking of changing their focus from preparing recent graduates to teach in minority and poor communities, to instead training experienced teachers, those who were already teaching in the schools of those communities. Although Teacher Corps had been issued nine previous research reports on the program that they thought might be useful in the transition, the reports were so extensive and technical that the managers of the program needed help locating the relevant information. They added I would be paid.

I had recently received my doctorate degree, and had decided to remain at the university in a research capacity as long as I could garner financial support so that my step-daughters could complete their high school in the city they grew up in. This offer was a step towards that goal.

Teacher Corps was right: there were over 4,000 pages from nine studies, written in formalized research language, pedantic and technical. The research reports were authored by teams of sociologists, anthropologists, political scientists and educators from a variety of research institutions including Harvard, two large research corporations, and a national teacher union. All researchers were far more qualified than I, with considerable experience in research and federal program evaluation. The reports generally focused on the teacher candidates, using categories like age, gender, and academic background. There were additional categories for why the candidates applied to the Teacher Corps Program; whether they had been accepted; had received their education certificates,; and whether they had continued teaching, or had left. No categories attempted to describe what the students did as students, as student teachers, or as teachers, or how they felt before, during, or after their training. They also neglected to consider the approaches used to train the student teachers, and only very little on the school and community contexts in which they studied and worked.

After weeks of going through the nine studies, and writing voluminous notes from their data, research results, discussions and recommendations, I reached two conclusions about these nine studies of Teacher Corps. My first conclusion was that the studies were done "well" to the extent that graduate school had

taught me. For example, the categories chosen for their analyses were discrete, well described, and consistent with the questions raised and the conclusions reached. My second conclusion was that there was nothing useful in the reports for Teacher Corps to apply as they considered modifying their program.

What was wrong? How can all nine studies be highly professional and useless? It had to be something about the categories they used and the questions they asked, but what else? I wanted a more complete answer for my report to Teacher Corps, and for my own understanding of how better to research educational policy and practice going forward.

Around this time, a professor of research, known for his expertise in quantitative research methodologies, told me about an "underground paper," one not yet published but circulating through the educational research community with considerable interest. The paper, titled "Illuminative Evaluation," was by Malcolm Parlett, a professor in England, and his former doctoral student, David Hamilton, a Scot. In unusually accessible language, the paper answered many of the questions I was asking, and gave reasons for why traditional approaches to educational research were not working well for their designed purpose. They proposed an alternative approach, called "illuminative evaluation," modelled after the way field work was performed in natural settings by biological researchers.

In contrast to traditional approaches that look for-cause-and-effect conclusions, the authors' alternative approach focused on teachers' actual practices, what students were doing with these practices, what aims educators and students had for what they were doing, and why, and what the institutional, educational, and community contexts were. These criteria set up a tough array of necessary conditions for successfully studying educational practices, but Parlett and Hamilton's conclusion was clear. Traditional approaches to educational research failed to fulfil almost all of their criteria for what an effective study should contain if the study were to inform educators and policy makers about what was actually done in an educational program and why, and explain how well that worked out, including some informed guesses of why or why not.

This paper provided the basis for the analysis I needed to complete my report to Teacher Corps, and to continue to pursue my own research of educational practices in differing contexts and for differing purposes. I critiqued the previous studies of Teacher Corps, using two different sets of criteria. One set included the criteria proposed by Parlett and Hamilton, the other from a chapter in the most recent edition of a national educational measurement manual. All nine studies of Teacher Corps scored highly when criteria from the educational mea-

surement manual were applied, but failed miserably from an illuminative evaluation perspective. I shared my analysis and results with Teacher Corps, knowing I was bringing them close to the edges of educational research methods. The Parlett and Hamilton paper was not published until two years later.

To prove that I hadn't yet learned anything about edGe-ucating, however, my final report to Teacher Corps was too long: 93 pages along with added footnotes and bibliography. I had many hundreds of copies printed hoping that the report could be distributed to the hundreds of university teacher colleges in addition to those involved in the Teacher Corps Program and to other state and national agencies dealing with educational program evaluation. I am not sure why I thought university professors and other trained professionals would listen to me or read my work when they were comfortable doing their own inquiries in a quite different way than I was proposing would be more effective. Except that seemed to be the way to distribute new ideas, just as Parlett and Hamilton were doing.

What was becoming clear to me is that I was getting into educational research at a fascinating time to explore educational policy and practice. With minimal experience in the field, I had entered real edges of educational research method. Other educational researchers, some highly experienced, some not, were also becoming critical of the traditional methods that had been and were still being applied. In approximately 1975, for example, the President of the American Psychological Association, wrote an article about the uselessness of his previously acclaimed research methods for understanding educational practice. He suggested, instead, that he would be applying a method close to what Parlett and Hamilton had described.

Although I was not considering non-experts participating at these edges of educational research, I did begin to meet a variety of newcomers who were producing unique research methods. Among them was a Scot, Barry MacDonald, whom I met at an international research conference in San Francisco in 1975. MacDonald described how he had begun investigating an innovative instructional program in England through a process he designed for interviewing all participative roles in the program: students, teachers, school administrators, program managers, and community members. After each separate group was interviewed, they received their recorded and transcribed analyses of the program's intentions, practices, and consequences. Importantly, no group was allowed to see another group's set of analyses until it had negotiated and released its own set.

The process of transcription and group negotiation of analysis took some time, but it guaranteed that every role had the same set of rules not only for participat-

ing in providing their data and analyses for the study, but also in seeing all other participants' viewpoints and analyses. All participants, then, could integrate all viewpoints while building an understanding of how the program performed, and why. He called his research method "democratic evaluation." As he was talking, I was struck by his sensitivity to what various participants would allow as parts of their public evidence. For example, some of their interview statements, he pointed out, although valuable to him as an investigator, were potentially damaging to the participant if made public. But even when he pointed this out to them, he reported, participants often didn't care; they wanted their views included and publicly shared as they had expressed them. He was more concerned about the potential consequences of their expressed viewpoints than they were.

At the same conference, before hearing MacDonald, I had heard a young Englishman, John Elliott, talk about how he was investigating an innovative program to improve classroom practice by having the teachers be in charge of the investigations. He argued, for example, that the teachers were the ones who had to put the program into practice and also had to make the decisions on how to change their practices depending upon the results. Thus, it was necessary that the teachers ask the questions about how the new educational practices were being performed, as well as how it could be redesigned. Teachers, in his opinion, had the fullest experience along with the widest range of doubts about how the processes were being applied, including what their students' difficulties were with the new instructional program, along with their own. Elliott called this approach "action research," a term referring to those responsible for the actions also being the ones responsible for researching those actions. ("Action research" was a term first applied to social oriented research in the U.S. in the late 1940's).

When I met with MacDonald after his talk, I referred to this other study that applied quite a different method than his for understanding and assisting the processes of educational reform. I asked him if he knew Elliott, and he laughed and replied, "We're on the same research team." I learned something more about how research at the edges of educational research was being conducted. The same research team could have two research approaches going on. One approach focused on not only how the data on the educational program is being supplied, but how that data needed to be shared equally between all participants. The other focused on which set of the many participants should have the primary responsibility for conducting the research. At least in England, two quite different methods for inquiring into educational innovations were being applied within the same study.

studying students becoming teachers

Changes in the Teacher Corps Program were confirmed through Congressional legislation. The program was to emphasize the education of experienced teachers in minority and low-income communities. In addition, each of the 50 newly funded two-year program sites would prepare four college graduates to become teachers in the same schools and communities. The graduates, called "interns," were expected to participate in a unique two years of teacher training, emphasizing community involvement along with teaching, with a Masters' Degree and a teacher's certificate awarded at its completion.

Teacher Corps also decided that the first month of intern training would be an experimental collective experience in which all 200-plus interns would be trained together. The intent for this event was to provide the interns with an esprit-de-corps for their work serving the education of students in minority, low-income communities. Since this singular one-month training would add considerable cost, a further hope of the Teacher Corps managers was for the event to gain professional attention as an innovation in preparing students to become teachers. For this reason, Teacher Corps decided to support evaluation research with the goal of communicating the import of this new training event to all educators preparing teachers for low income and minority communities, to the Teacher Corps managers, and to Congress, their funders.

I had been hoping that I'd be chosen to be on the team of instructors for the training. Instead, I was picked to head the evaluation research study. Responding as an educator, I was greatly disappointed. Events soon showed me how lucky I was.

Heading the research study would be nearly a two-year assignment, including a few months to prepare; one year to research the event and its projected influence on the interns for their first year, and several months to complete a final report and to communicate its findings to the profession. The study had a healthy budget, including support for both the research and communication of the event to educational researchers, teacher educators, and all extended members of the Teacher Corps Program at its one hundred sites.

I quickly realized that the event would be a highly interactive month for participants from various minority populations from around the country, urban and rural, male and female, Native American, African American from rural and urban areas, Hispanic and Latino, rural and city White, Asian American, Puerto Rican, and Micronesian, all living together, all young. My first decision was that

a full-time photographer needed to be at the event to catch its interactive nature. Photos might capture interaction better than words. I budgeted it accordingly, and after initial resistance, Teacher Corps management agreed to support this step into the unknown.

Another early decision was to have our research include both quantitative and qualitative research methods. At the time, there was a professional battle brewing between quantitative researchers in education and qualitative researchers. Few studies tried to do both, despite what Parlett and Hamilton had suggested. (For doubters of this statement, I had to fire two professors I had initially hired because they said they wouldn't continue to work on a project where quantitative research was included. They changed their minds in a couple of days, and were rehired.) I began looking for a statistical procedure that might capture some of the dynamics I expected to dominate the education of over 200 neophyte teachers-to-be from a variety of multi-cultural identities. Time-series analysis – a statistical process applied primarily by economists who assumed that dynamic changes can occur over time, without warning – fit the bill. A recently published paper (by Gene Glass) had suggested that its assumption of dynamic change could make it particularly useful for educational research. Yet, time-series analysis required multiple points of measurable data to identify when a meaningful statistical change had occurred.

After talking with Gene Glass, it became clear that at least eight "points" of data had to be collected within the four weeks of the event, and at least 10 more times over the rest of the year. Administering the survey at the beginning and end of each of the four weeks would satisfy this bare minimum. In addition, time-series analysis required a detailed account of what happened at the event, in order to identify not only a change, but what might possibly be related to why a change had occurred. That is where qualitative research methods came in. We had to record what happened over those four weeks, including how the interns and their instructors were engaged during the instructional times along with how they were thinking, behaving, and interacting, including the times outside of instruction. We therefore needed a team of full-time researchers at the site for the entire month to collect data throughout the days and evenings.

Designing the research proved to be an active couple of months. Along with the photographer, I hired five faculty members to work with me on the study. One was an African American assistant professor of multicultural education, one was an experienced professor of quantitative research who assisted in our time-series analysis, and three were professors of teacher education, primari-

ly in the social studies, one professor and two assistant professors. In addition, three young Master's degree students (one African-American, one Hispanic, one White) were hired to work full time as data collectors at the summer event, and to help in our design and testing of the observation and interview protocols, and survey questionnaires. Our team of a photographer, 3 students, 5 professors, and myself took weeks, mostly in half days together, to discuss the anticipated impact of this event on the interns, including within their first year of training after the initial month. The four teacher educators led our discussions on how the interns might deal, during the event and after, with the expectations of teaching students in schools serving minority and low-income communities. We decided we needed a variety of research methods to elicit how the interns were developing their concerns and values around teaching and working in minority communities, during their training as interns, but also in terms of how they saw the teaching profession which they were aiming to join.

In addition to photography, we prepared three methods for collecting data within our study: observing, interviewing, and administrating survey questionnaires. For observation, we prepared one form for reporting events observed within the instructional periods, and a different form for non-instructional parts of the day. For interviews, we prepared an outline for the interviews that would be conducted during non-instructional times. Designing the questionnaires that needed to be taken twice a week, without any repetitions, took considerable effort to compose and then test through trial and error before we could claim that they were capable of identifying the interns' perspectives.

We coalesced our understandings of possible professional impact of teacher training on the interns into five perspectives about teaching. The five perspectives were that teaching included: 1) applying educational techniques, 2) focusing on the personal development of students, 3) being involved in the community served by the school, 4) developing curriculum, and 5) working within the school organization. One part of the questionnaire asked the interns to prioritize the 5 perspectives on teaching for themselves as interns, another part asked them to identify the importance of these perspectives for experienced teachers.

We decided each perspective required five differently worded questions for each administration of the questionnaire. With eight administrations, that meant designing forty questions for each of the five perspectives. Writing, testing, and rewriting the sentences used for each question took more than a month with the testing done using undergrad education students. We hired a fourth graduate student, a wordsmith and published poet, to work with us as we wrote the ques-

tions, which proved extremely valuable to completing this task as well as we did.

We sent the general plan for our research design to the instructional team and to Teacher Corps management. We then waited to receive the instructional team's plans and intentions knowing they had the tougher assignment. Their plans arrived two weeks before the event was to start.

The two directors of the instructional team had split their task into two content areas. The first two weeks was focused on understanding institutions and how they worked by applying sociological and anthropological perspectives. The second two weeks focused on applying instructional strategies in the classroom. Having student teachers focus their initial attention on understanding institutions was a clear innovation in teacher education in the U.S. It also had been a primary recommendation from the most recent study on Teacher Corps by Ronald Corwin, a sociologist and one of the two instructional directors.

Corwin's study had suggested that Teacher Corps interns needed a more sophisticated understanding of schools as institutions if they were going to be successful in their roles as student teacher and as change agent. No teacher education program focused on institutional understanding as an aim at that time. Or now.

The second two weeks was more traditional, focusing on how to apply a variety of classroom strategies. It was headed by a well-known innovator of educational practices who was simultaneously coming out with a new book on divergent educational strategies for the classroom. Looking at both plans, we researchers recognized that the instructional team had aimed to the edges of teacher preparation, as we were doing with our research design.

The instructional team's plans, however, had also arrived with their absolute refusal to accept the research design that we had sent earlier. No photography, no classroom observation, no multiple questionnaires. Teacher Corps was horrified.

At Teacher Corps' demand, we three directors, the two for the instructional halves and I, met alone in the middle of a hotel room in Washington, D.C. As the door closed on us sitting in three high backed chairs, no table between us, we three knew we had to arrive at an agreement before the door was to open again. Only after sitting down and looking directly at them did I realize that I had nothing to lose. I was the researcher. They were the educators. They designed the instruction; I designed the research on the instruction. If anyone were to dictate an agreement about the research, it would be me.

I let them know I heard their concerns, but there would be two administrations of intern questionnaires each week. There would also be a full-time pho-

tographer at the event, before, during, and after instructional times. I told them that we had a team of five data collectors for the event, including the photographer and me, with the three others being graduate students about the age of the interns. Those three young researchers would be attending the classes and all other events as participant-observers during instructional hours, and often as interviewers at other times. I would be full-time at the event and would be both an observer and interviewer, as well as study director.

I told them that they and their instructors had full right to let me know immediately if any of the research team were bothering their instruction. As educational researchers yourselves, I added, you know that my team can not interfere with the education that occurs. The educational team doing their contracted work, and the research team doing their contracted work was important to us all. We had to trust each other, but this was my study; the instruction was theirs. The meeting was intense, combative, and unfriendly as such confrontations often go. But, after working out the specific times for administrating the questionnaires on Monday mornings and Friday afternoons, the two reluctantly agreed to the conditions I laid out, as they had to.

I must make one thing clear. Our research team was inexperienced as field researchers. Of the five professors I hired, the only one who had considerable research experience was the quantitative researcher who had little experience beyond his stochastic expertise. The other four professors were teacher educators with academic backgrounds but had never before worked on a largescale research project like this one. Neither had I. The photographer had done considerable photographic work recording African cultures where she and her husband lived periodically, but had never focused on educational settings in the U.S. The three Master's degree students in education who were hired and trained to be the observers, interviewers, and immediate analysers during the event, were entirely new to research of any kind.

This was the team that worked together on designing the research, its aim and its methodology, each of us drawing on the experiences we brought to the work. The teacher educators relied on their experiences teaching student teachers; the multi-cultural educator relied on his experience working with educators in settings aimed for students from minority cultures; the three Master's students relied on their experiences as students, young teachers, and their own cultural backgrounds. Added to those were the quantitative methods professor who had joined, he said, because he wanted to see how this team project would work, and me, a director with one research project behind me. As we worked together, I

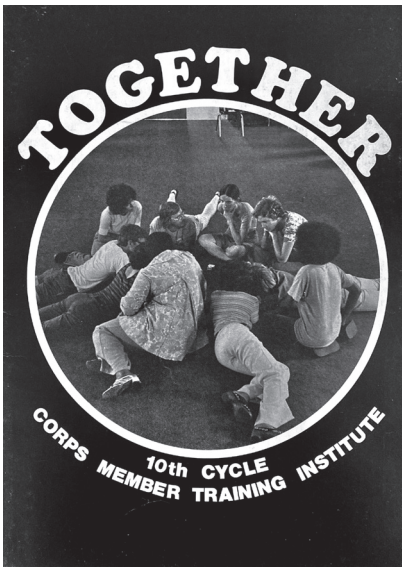
became more and more convinced that our collective newness to this research enterprise, along with our requirement to share and work out solutions together, were responsible for our collective innovation and eventual research successes.

At the event, I was constantly impressed by the focus and perceptiveness of our team of five: the three young Masters students, the photographer, and myself. At our team meetings at the end of each day, we five offered observations, insights, and considerations of what the interns were experiencing. As we documented the day's events, including its issues of multicultural interactions and student-teacher interactions, every evening meeting became an energetic, engaging intellectual conversation.

A brilliant move suggested by the photographer within the first day or two was to provide copies of over a hundred photos at the end of each week for the interns to choose up to three for themselves. When we did this the first Friday, we realized that this decision had placed us in an entirely different role. Instead of being a nuisance to the interns, we became a friendly supportive presence. Whenever an instructor happened to request a researcher to leave the room, for example, the interns always said, "no, she (or he) is one of us." We distributed over a thousand photos in the four weeks. I know of no research project that has performed that kind of service, but it was a definite reason for why we had full cooperation and support by the interns throughout our research of the event and the year after.

On the third weekend, the professors on the research team visited the site and participated with us in the evening meetings, along with collecting data through observing and interviewing. What impressed me over those three days is that the professors weren't nearly as capable as the student researchers in observing, interviewing, and immediately analyzing the day. That understanding has stayed with me over the many years since. Later, for example, I wrote a chapter in a book on research pointing out how our collective inexperience in research, including the three graduate students' participation in data collection and our corresponding need for extensive dialogue through planning and analysis, were what made our research innovative and valuable. I suggested more researchers of teacher education try it.

When the month's event was over, we packed up hundreds of taped interviews, thousands of photographic prints and negatives, boxes of written forms, questionnaires, and summary notes from our evening meetings. With these as our documentation, the professors and I wrote our interim report, and completed plans for our continuing study of the interns' first year.



Cover of "Together," a technical report of 1975 CMTI

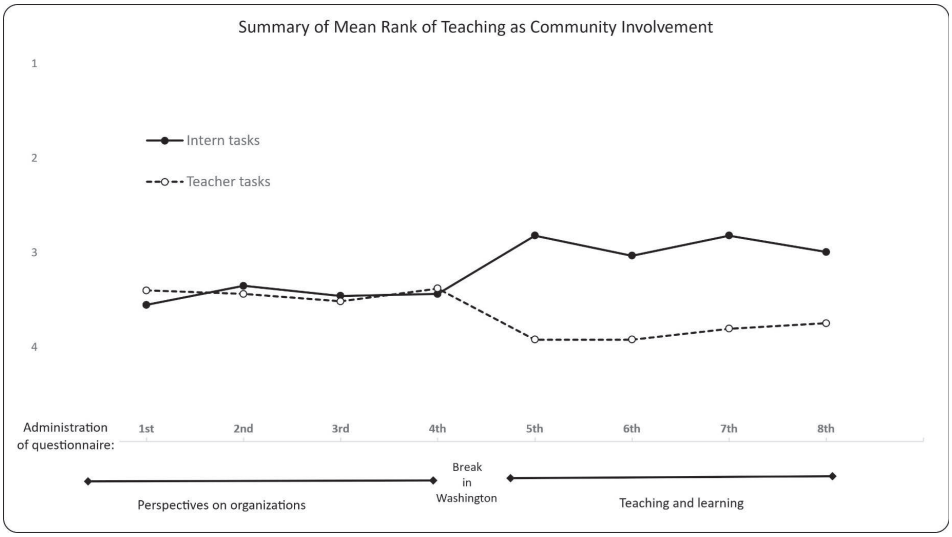
An interim report was presented to Teacher Corps within two months. The report described the month's event, relying on the observation forms, summary notes from the evening meetings, and the transcribed interviews. Also included were the charted results from the questionnaires, along with the analysis and discussion of the results, and a photo essay of about 40 photos, without words. The interns received the written parts of the interim report but not the results and analyses of the surveys since the surveys were to be continued through the school year following the event.

The written description of the event was 75 pages, a day-by-day account, capturing a variety of personal, social, or educational occasions, some intended by the instruction, some not. As drafts of this description were written, discussed and rewritten, I became concerned with its length restricting it being read, especially by the interns. So, I gave all our data to the poet who had helped write our questionnaire, and asked her if she could write a poem from the near thousand pages of data. She did, creating a five-page poem. (The interns reported that they read the poem closely, and praised how well it captured their experiences during that month.) Teacher Corps management, however, requested that the poem not be included in the more generally shared interim report. They said they were concerned that the entire report would be branded "unscientific" if it had a poem included. The poem was included as one of the final 22 technical reports when the study was completed.

When a draft of the interim report was presented to the management and staff of Teacher Corps, two items attracted the most attention. One was the photo essay, which I had put on the walls around the program's large meeting room, hoping to get some interest before the formal presentation of results. It did. Many of the young African American members of the staff who had been at the event as participants passionately said, "There are too many Blacks in the photos!" After much pointing to specific photos and heated debates between the White and the Black staff who were at the event, I suggested we count who was in what photos. "No!" was the response, emphasized by a loud pounding on the table, "We are talking about impression!" Then they began to refer to features such as who was in the foreground, for example, emphasizing that they weren't raising a black-white issue, but one that included many more minority who were at the event, but were not as centrally located in the photos. We replaced a number of photos, and also added a few words to the photo essay at Teacher Corps' collective suggestion.

The photographic essay became one of the final 22 technical reports, bound in a shiny format of its own, titled "Together." This photo essay had to be reprinted every year for Congress because it became the singular feature of our report that Congress would consistently "read" over the years when considering legislative funding for the Teacher Corps Program. Can you identify the instructor? We couldn't, which is why we liked it. It also included one of our observers.

The other significant response to the interim report by Teacher Corps staff was to the charts showing the results from the questionnaires. The charts, one is below, showed how interns judged the importance of community involvement for themselves as compared to its importance for teachers over the eight administrations of the questionnaire during the four weeks.



As the chart shows, for the first two weeks interns consistently rated community involvement as an equally important mid-level task for teachers as it was for themselves. Over the weekend between the two instructional events, however, there was a dramatic shift where community involvement became a significant task for themselves as interns but of little importance for teachers. This was but one example of a dramatic change in all the intern perspectives on teaching that occurred between the Friday and Monday of that middle weekend, and stayed consistent over the next two weeks. Within that weekend, interns clearly had separated what teaching meant for themselves from what it meant for teachers. Every alteration was statistically significant and had occurred after that weekend which separated the two instructional topics.

"Why?" The program managers asked about these changes. "What happened that weekend?" Success! They had just expressed their genuine interest in what had happened, not only in the "final result."

Unfortunately, the weekend when the big change happened was between late Friday afternoon after their two weeks of analyzing institutional behavior, and early Monday morning, before the start of learning multiple teaching strategies. That was the only weekend when we had no evidence of what had occurred. All the interns and Teacher Corps staff had gone to Washington, D.C. to attend a couple days of a full week Teacher Corps conference held for members from all 100 sites. Instead of going to the conference, we researchers used that time to review our data, plan a bit, and relax.

Still, the survey results clearly demonstrated a number of significant points. One was that that weekend had been a time for interns to re-analyze their roles and the teachers' roles. Another was that, other than that one weekend of significant change, their views during the month were relatively stable, both within the first two weeks and then within the second two weeks.

Since neither instructional team directly referred to teacher tasks versus intern tasks, we concluded that the interns were reflecting on their own. But we weren't sure why. Perhaps they reflected together over the weekend. Perhaps they were influenced by those they met and interacted with at the Teacher Corps Conference, including representative teachers and faculty from the sites where they would be going after their first month of training. Perhaps, a combination of these or other explanations. We researchers could not say. But it does suggest an internal analysis by the interns had occurred from consistent over two weeks to another. Perhaps this was natural, especially when a student is being introduced to a new and challenging profession.

But to a researcher, once a program manager asks, "what happened" about an educational event, once the educational process has their full attention, not only the "end product," then the research can have meaning. From this time on, for example, Teacher Corps management and staff asked many more questions about the processes we were seeing and gathering from the interns as we continued our study over the year following the event.

In continuing our study of the interns after they returned to their respective university and community sites, one conclusion became significant; not only was it a conclusion about becoming a teacher, but perhaps it may be significant to educating newcomers into all challenging professions. Much of the interns' first five months were spent working in the schools and in the community, with their responsibilities within the community taking considerable effort and decision making on their own. They were often the initiators, independently finding appropriate roles and situations for their attention and time. Not surprisingly, then, being involved in the community continued to be given the highest rank as an intern task on the interns' questionnaires over those first five months at their respective universities. In early February, however, their ranking of the importance of community involvement dropped dramatically. The community involvement score, both as an intern task and as a teacher task, plummeted to being the lowest score ever recorded for any of the five tasks.

This time, however, after talking with the interns, we had an answer as to why the change had occurred. January was when the interns received their first semester's grades from their university. The interns' work performed within the community received no grade at all. The time, effort, and personal responsibility taken to perform service within the community was irrelevant to their university's judgment of how they were learning to become teachers. The severe drop in the importance of their community involvement was a direct response to the reality of a non-grade. In addition, over the last months of that first year, that ranking never rose close to its previous significance.

We had clear evidence of the failure of the Teacher Corps Program to recognize the importance of community work for the interns who were aiming to become teachers of low income and minority children. Unfortunately, we should not have been surprised. Student work that is performed outside of the classroom context of school or university was then, and remains, an edge where few educators have focused their analysis.

What our study made clear to teacher educators was that all students who are entering into the complex profession of educating will understand the implicit

values being attached to their educational training. Such a conclusion, of course, refers not only to those in teacher education but to all who are being introduced into a complex profession through university training. If the professional time, engagement, and decisions made by a student away from the university are not being acknowledged and judged as professional performance, then the student will consider that work not significant to what it means to be an active member of that profession.

The significance of that conclusion from our study may be wider than Teacher Corps intended. And our team's lack of research experience may have contributed to our study's contribution to all professional training. Without intentionally aiming to do so, we may have been edGe-ucating all complex and challenging professions.

the residual impact of an educational event

Determining the long-term impact of a brief educational event after the event is over is an impossible aim for research to promise. There are simply too many variables that may influence the residual impact of an educational event on a participant, as well as many possible judgements of what "residual impact" might mean. But the cost of its one-month training event and its accompanying year-long research on its students is why the Teacher Corps Program asked me to look into the residual impact of this training event more than two years after the event had occurred. As we discussed the research challenge, including Congress' aim for the Program to influence the teacher education profession serving minority and low-income communities, we agreed that the study would look for the impact of this training on all the event's professional participants. That included the instructors, the researchers, and the school and university institutions responsible for reforming their teacher education programs, along with the impact on the recently graduated interns. My decision was to have four sub-studies, one for each set of professional participants, along with a synthesis of their findings.

A modest budget had been provided for me as the primary investigator and my secretary who was to transcribe the taped interviews, along with a token amount for a few investigators, with a little travel. Our aim was to document and analyse the residual impact of the one-month training event in order to shed some light on what Teacher Corps could do to encourage the reform of teacher education for minority, low-income communities.

The four studies were to be done primarily through interviews along with an analysis of any documentation that could support the claims made by those

interviewed. The study on the interns was performed by two researchers, the associate professor of multicultural studies who had worked on the previous study of the event and one of his doctoral students, a creative and inquisitive woman. For the study of impact on the team of researchers, I wanted someone with a position independent of a faculty role since we researchers were faculty or students. I had recently met and been impressed with the analytical approach of the young Associate Dean of the School of Education. He was willing, and had access to documentation that could be used in determining the impact of the research that the five faculty and I had performed. To investigate the impact of the event on institutions, I looked for a researcher who had a role outside of a university, but also had some experience in working with university management, and was fortunate to find that person close by. I investigated the residual impact on the instructors of the event.

We five researchers prepared by discussing the various ways in which we could interpret the meanings of residual impact to each of the four sets of participants. We shared possible approaches for eliciting experiences and perspectives from the various participants, but we also decided that each sub-study would be conducted and reported independently. We would consider their synthesis later.

I am still impressed by the quality of persons who were willing to work on such an intellectually challenging inquiry for comparatively little money. A lesson that has stayed with me is that there are a variety of potential investigators out there who have the curiosity and energy to inquire along with the skills, understandings, and experiences to learn from others and report independently. When one is given such an open intellectual challenge, I realized that there are many human qualities that can be valuable to achieving a demanding research aim, or even to try. Furthermore, there may be many who have the variety of common human qualities that can be useful to an effective inquiry starting with being curious and open to others' lives as they are being expressed, along with an independent and creative mind that goes beyond professional clichés.

Each sub-study brought up unexpected results with details that suggested how Teacher Corps could re-imagine their approach to achieving their primary aims.

The interns remembered their beginning month's training as a lively event, but not nearly as memorable or powerful as their experiences from the following two years in the schools, community, and university. Their two years of education following their first month were simply too full, varied, and contradictory, thus cancelling out any memory of detailed professional impact from that singular event. This research study was told as a detective story.

In contrast, many instructors claimed extensive professional influence from their work in that month, especially those teaching institutional change. It was a new set of circumstances that they were working in, aimed at graduate students with little background in analyzing institutions, but who were energetic, committed and focused on change and reform. Perhaps even more powerful, they admitted, was that the students were from a greater variety of cultures and backgrounds than the instructors had previously experienced. Some instructors referred to being a bit overwhelmed by this new context, but most said they took this as an opportunity to see what they could do with their specialty, and how they could adapt to the new set of circumstances. They reported that working at this event was not only a personal challenge, but one where there was much discussion with colleagues about alternative creative teaching strategies that they could use to engage students in analyzing what the interns could do to change educational institutions.

In sum, many instructors were proud to report the impact of that month in altering how they taught their respective fields, reporting that the event stimulated them to apply new techniques and new attitudes to their subsequent teaching responsibilities back at their universities. This result was reported primarily in direct quotes from those interviewed.

Two features of the discussions with the instructors were noteworthy. One was that it was often the most experienced and better known of the instructors who reported the strongest and most positive influence. The younger and inexperienced weren't so sure how the event had changed their professional focus or teaching styles. The second feature was how little documentation existed to support what they said. Within universities there was little documentation of individual teaching strategies or attitudes that had been developed over time to stimulate student understanding.

For the researchers, on the other hand, there was considerable documentation of change in their professional focus and output after their involvement in researching this event. In fact, the documentation conflicted with the claims of some of the researchers that there was no impact. Two who had gone up for promotions in the past two years, for example, claimed that they experienced no professional influence from their work researching the event. That research, they said, was similar to their prior field research experience. The university records of their research, including their professional presentations and publications, along with claims of professional expertise written for their respective promotions, pointed out an entirely different conclusion. The professional impact had been

significant in changing their areas of expertise, lines of research, and the focus of courses taught.

Similar evidence showed the same conclusion for all us researchers, me included. The quantitative research professor, for example, the only one of us with much previous research experience, reported that working on that study stimulated a new professional involvement in qualitative research, including focusing more questions about educational process, and in focusing more on answering those questions more fully in his later studies. This study of the impact on the faculty researching the event had the greatest amount of documentation that supported the conclusion that the professional work of all the faculty involved with the research had been changed dramatically through researching this one event.

For schools and universities, the training event was determined to have "virtually non-existent impact." As far as the managers and employees of the schools and universities were concerned, the one-month training event had never occurred, regardless of interns' involvement. Where the small team of four interns did have an impact, however, was in the local Teacher Corps project, where their impact was judged to be an unwelcome intervention. The interns had applied their increased understandings of how to influence institutional change to the organization that affected them the most - their local Teacher Corps project – and not to the university or the schools where the interns were considered outsiders. This study included many examples of the research efforts taken to try to locate any institutional impact, and finding none.

Our summary of these four studies suggested that the surest way to ensure impact of an educational event on teacher educators is to involve her or him in the research of the event. The task not only required considerable analysis and interactive discourse, and time, but the work was applied, recognized, and rewarded in a university context. Being an instructor in an innovative event at a professional edge could also have an impact on the person as an educator, especially on more experienced faculty, but with less institutional documentation or continued interest or reward.

We also suggested ways to consider the costs of training in terms of the purposes for professional impact on teacher education and institutional design. One suggestion was to focus on the time allowed for the planning and evaluation of the event, as well as on the promotion of creative approaches to educating teachers. The more the challenges aim at gaining professional rewards after the event was over, the less cost may be required to gain professional engagement and innovation. In terms of the cost of professional residual impact, for example, the

study suggested that the more creative the professional challenge - that is, the more unique the challenges were to those who were chosen to train and research the event – the more economical and effective may be the promotion of long-term professional reform.

These four studies of residual impact, achieved at a relatively small cost, provided a variety of insight, questions, and possibility for improving teacher education that served minority and low-income communities.

From my perspective, this modest study provided more insight into new possibilities for Teacher Corps policy, and the wide professional contexts that they were aimed to reform, than the much larger study on the event that I had directed three years earlier. Clearly, edges of educational understanding can be built from "minor" studies, even when aimed at nearly impossible goals. The imagination supplied to making the research captivating and challenging professionally, the more professional residual impact may occur.

One final lesson. As my secretary had been typing up all the interviews and analyses from each of the four studies, she came to me and said, "I am the only one who has seen all the data from these four studies, so I think I know the whole research now better than anyone!" Caught by her truth, I suggested she use her area of expertise to construct her interpretations of the research project. She had a Master´s Degree in musicology, and wrote a musical score that integrated themes from all four studies. Her composition, titled "Kaleidoscope," was subsequently performed by marimba, percussion, clarinet, piano and bassoon, and the score and recording were included in our final report. A chapter was added to the final report on how music can be an appropriate medium to provide a summary interpretation of residual impact. It also became a paper we wrote together for educational conferences.

About three years after our study was completed, I got a call from Washington, D.C. from a member of the State Department to tell me that they were completing a special two-week training event with researchers and program evaluators from island cultures of the South Pacific. They had used our residual impact study as one of the research examples, including the musical interpretation which they had discussed extensively for its view of how educational influence can be interpreted over time. In addition, they had danced to that same tune every night. That musical interpretation, she said, was the highlight of their engagement with the challenges of educational research and program evaluation.

Impact, it seems, may come in many forms, years later. That may be true for edGe-ucating as well.

Five

journeying further into the research community

research conferences

I found attending educational research conferences a joy. They were also, generally, expensive, but were paid for by my research contracts and later partly by my university. I always appreciated hearing researchers talk about their work, and enjoyed when it was possible to ask them questions. I was especially interested in those I hadn't heard of or read previously, as I learned what they were thinking and doing in a variety of fields, including from international contexts. My main intent was to re-consider my understandings of educational practice, learning, gender and other features of human development, and the variety of contexts in which we try to draw out information, imagination, and newly elicited understandings. Whatever I heard often raised new questions, increasing the uncertainties of what I thought I knew.

One early memory, was going to hear a full session talk by Egon Guba, a name I knew as an expert in educational policy making who had written a popular textbook on "rational decision-making" used by a variety of U.S. educational leadership courses. A few thousand of us were packed in a large hall - mostly men (old, in my eyes), many standing against the walls and outside the wide doors. The first sentence Dr. Guba uttered was, "Anyone who thought decisions are made rationally has never performed or seen one." There was an audible gasp from the crowd. He went on to say why he was disowning his previous writings, and that the approach he was promoting now was applying qualitative methods of inquiry that looked closer at what was actually done while making decisions. When he asked for questions, the response from the audience was outrage. "How dare you say all that was in your book is horseshit?" asked one older man who went on, "I have been using your book with my students for almost 20 years, and now you say this?" The answer was, "Perhaps you won't believe me so completely now, in case I change my mind again." As it turned out, Professor Guba was learning different lessons about qualitative inquiry than I. He wrote a book on what one was required to do if one wanted to perform qualitative research correctly. It was nearly 600 pages long.

Not all studies had to be perfectly done to be worth thinking about. At the same conference I heard about a study that focused on documenting the internal stress felt by different groups of high school students. The speaker said she and her colleagues measured stress through multiple readings of blood pressure. (Blood pressure was known to be fairly consistent for individuals, not a direct reading of stress but over time a suggestion of internal stress.) She asked us to guess which high school students showed the highest degree of internal stress, and we all were wrong. The result of her study was that the popular high school girls showed the highest stress, where "popular" meant being most liked as judged by other students. The most popular high school boys had the least stress, where "popular" had the same meaning but also included being good in sports.

The most stressed boys had the best grades, while the lowest stressed girls were the least popular.

This study got me thinking about popularity and stress in adolescents, including my own at that age, but the study has been especially useful over the years in stimulating my students of research to raise and consider their own life experiences and assumptions while critiquing a study.

Almost every year when I was in the U.S., from the early 1970s to 2015, I went to the AERA conference, run by the American Educational Research Association. It lasted a week, with about 10,000 at the conference when I started going and more than twice that when I stopped. It always included a large number of international educational researchers which I found important. A thick catalogue of presentations was sent out before the meeting with at least 15 simultaneous sessions each hour and a half, beginning at 8:00 am and going until 10:00 pm. Most sessions had four presentations of about 15 minutes each with 20 minutes at the end for questions to the presenters. The catalogue included a many page index of topics, and more pages identifying individual participants' presentation times.

Each year, I prepared for days by going over all presentations, highlighting possibilities and making lists of those I wanted to hear. After reducing the many conflicts at any hour, I usually attended over 40 sessions, or well over 100 presentations, in each conference.

No one I knew spent this kind of planning time, nor went to as many sessions as I did at every AERA. I don't know why except that serious people go to conferences for many differing purposes. My purpose was to engage with ideas, experiences, or analyses that I had never met before. If I attended three presentations that excited me out of the 40 sessions I attended, that was a successful AERA conference. That meant I met new researchers, new considerations, or excitingly

new insights into educational practice, outlook, or research approaches. Most of my AERA's were successful. I also brought home armfuls of papers that I read, catalogued, referred to in my own work, or shared with colleagues. I presented at AERA myself, averaging about two a year. But hearing others was my main interest.

I remember the first and only time I met Rosalie Wax, an anthropologist who worked primarily with Native American Tribes in the Southwest and who was unknown to me at the time. She was on a stage behind a long table with a number of well-known educational researchers who often applied anthropological techniques in their research. She was the only woman, and the only anthropologist, sitting in the middle of the group, knitting throughout the comments made by the others. Then she put her knitting down, got up to talk and simply, directly, honestly, and with no fanfare described how she worked with Native Americans, talking to them in their homes on their reservations. She spoke quietly, assuredly, with sincere respect for those she had been visiting and talking with. She emphasized how important it was for her to recognize that she was the visitor, that they were the experts on whom she was dependent for information and understanding that she didn't have. She was the intruder, she said, and it was the women, men, and children of the domicile who were willing and able to inform her, not the other way around. Her comments, her manner, her quiet and unobtrusive professional nature, were so different from the other researchers that I never forgot her or her short talk.

She wrote in a similar style to her manner of speaking, and for the years I taught research I always used her book to demonstrate the attitude required to do good field research.

Occasionally I went to BERA, the British Educational Research Association. BERA was very different from AERA, which I appreciated. It was held on the British Isles, usually England, with maybe 150 attendees, meeting for 3 or 4 days. Each session lasted two hours, with one or two presentations in a session. Sessions were filled with lively dialogue, pointedly aimed questions, passionate arguments reconfigured, loud laughter and intense voicings. When a session was completed, and we had to leave the meeting room, an open bar with beer, whiskey or other drinks were available in the same building for us to continue our lines of questions and interactions or create new ones. Papers were seldom handed out; most BERA presentations occurred while the inquiries were still ongoing, which meant that most of the researchers' analyses were potentially malleable. Going to BERA was a treasured opportunity for me, where I felt great pleasure

in being included in the full participation, intellectual debate, and professional comradery.

My favorite yearly conference, however, was the North Dakota Study Group (NDSG) headed up by Vito Perrone. At the time when I first went, he was the Dean of the North Dakota University School of Education, and was a Harvard professor the last few times I attended. It was my favorite conference. Like BERA, it was a small group, about a 100, living together for a few days, usually in double or triple rooms, eating our meals together and sometimes taking a halfday trip as a group to experience the locale in which we were meeting. The main attraction was that there were near equal participants of school teachers and school administrators, along with educational researchers from private research organizations and universities, teacher educators, and often a few from state or national educational agencies. Considerably more women attended than either AERA or BERA, and all the attendees were educational innovators, many of whom had created a unique variety of new approaches within the classroom, or school, or educational program, or research approach. To me, this was the most intensely satisfying conference because of the varied population of educators in attendance, and their shared intensity of interest and respect for educational processes, and their commitment to action and reform as well as to the intellectual complexity of educating as an action. Many should have been more famous as an educator than they were.

Professional conferences in all fields of inquiry are intended to bring the edges of work to their professional attendees. Applying professional judgement and argument are part of the enterprise, with disappointment and amazement included, along with collegial engagement in discussion, debate, and encouragement. My current concern, however, is how professional conferences can be made more accessible to those of us who are not experts in the fields of inquiry which define a professional conference, yet may be stimulated by the conferences. In fact, edGe-ucating would require participation by non-experts in all conferences aimed to discuss the edges of fields of inquiry.

How can that happen?

Research conferences are considered to be, and funded as, events for professional dialogue – not for educational performance to non-experts. But as every member of every professional conference knows, they are stimulative, both educationally and professionally, and aimed and funded to be both. Having a wider attendance within these events, open to non-experts interested in the field, may help both the educational and professional aims of a conference be met better.

In addition to streaming to more general audiences, research and inquiry conferences could also include effective, prior minimal training to help prepare the untrained for their participation in particular sessions. The impact of sharing the work at specific frontiers of all fields of inquiry with interested non-experts may be more exciting than can currently be imagined.

demonstration

The more I worked with the Teacher Corps Program as a consultant for local projects doing research and program evaluation, the more concerned I became that neither research nor program evaluation were what was needed at the local level. Communicating lessons being learned through teacher education reform that involved cooperation between school, university, and the communities being served required something more than the information provided by research or program evaluation. This became a problem because a primary responsibility for the local projects – housed in universities and working with teachers in local school districts, and with the minority, low-income communities they served – was to communicate what they were learning as they tried to accomplish their Teacher Corps goals. The primary way in which they supplied the documentation and analysis of the local project experience was through their university research or program evaluation expertise.

One reason for the difficulties of relying on such university expertise was that conducting local teacher education reform through schools, universities, and low-income multicultural community cooperation brought significant institutional tension. Capturing the actions taken or avoided was not only an expansive challenge for any researcher to accomplish, but it raised questions that could be sensitive to the three major constituents – especially to the university, the institution most responsible for teacher education. The result was that local documentation of the challenges created was more problematic than anticipated or prepared for.

When I talked with a variety of organizational participants at local project levels, for example, I would hear a range of lessons being learned as they confronted and attempted to deal with the inbuilt institutional habits of procedure and attitude. However, the insights that were being constructed from the challenges met and the participants' responses were not being included in the local project reports. Valuable insightsd about teacher education reform were being constructed by local project participants as they worked to achive Teacher goals,

but these insights, challenges, and even actions were not being communicated to Teacher Corps or to its wider professional audiences.

In responding to the expressed need of Teacher Corps managers to improve the communication of what was being learned about teacher education reform by their 100 local projects, I tried to come up with a new process within the idea of "research" or "program evaluation." My efforts failed; these two professional terms already had too many separate purposes.

Then I realized that a new title had been put on Teacher Corps projects by recent Congressional legislation: they were being funded as "demonstration projects." When I asked what that meant, I was told, "Who knows?" It was a word that implied that something new or unique was done, lessons were learned, and what was learned was to be communicated to others faced with similar challenges. A cooking demonstration, for example, isn't just a recipe or a claim that a new recipe is delicious, it has to relate what had been learned through the developmental processes so that the recipe can be adapted to other culinary contexts. Differing tastes, talents, intentions, or available ingredients requires that the cooks in other contexts learn more about the details learned when developing a new recipe.

"Demonstration," I thought, might be a much better word for the kind of inquiry needed to communicate the lessons learned when new approaches were taken to the institutional and professional challenges of teacher education. Like cooking, different contexts in teacher education can require significant adaptations in the lessons learned from one context to be applied in another. No lesson gained from teacher education reform experienced in one university working with multiple schools and in a particular community context could be expected to be followed and become successful in other sets of differing contexts.

Unfortunately, I wasn't even as clear to Teacher Corps with what I was trying to say about demonstration than I just have been using cooking as a metaphor. I had been writing to Teacher Corps management, for example, about my insight that they could take the notion of "demonstration" as an approach to documenting experiences of their local projects that could communicate more effectively what they were learning to other professional teacher educators. I suggested that "demonstration" could be considered a form of academic inquiry that can replace "research" or "program evaluation" because the basic intent of demonstration was not to arrive at a better form of truth or to judge the success of a single approach. I tried to use verbs that referred to intent, failure, context, revision, and learning while engaged in a new, dynamic, complex, and often unexpected set of challenges to the institutions and to the profession. The point was to locate improvement

in the understandings of teacher education reform while trying to combine people, actions, institutions, and intentions not normally integrated into the processes of teacher education.

The evening before a National Teacher Corps Conference, William Smith, the Director of the Teacher Corps Program, called me into his hotel room to discuss, once again, my views of what demonstration might mean at the program level. Bill, as he called himself, was a tall, broad-shouldered, African-American and a former Naval officer. He not only peppered me with serious question after serious question about what I was suggesting, he disagreed vehemently with every answer and every explanation I gave. And he told me why. We went on for hours with him asking detailed questions and then disagreeing with my answers; me answering, explaining, and trying to find ways to argue for my view. At not quite daybreak, I left deflated. Clearly, I had convinced Bill of nothing. I knew that at his morning's scheduled address to the crowd of National Teacher Corps members, nothing I had offered would be considered or developed for the audience's consumption.

I was wrong.

Bill got up and addressed his group of many hundreds of Teacher Corps local project directors and members, along with his national program staff, in his own inimitable style. He was personable, direct, certain, and challenging. And demonstration was central to it all. Whatever I had expressed earlier that morning was expressed more cogently, more precisely, more concretely, than I had conveyed to him. They were his ideas and examples, not mine. He emphasized the need to communicate failures of local projects along with successes and partial successes. He talked about the need to record what was done, what made that difficult, and what had to be re-done. He referred to misunderstandings and mistakes being the source for any lessons learned from new experiences garnered in trying to apply differing roles and expectations of teachers, administrators, teacher educators, community members and organizations – as well as students. He referred to the need to accept the real challenges of working together effectively, and how new strategies could work differently in some situations but not in other situations. He emphasized the need to try to explain why – or why not.

Somehow, Bill Smith had created a working alternative to the concepts of research and program evaluation that had been operating in the Teacher Corps projects. It had also not been operating anywhere in the academic educational community at large. Decades later, I have not forgotten my night of conflict with Bill, and have never lost my respect for the intellectual creativity he had applied

to make what I was trying to construct more meaningful and more useful than I had.

I carry two big lessons from this effort by Bill to give "demonstration" a focused meaning about how to learn from complex innovative educational experience. The first lesson was a deep respect for the expert intelligence displayed by Bill who was untrained in the investigative profession he was trying to improve. As an outsider to the field of educational research, he had improved the edgy views that I had been trying to construct through a lengthy late-night argument. He should have been recognized by the educational research profession for his accomplishment. I should have stated his accomplishment more forcibly to the profession myself. Now is too late.

A second lesson became clearer as I kept trying to communicate the idea of demonstration. Inspired by Bill's brilliance, for example, I wrote and presented a number of talks about the possibilities and potential of demonstration to members of AERA and other conferences of educational researchers. Although these talks and papers had limited takers, I participated in two wider attempts to show the reflective nature of demonstration in teacher education. Both were supported by AACTE (American Association of Colleges of Teacher Education), the national agency that represented over 700 colleges of education in the United States.

The first attempt to use AACTE as the active audience for applying the approaches of demonstration to teacher education was a series of conferences with a chosen group of fourteen nationally recognized educators to discuss what would need to be done to reform teacher education throughout the United States. The members of this group were leaders in educational research, teacher education, the two major national teacher unions, state organizations overlooking teacher education, and Teacher Corps. They met four times, for two days each, in the Washington D.C. headquarters of AACTE. I was the recorder for the event, writing and sharing drafts of their discussions after each meeting, and completing a final report that was published and shared with all AACTE members.

The group's discourse included identifying and analyzing the challenges of teacher education, and the variety of the problems of the profession that had to be solved across the board. The final report included a description of the range and complexity of what needed to be addressed if teacher education were to be reformed in the U.S., a recognition that the problems were interconnected, with any solution requiring coordinated attention, and suggestions for how this could be accomplished. This group was clearly attempting to provide reflective

leadership for the general reform of teacher education in the U.S., with a clear explication of the complexity of the challenges, how the primary challenges were integrated, why they needed to be addressed together, and suggestions on how to proceed. But it was missing the primary ingredient of demonstration, and that was specific reference to experience and lessons learned – often from failure – that needed to be applied. The discourse engaged in by a diversified set of experts in teacher education was a substantial form of professional reflection, but it was without the focus on past experience to guide subsequent action.

The second attempt funded by AACTE was to stimulate reflection by three experienced Teacher Corps local project directors on the lessons they had learned through their five to ten years of experience in working to achieve Teacher Corps goals. Each were tenured university faculty members in teacher education, one from the East coast, one from the Midwest, and one from the South. The aim of this project was to elicit their specific experiences while trying to meet the challenges of teacher education reform with reference to university schools of education, local schools, and minority low-income communities. I was the initiator and recorder for the meetings, but the four of us wrote the final report together. Over five months, we met five times, two days each, at different locations.

Every challenge raised was demonstrated with specific project experiences, and every lesson learned was contrasted with three different sets of experiences. The process of reflection and analysis was often painful for the three professors recalling their experience and bringing up the deeper challenges they faced while working closely with schools and communities from their local university settings. To me, it seemed a fine example of demonstration being attempted from separate past experience with a range of challenges, analyzed and described in specific detail from the perspective of university-based faculty. Given that many of the lessons learned were about the resistance of the university structure indealing effectively with schools or communities, it was not a complete surprise that AACTE required that our jointly written account be negotiated before its publication. But the negotiations for publication took more than twice as long as the year of meeting and writing up of a draft of our report.

In summary, demonstration has never been recognized by university educational research communities as a professional set of investigative processes for communicating educational experience. Instead, research and program evaluation have kept the more traditional criteria for judging the outcome of a specific educational performance. Learning from a variety of failures and challenges produced by taking innovative educational actions in currently operating edu-

cational institutions was considered too great a risk. Although I understood it at the time as an educational risk – that is, one feared by the educational profession – I did not understand it as an intellectual or academic risk. But maybe I was wrong: perhaps demonstration should indeed be understood as an intellectual and academic risk. As was proven by the three faculty and former project directors, demonstration is a personal risk that can be resolved; but it is also an institutional and professional risk which is much harder to overcome.

As I have tried to expand my notion of edGe-ucating, both lessons related to that night with Bill have emerged as central. The first lesson is that expert intelligence, including the question of how to seriously engage with expert intelligence, is held by those with no training. The second lesson is about how powerful the resistance to change is, held by those with institutional expertise supported by training and funding. There may not be many management minds like Bill's, but I know there are many untrained among us who can add more sense, more meaning, and more understanding towards expanding the edges of what is known in all knowledge producing fields. Resistance by experts to a new idea is natural: what is needed are more hard arguments engaged with non-experts, like the one I had with Bill that night.

There are many more Bills among us than we know, of all ages and backgrounds. We just need to allow them the time and respect to argue seriously with us. We experts might learn more about what we are missing at the edges of our fields if we encouraged and asked for more debate from those outside our fields, and then listen to them as they respond.

What are high schools like?

Nothing perhaps is more arcane in U.S. education than the number of high school credits that are awarded for specific academic courses. At least that is what I thought when I was asked to participate in a study of high schools in the United States sponsored by the Carnegie Foundation in the early 1980's. For most of the century, the primary focus of the Carnegie Foundation had been to specify how the number of high school credits in the United States was to be determined. In fact, these U.S. high school credits were called "Carnegie Credits." This study, instead, was aimed at documenting the current nature of high school education in America to the general public and to the educational profession.

Fifteen schools were described in the study, in various urban, rural, and suburban contexts, distributed throughout the U.S. with each school being visited

by a team of two researchers. Of the twenty-five researchers, I was among the three most experienced in research, as most were primarily educators. I visited two schools, both urban, one primarily African American, one becoming more so, both located in the Midwest. My job was to visit the two high schools for 20 days each, along with another researcher, and together to write up a report on how each high school was working, including descriptions of students, teachers, school climate, school context, curriculum, teaching, and learning. In other words, it was an open invitation to find out as much as we could about what it was like to be in a high school at the time.

We 25 researchers met once, midway during our high school visits, to discuss what we were observing and discovering, what surprised us, and what we had found most important so far in the high schools. It was also a way to learn more from each others' visits.

I had visited my two schools for about a week each before the meeting, and asked the others if they had discovered what had impressed me so far. As I visited science, history, English, and mathematics classes, one kind of class always seemed especially lively, with the students intellectually active and involved in analyzing and problem solving. What surprised me was that these classes were always in the industrial arts and domestic sciences. These so-called nonacademic courses seemed to have the most independent intellectual challenges with the greatest variety of learning activities for the students. Students would be involved in trying to break down motors, for example, recording in their notebooks how the breakdown occurred, and then try to answer why. Others could be given a difficult or unusual sewing or cooking problem to solve, often with another person to work out a solution together.

In these non-academic courses, students were always problem solving, recording, analyzing on their own. They were seldom being given answers, but expected to work answers out for themselves, and then share and discuss their solutions. I had not yet seen similar intellectual activity in the science classes, history classes, math classes, or English classes.

"I was wondering," I asked the other researchers in our meeting, "have you found anything similar in your visits?" The meeting perked up as others began to express how interesting the learning activities they saw in the non-academic classes were, and found this observation not only surprising but rather troubling. It was troubling not because the non-academic classes were demonstrating engaged learning, but because the classes in the academic subjects were not. Furthermore, since they had not gone to a teacher preparation program, or even talk-

ed much about teaching their subjects with others, most of the teachers of the industrial classes had worked out their teaching methods by themselves.

As we became more excited sharing our observations and concerns, we were suddenly told to stop. The Carnegie Foundation, we were told emphatically, was not interested in non-college preparatory, non-academic courses. The Foundation was only interested in courses that received Carnegie Credits. Our observations on this topic, we were told, were irrelevant to our study of high schools. "None of it will go into your reports," they told us.

I was shocked, along with the others. That was the first time that a sponsor of a study had so restricted me. It did not matter that we, as educators and researchers, felt we had come upon a very interesting and valuable finding about high school teaching, one worth looking into in more detail. I wrote a six-page letter to the Director of the Carnegie Foundation expressing my outrage and my reasons for thinking this was an important finding that related to academic courses, not just to non-academic courses – and, not incidentally, to the high school teacher education profession at large. But I might as well have sent blank pages.

The lesson I learned about the sponsorship of educational research was an important one, namely a research study funded by a respected sponsor may disregard a significant result to educational practice and critique if the result does not serve the sponsor's specific purpose. At the end of our study, there were a few words of praises for non-academic teaching in the published 656 page book profiling 13 of the high schools we visited. But it was nothing like the discussion we researchers had begun in our single meeting at the Carnegie Foundation.

Fundamental lessons learned from educational research do not always become shared by researchers if the results appear to be unrelated to the study's primary focus. As a researcher, I had done something similar in my doctoral dissertation as I discarded the significance of context in language production. In this Carnegie study, a wider involvement by non-experts interested in high school education may have captured, applied, and shared our collective findings about the teaching of non-academic subjects more widely than I or my colleagues did. Non-experts may have had less to lose. The same may be true for inquiries in all fields attempting to improve expert knowledge about practice in their field.

evaluating teacher evaluations

In 1981, I applied for a large competitive research grant from the U.S. Office of Education. The aim of the grant was to evaluate how effectively teacher evaluations were being performed throughout the U.S., and to recommend approaches that

appeared to be the most successful and why. By the late 1970's, greater attention had been given by school districts and some states to formalizing the evaluations of teachers. Because of the perceived inadequacies of many approaches in evaluating teachers, teacher unions were becoming more resistant, and so was the educational research community. The situation seemed to require an identification of the more effective approaches to teacher evaluations that could replace experience as the primary factor for determining teacher salaries, and also to help improve the recognition of teaching excellence in the United States.

I was one of many who felt it educationally dangerous to expect to identify and reward the quality of one's teaching through a simple evaluation process. But I had also seen some recent practices that were evaluating teaching with complex approaches and professional insight that I thought could help the teaching profession as well as the public.

This was the largest grant that I had applied for, and at that time one of the largest grants supported by the National Institute of Education. Competing with major university research centers and private research corporations would be tough. Most proposals would have research directors with considerably more research experience than myself. I worked hard to gather a full team of experienced educators as field researchers, along with a cadre of well-known and respected educational leaders to serve as an advisory panel for the research study that I was proposing.

My research team and panel of advisors included teachers who had published articles and books on teaching, school administrators who had started innovative public schools, teacher educators who were recognized leaders in the field, members of state educational agencies, and recognized researchers who were studying the relationships between teaching and learning. Their agreement to take part in my research proposal as members of either the research team or the panel of advisors humbled me.

In addition to the research team and the panel of advisors that I had organized, there were other features of my proposal that made me proud. One was my grasp of the variety of ways that were being performed or recommended to evaluate teachers. These included test-oriented, data-driven, quantitative methods for evaluating teachers; new ways for observing teachers directly in their classrooms, often through extensive observer training; applying various tests of students' gained knowledge or some other kinds of assessments of student production; and a few that tested teacher pedagogical knowledge. I tried to make

my proposal one of the most inclusive when it came to acknowledging the many approaches being used or proposed to evaluate teachers at that time, many innovative and only recently applied at that time.

My favorite approaches to evaluating teachers were the few that had created teams of practicing teachers in a district to design how to evaluate all teachers in that district. I was most proud that I had found and identified resources that described these approaches while also listing some of the lessons that teachers learned from being involved in designing teacher evaluations. One lesson was that, although the teachers were successful in designing local teacher evaluations, the teacher designers were never satisfied. They always wanted to take another try at designing a better approach at teacher evaluation after they had completed their first approved design. They said that they had learned so much about the variety of good teaching through the processes of developing their approaches to teacher evaluations that they needed to apply these lessons and create a new and better system for evaluating the variety of good teaching practices that were being performed.

I considered that conclusion to be a valuable insight into the challenges of teacher evaluation, and perhaps a major contribution to understanding effective educational practice. I thought the results of teachers evaluating teachers were worth pursuing in a larger context. Part of my proposal was aimed to do that by looking into the wider professional consequences of this approach. I was sure that my proposal was the only one with this information about teacher developed evaluations of teaching, and I considered that an evaluation of this process may be valuable to any evaluation of good teaching. I had never heard these sources being referred to in professional educational discourse as I was preparing my proposal for the competitive grant deadline. Nor have I since.

Although I was proud of the range of educators who had agreed to participate on my team, I anticipated that the emphasis on including school teachers and district administrators might not be considered a proposal strength by the judges. Thus, regardless of the unusual effort and time I had put into preparing my proposal, I was unsure just how it would be assessed within this grant's competitive environment.

Some months after the due date, I was told that my proposal was one of a few that had survived the first cut. Specific questions were raised for me to further clarify my 225-page proposal. I did so. More months passed before I was informed that my proposal was one of the two final proposals still being con-

sidered. Included in that announcement were additional questions that needed to be answered in detail. I did. I began to feel encouraged that my proposal had become one of two finalists for this three-year research grant.

A few months later, I received the message that my proposal had not been awarded the funding. After almost two years of analysis, it had lost to a proposal offered by the former director of NIE, the agency funding the research study. End of story, but a continuing tale of me becoming edGe-ucated. Let me tell you why.

Throughout writing my proposal, turning it in, and the many months after, I knew that a primary edge introduced by my proposal was that teachers, administrators and other practicing educators would be participating in research that investigated the practices of teacher evaluations. I also knew that researchers and teacher evaluators with recognized qualifications and certified degrees may look at some of these educators as unqualified to do research: although they were recognized expert educators, they were not experts in research. I knew that proposing that recognized educational practitioners could perform these professional research activities along with recognized educational researchers may have made my proposal unique enough to consider, but the possibility of it being a winner was slight. I did it anyway. I must admit, however, that I put a lot of hope into getting funded because educational research was beginning to receive less and less funding, and my continuing to earn a living through research was at stake.

As I considered my ultimate failure of this proposal, I remembered my first study on individualized instruction. In that study, the teachers who had designed their individualized instruction programs had learned so much in the process that they were unsatisfied with where they ended up. They wanted to try again, to apply more of what they had learned in the process of development and application, and had specific ideas on how to do so. As did the teachers who designed their district approaches to teacher evaluations.

Both sets of teachers showed a deep educational professionalism in acknowledging the complexities of being a successful educator. I also remembered how minimally trained graduate students were better at field research than their professors when we studied a one-month training event. And later, how our study on the residual impact of that one-month training event showed the comparatively strong impact of research on the researchers, and of instruction on the instructors. These results suggested that there may be some lessons here for me to learn and to share. I began to write something that tried to connect what I had been learning from my research experiences, and I titled it, "Beyond Education." It

always seemed to be a draft, however, never quite ready to be published. Now I consider it to have been a 250-page preface to edGe-ucating.

Some months after the rejection of my proposal for researching the evaluation of teachers, I was offered a position to teach teachers to do research at a research center in a university in Norwich, England. That six-month contract turned into two and a half years after which I was offered a contract to research teacher education in Iceland. My last few research contracts were performed in Iceland in the later 1980s.

setting new scenes for becoming a teacher

My research contract with the Icelandic Ministry of Education charged me with looking for Icelandic views on reforming their teacher education programs, and included me working closely with faculty at the Icelandic University College of Education. It was fall, 1986, and the University College of Education in Iceland was independent of the University of Iceland at that time, having its own unique history – as did many higher education institutions in Iceland. To give a sense of the dynamic changes for higher education in Iceland during the late 20th century, I will provide a thumbnail history of the University College of Education.

The University College of Education had been established in 1908 as the Icelandic Teacher Training College and in 1971 had been upgraded to an independent University College of Education. In 1988, soon after my study was completed, it was upgraded again by law from the Icelandic Parliament with full university status with various undergraduate programs within the wide field of education studies along with graduate studies at both the masters- and doctoral levels. In 1977, the College for Home Economics Education had been amalgamated with the University College of Education, and in 1998, three independent colleges, the College for Early Childhood Education, the College for Physical Education, and the College for Social Pedagogy, were amalgamated with the University College of Education. These four amalgamations brought the respective teacher education programs formally to a university level. Later, in 2008, the Icelandic University College of Education itself was finally amalgamated with the University of Iceland and became the School of Education within the University of Iceland.

In the fall of 1986, I was told that the University College of Education was re-considering their approach to teaching students to become teachers, and the Ministry of Education was quite sure that there were many in Iceland who had some creative and useful ideas about how teachers could be educated. Their aim was that I would not only elicit various views from Icelanders about how stu-

dents could be better educated to be teachers, but also that I would involve the University College of Education faculty in analyzing these alternative views.

The combination of conducting an inquiry to identify new Icelandic models of teacher education, while including the college's faculty in seriously examining and expanding these new models, was a challenge of particular interest to me. I couldn't think of a more meaningful research assignment, one that engaged the intended audience in interpreting and analyzing the research data.

Iceland is an independent country on an island in the North Atlantic that gained its full independence from Denmark during the Second World War. In 1986, Iceland was a country of a quarter million people that had accelerated into modernity, and, even 40 years after its independence as a republic was formally declared, was still feeling that dramatic change. Although Iceland appeared to be a modern country – with, for example, a high number of cars with new roads being constructed everywhere – it was still a developing country in terms of organizing and funding its governmental services, including education. Iceland had an active and modern university, the University of Iceland, but by tradition general teacher education was not a part of that university. As I stated above, the University College of Education had only been given university status in 1971, including its teacher education graduates gaining university diplomas.

To say that this was a fascinating time to be working in Iceland with a vibrant national context of educational development is a large understatement.

For the inquiry part of my contract, I was given names of about 15 people from a range of positions, including retired rectors of the University College of Education, individuals in the Education and Cultural Ministries, officers from the national teacher union, teachers from the Demonstration School connected to the University College of Education, philosophy professors at the University of Iceland, and a few other individuals without direct involvement to educational institutions.

The range of this list of men and women who had given much thought to education and who may have much to contribute to an expert area, some within the related profession, some not, was common in Iceland. Consideration of who may be an intellectual expert was wider in Iceland than other places I had been. Icelandic plumbers were recognized poets, for example, and Icelandic farmers were translating Shakespeare into Icelandic.

Given the list of names, the path for the inquiry part of my contract was relatively set. I taped my interviews with agreement of the interviewed to maintain her or

his anonymity by using no direct quotes or references. Instead, I called each approach I heard a "scenario" for teacher education, and wrote up each of the separate approaches for educating teachers that I heard with a different scenario title.

I quickly became shocked by the variety of scenarios that were being described to me. In the first nine interviews, I had 10 scenarios, most of which I had never heard of or seen in my many years of researching teacher education in the U.S. or in participating with a variety of reformers of teacher education in other national contexts. Most models I had previously encountered, for example, focused primarily on three issues related to teacher education: 1) how students gain experience in teaching; 2) the most effective approaches to teaching and learning (pedagogy); and 3) how to learn the subject matter to be taught most efficiently. Differences between these models existed with regards to the timing and sequence of these three components, but not with the components themselves. Within the first ten interviews, I met a much more fascinating array of perspectives on teacher education - some not focused on any of those three features at all!

Nearly every person I talked with emphasized teaching as an intellectual activity when describing their strategy for guiding students to become teachers. A few described more than one scenario with separate rationales for how the mind worked, including separate educational and institutional implications. They all explained their scenarios in detail, including why such a model would be culturally necessary and effective in Iceland. I ended up with thirteen discrete scenarios from twelve interviews, each scenario written in a brief one-page synopsis.

Eight seminars were scheduled for faculty from the University College of Education and its Demonstration School to meet one afternoon a week in order to analyze, discuss, and expand the scenarios. Participation was voluntary with about a fourth of the College faculty participating, 15 to 20, most of them regularly.

The seminars began by forming three small groups by lottery. Each group then was given a single scenario to discuss and expand further in terms of its educational aim, rationale, institutional and inter-institutional arrangements, experience of the students, responsibilities of the faculty, the role for educational research, and the educational principles underlying the strategy. One absolute rule held for all seminars: no judgments could be made about a scenario. The task was descriptive and analytical. After each group analyzed and drew implications from its scenario, they would present it to the group, and answer questions. A final description of the scenarios would then be written up and distributed to

the full faculty of the University College of Education and the Demonstration School.

Below are a few scenarios, briefly described.

The *independent questioning scenario* emphasized that each student teacher would be encouraged, supported, and expected to ask her or his own questions; subsequently, they would actively seek to answer those questions. To begin, the questions could be about private business, public organizations, art, childhood, adulthood, the countryside, family life, play and work (in Iceland and elsewhere). The student teachers would then apply appropriate research strategies to gather answers to their questions, which would be shared. Questions about schools, children, youth, learning, teaching, and education would come later. The argument was that the best way to understand education is to take responsibility for educating oneself.

The *assertiveness* scenario emphasized that student teachers would be trained, educated, and prepared to pursue their own intellectual interests with the students. This aim also required learning how to refuse, occasionally, some teacher responsibilities that she or he judged to restrict the primary aim of pursuing one's own intellectual interests with students. The argument was that the only way a teacher could expect to survive the intellectual and educational sameness of teaching was to have the strength to refuse these demands periodically, and not feel guilty. Included in this approach to assertiveness would be taking a deep pride in being an educator. This was to be demonstrated by the University College of Education in supporting, guiding, and stimulating all Icelandic educators to create and experiment with their own uniquely designed educational theories and practices.

The *exchange roles scenario* emphasized that all roles related to Icelandic education should be shared by all educators, including those in teacher education. This meant that student teachers would need to be educated to be flexible, adaptable and ready to "read" a variety of settings and situations if they were to take on a variety of roles within their career as an educator, including research. Movement throughout the educational system would be encouraged, supported, and demanded, with five years being the maximum in any one job and location. The argument was that, with institutional roles largely remaining the same, an individual's enthusiasm and liveliness in the work would be enhanced by new venues and challenges. In turn, this would make the education experienced by children and youth richer and more varied, whether they resided in the countryside, town, or city. To accomplish this aim, the preparation of Icelandic educators would

require practice in a variety of educational roles and in a range of places within Iceland.

The *independent cells scenario* suggested ways to continue to develop and to test new approaches to teacher education in Iceland. This would be accomplished by separating the College of Education faculty into a number of different groups, or cells, each with seven faculty from varied educational backgrounds; including, for example, having been educated in different countries, subject matters, and educational philosophies. Each cell would be responsible for developing its own unique integrated approach to educating students to be teachers, and each cell would have its own students for the entire teacher education program (three years at that time). Although each cell would design its own approach through dialogue and group decisions, it was emphasized that cross-cell communication would also be essential. What was important was that each student would be involved in an open-ended excitement of debate and communication between many separate forms of teacher education that were being discussed, reviewed, and tested out. It was felt that this was one way to get a variety of new educational perspectives practiced within the education of Icelandic teachers.

Most of the 13 scenarios were similarly unique as compared with what I had seen in practice or read about in the literature or heard in presentations on teacher education from a variety of international contexts. Each scenario had strongly argued reasons related to the aims of education, the nature of human intellect and the human mind, along with the needs of Icelandic society in general, and for a powerfully educated citizenry in particular.

What made the interviews a powerful experience for me was how creative and out-of-the-box these models for teacher education were. Each model was described thoughtfully in institutional and educational detail and argued passionately in terms of educational purpose and need. Most powerful were the individuals' respect for an active mind and independence of thought, along with the importance of culture. What has stayed with me over these decades, however, is just how many different models came from so few.

Was Iceland in 1986 an unusual place where thoughts on teacher education could be so diverse? I continue to ask whether the variety of educational creativity displayed by my Icelandic interviewees could be repeated in other circumstances. Iceland was certainly a different place then than it is now; then it was both a small, isolated, traditional society and a globally interactive post-modern one. For example: most of the teacher educators had experienced their higher education in a variety of countries other than Iceland. Today, Iceland is primar-

ily a post-modern society. In 1986, it was a culture going through extreme flux stimulated by its involvement in the Second World War nearly two generations earlier. Now, another two generations after that, it is primarily a hyper-modern, European nation with, perhaps, a bit stronger connection to the U.S. than to its European neighbors.

The seminars that analyzed these scenarios were also stimulating and memorable, but in a different way than the scenarios themselves. First, the "no judgment" rule turned out to be absolutely essential. The College and School faculty often remarked on the fact that holding back on making judgments was very difficult, especially at first; but, they added, by the second seminar the increased comfort of withholding judgments brought out new possibilities for these models for teacher education that they had never previously considered. Often many admitted, "I simply did not like this scenario when I first read it. But then, when I tried to understand it and expand on it, I saw some real possibilities and became excited." One said: "When I looked into this scenario, it looked so weird, but after considering it, it didn't seem so impossible." Another said, "I've argued against this scenario for years. Now that I have just considered its educational assumptions and justifications, I see some sense in it."

One day, as we were completing a seminar, one participant said she was feeling guilty about enjoying the processes of the seminar. "I'm afraid I'm being too playful and imaginative," she said, "at a time when there are absurd and real consequences of the educational structures we have to deal with now. Can't we do something with these realities other than play with imaginary scenarios?" A murmur of agreement from the group emphasized her point. I responded by saying I considered the two processes of play and engagement with reality to be less distinct than that. What I felt we were doing was analyzing the research data together, expanding upon some Icelanders' views of what may be possible for teacher education in Iceland. I was not asking them to decide what needs to be done to change teacher education in Iceland, but to help them prepare themselves for a time – expected to come soon – when they would be asked to provide suggestions, make decisions, and apply them.

Was this process of using inquiry to look for alternative views of what needed changing and why, along with seminars engaged with those responsible for the changes effective? I can't say, except a few years after the project was over, the Teachers College of Iceland ended up with a vision not considered in the study. It became a five-year teacher education program, including a Master's Degree, that looked like one proposed by about 15 major U.S. universities around the same

time. When I heard, I was disappointed, but that is irrelevant. The aim of the research was to elicit a variety of Icelandic views on teacher education reform, and for faculty to consider those views seriously. That was done.

Without a doubt, however, this six-month study using interviews and seminars brought me further towards the idea of edGe-ucating than any previous single research effort. The range and depth of educational creativity represented by the scenarios deeply impressed me as an educator. Even more important to edGe-ucating, they were unique to the professional edges of practical and theoretical expressions of how teachers can best be prepared and why. Those interviewed not only went beyond the expressed edges of teacher educational reform that I had previously seen from national - or international - research and policy debates, but they often came from those not in the teacher education profession. Furthermore, in the seminars it was the teacher educators' attention to open processes of analysis that struck me as they dealt with unique views of doing their professional work, and why. This was work at the edges of educational thought that I had never met before, or had seriously considered. I learned that if educational edges are to be seriously entertained, professional experts need to leave aside their experiences of expert identity, and more openly consider multiple alternatives expressed by outsiders to their profession if new edges are to be seriously imagined. How does that happen?

One way it did happen in this circumstance had to do with language. I did not understand Icelandic, and so at the first seminar, I asked the faculty what language they wanted to speak in their small group discussions. Their answer shocked me. "English," they said. When I asked why, they answered, "Because in Icelandic we know each other too well. In English we have a better chance to step out of our public, professional persona, and surprise each other. Maybe ourselves." They did use English, and they did surprise.

Educational expertise was democratized, maybe even turned around. At least for a short while.

bastards of higher education

I did two more studies on the reform of higher educational institutions in Iceland. The first was for the Education Ministry of Iceland in 1989-90, which asked me to look into the challenges being addressed by three educational institutions attempting to achieve university status, and the University College of Education which had previously achieved university status. The change process had been taking considerable time – fifteen years after the change, the University Col-

lege of Education was still experiencing the change process – and costing large amounts of money, effort, and difficulty in the process. The Education Ministry wondered if a study could provide guidance and support for the three institutions during their processes of change. Equally important to the Ministry was a need to provide advice to a variety of other professional colleges in Iceland that were also beginning to consider changing to university status.

Six years later, a follow-up study was requested, asking me to look at an additional five colleges that had been considering the change to university status during the earlier study and were currently going through the transition. The aim of the second study was to see what more could be learned about the processes of institutional change in higher education in Iceland, and to see how effective the previous study had been in helping additional professional colleges, and the Ministry, through these processes.

The first study focused on three institutions, the Nursing College, a Business College, and the Technical School, in addition to the University College of Education. It focused primarily on interviews of the faculty and managers of these institutions. It ended in a variety of recommendations to the Education Ministry for assisting, guiding, and supporting an educational institution that was aiming to change to university status. These recommendations included themes focused on leadership, vision, outside circumstances, research in the profession, and economic support.

The second study added four additional Icelandic colleges that were changing to university status, the College of Art, the College of Music (two were combining), the College of Drama, and the School for Early Childhood Education. This study concluded with implications about the nature of the experience of institutions trying to achieve university status. In particular, it focused on their years of in-between status, being neither the college or the school they had been, nor the university that they were trying to achieve. The themes of the second study included identity, professional connection, maneuverability between old and new, and the importance of economics over professional ideology.

I will discuss the two studies as if they were one, since both studies used a case study approach for understanding the experiences of each of the eight institutions, combining interviews, visits and observations, and related documentation.

Both studies documented how all those working in these institutions needed to accept how different they were during the process. They were neither the college they used to be nor were they the university they were striving to be. Said

one college head as her institution was going through the process, "We are the bastards of higher education." Furthermore, she went on, "We must break the rules we used to have to get the job done."

What fascinated me in both studies about the transformations of each institution was how interesting they each were in educational terms.

The drama faculty talked about their approaches to teaching acting. They showed a rare sophistication, for example, for linking specific intentions involved in instilling an actor's capacity to be another individual with a range of creative and reflective approaches for all students to learn through individual and group practices.

The music faculty referred to the educational roles not only in the practice towards successful performance, but to the central place of musical understanding, both theoretical and anatomical. The engineering faculty talked about one primary reality faced by all their graduates. In Iceland, they pointed out, graduates would seldom, if ever, be able to go to a specialized expert to resolve a problem they were confronting. Because of the limited population, problem-solving in Iceland demanded that the engineers solve new problems by themselves. Thus, their education emphasized how to solve problems with minimal background or training to fall back on. Learning had to be focused on creating processes for oneself to address new problems on one's own.

The technical faculty referred to students who were often more sophisticated and experienced with many of the technical computer skills than their instructors were. Consequently, they had to come up with training methods that acknowledged that as fact, build on it, and bring students to places of action and performance where their instructors might not expect to go.

All faculty and heads spoke in educational details about how to encourage students to engage with new ideas in their respective professions that faculty were still trying to form for themselves. They referred to challenges where they were teaching students beyond their own understandings or experience. They not only acknowledged these challenges as educational ones: they immersed themselves into creating new educational approaches that made sense to them as they prepared their graduates to work well within the changing profession they had chosen to enter. These included educational approaches that they had never seen in practice themselves, nor heard of. Nor had I. What was significant to me, as one who had talked for many years with a variety of well-known educators, was how many faculty and heads were so articulate, clear, and detailed in how they explained themselves about new, practical, educational action (English, by the way).

One of the biggest educational surprises that I encountered was with the business school, a private school, located a couple hours from the city of Reykjavik. It stood alone in the empty country side of Iceland, with necessary housing for all their students and in many cases the students' families, and was the only institution I visited that operated independently from the Education Ministry. As the school was pursuing dramatic changes in order to achieve university status - such as replacing nearly all school faculty - this business school had begun to emphasize the full everyday life of their students as a primary feature in their becoming educated in business.

The students' education, in other words, was not focused only on the classroom. Instead, focus was equally placed on the organization of the community of students and their families, on the services required, on the collective decision-making of the community, on working on cooperation towards agreed-upon goals by accommodating differences and developing group cohesion and support. In these deliberations and actions, the students were in charge, and classes were designed to assist their preparation and increase their capacities to support their community's decisions. In short, as the school oriented itself to university status and identity, it made the student community a primary feature of its educational plan, with courses, actions, and sources of information and experience that could be used effectively as part of a business education. Thus, as the school became first a college and then a university, the practical nature of student families living together became a primary feature of the institution's approach to the professional education of a business-man or woman.

I do not know how much of this change survived the transformation to university status, but I do know that at the stage when I was observing and talking with the various staff, faculty, and management of the business school during its transformation, it was probably one of the most unique approaches to business taught in a higher education institution located in any Western modernized country.

It was this kind of educational uniqueness that struck me hard then, and has stayed with me over the years. These were not schools, colleges, or universities that identified themselves first and foremost as educational institutions. Yet, during their times of transition, they were certainly at the head of any class of educational institution, with uniquely clear educational goals and intentions, unique rationales for how they were operating, sometimes unique faculty teaching towards those goals, and a unique kind of identity that was not what it had

been, and not yet the recognized institution for professional advancement in their respective fields.

If there were an example of an educational institution that worked at the edges of educational knowledge, all these institutions would have qualified at that time. They were all working at edges of educational thought and practice where few had tread. They may not, of course, be currently operating in a similar manner now. But that is precisely the point.

We have examples, not only in Iceland at the time of my two studies, but around the world and in many different epochs of human history, when the edges of educational knowledge have been expanded on institutional levels as they aimed at higher goals. What is almost as clear from this time in Iceland is that these may have been limited educational occasions, relatively brief times of transition as professions reached towards a philosophical or theoretical goal that, once approached, existed no longer. In physicists' terms, their half-life was about two years. There may be many more times in human history when similar cultural circumstances required similar attention to educational transformation. Hopefully in the future we can make them last longer, and thus achieve greater educational transformation than we ever have before.

It may help those who consider edGe-ucating a reasonable aim to look closely at events and experiences of other institutions as they have changed to university status. Those, too, may help demonstrate what edGe-ucating can mean at the educational edges of an institution transitioning towards a status other than what they traditionally had been. From my research in seeing a number of Icelandic institutions within this transformational process, two features stand out.

One feature was that the educators I saw operating in these in-between stages of institutional change towards university status had no special training to do so. Yet they were doing extremely well as they worked through new challenges required to achieve a universally recognized university status for providing both education and research in a professionally oriented institution.

The other feature is that the primary cause for many of the new challenges was how to arrange a new professional balance between educating and researching. In fact, what I learned from my research is that, during their difficult institutional transition, they were focusing so much on their educational perspective that they may never have been as educationally sound as when they were going through that transition. Combining new relationships between research and education in their respective fields, through extreme uncertainty and doubt, seemed to have

created a context in which the educational part of professional higher education blossomed – at least for that short in-between time, before each achieved full university status.

Both features may be significant to anyone interested in edGe-ucating. The process of trying to achieve edGe-ucating along with educating may be similar to integrating education with research. That may mean that the transition time is richer than the time when the goal is concretely achieved. For example, the research orientations of these professional schools during the transition time of my two studies may have been as unusually rich as their educational orientations had been. But I did not document their approaches to research to the extent that I would have needed to suggest that their research ambitions had also changed during the transition. Maybe next time.

Six

teaching teachers to research

teaching as intellectual work

A first step towards accepting that teachers can do educational research is to understand that much of the work of teaching challenges the intellect. Teaching requires constant independent analytical activity because minds of humans, young and old, are so individually variable with so little known. Although I began teaching by holding an uninformed attitude that teaching was about the mind, the act of trying to teach children soon taught me more about what I had gotten myself into.

Teaching a classroom of kids required two competing features of my intellect: planning and flexibility. I spent considerable time and effort creating and planning activities for student learning, focusing on my intentions for what they could learn, along with possible activities. But after I went into the classroom with actions planned to gain full student involvement in their learning, I often had to throw them away, and immediately improvise something new in order to respond to an unexpected need, or failure. In other words, teaching kept me on the edge.

I remember in my first month of teaching, I had planned an especially detailed game with 6th grade students to focus their learning on fractions. As I was starting to introduce the activity, one of the more twitchy members of the class couldn't stay still and was gaining all the class attention. I kept trying to calm him down to no effect, and then burst out in anger, picked him up by his shirt, carried him out the room, with his book, told him to work on his own out there in the hall, as the class would get on with the planned activity. Returning, I found the room absolutely silent, shocked, scared, and in no mood to try an interactive game.

Because of my action, the prepared activity was out; immediately I had to come up with a different approach for the day. I was terrified. Sitting in a chair, putting myself at their level, I asked them questions about their morning and then their thoughts about operating on fractions. I brought the boy back soon after, tried to apologize, realizing that the game was my activity, not theirs. In

time, I learned how to plan better, and, more importantly, how to throw out the plan better, often due to my limitations, not the students'. But it also impressed upon me that I had to consider where my students were, not where "students" might be.

As significant as my personal experiences were to my learning about teaching, my respect for the intellect of teachers was expanded further by those I taught with in public grade school. Mostly women, they each had constructed a style of her own within her classroom. Each was confident in her own way of working with the ambiguous relationship between plan and flexibility, as they relied on their unique and various ways to engage all the children in their classrooms to learn the skills, attitudes, understandings, and behaviors that had been deemed important to learn. Seeing how each teacher worked differently, with their own personal style but a shared intent, further reinforced my understanding that teaching was a challenge for the mind. To be a teacher over time, as they were, to respond flexibly to the demands of getting children to learn within school classrooms on a daily schedule, required a highly engaged intelligence.

I never lost my deep respect for teaching as an intellectual challenge, but my respect was deepened when I began to see teachers doing formal inquiry on their own. Pat Carini was my first encounter with someone who acted to respond to the fact that teaching is an act of intelligence. At the time I met her, she was a unique and creative head of a school in Vermont who designed opportunities for her teachers to learn more about their students by studying the art and literary work of each child, made from kindergarten through grade 12. To make that possible, she had built a school library of all the poems, stories, and art work that every child in the school had ever made.

That school collection of children's work made it possible for teachers (and parents and children) to study and learn about each individual child from what each child had produced on her or his own. Pat Carini had also created a process through which a small group of teachers could gather to analyze a child's collection of work, with the purpose of providing a richer view of who the child was, beyond being an entity in the school and classroom.

When I saw small groups of teachers in her school perform this process of analysis, I not only learned more about a child in 20 minutes than I thought possible, but I realized that the teachers' discourse, interaction, and bringing forth new ideas about the child as a person was an act of the group's near genius in educating. I saw teachers share a curiosity of individual children's minds, applying careful observation, listening to each other's analyses, contrasting and com-

bining together rich understandings of singular childhoods. This was an action expected of all teachers in that school.

At the time, Pat Carini's support of teaching as an intellectual activity was at the edge of educational understanding and action. Currently, that support seems as far away from the edges as it is from the centers of educational practice. EdGe-ucating requires similar attention and respect for the human mind as Pat Carini had for each child and each teacher in her school.

Howard vs Piaget on how children learn

On my first day in Norwich, England, at the Centre for Applied Research in Education (CARE), in early January, 1984, my new colleagues told me that they thought that I would be a good person to serve as Howard's primary doctorate advisor. When I asked why, they said because they knew of my math background, and that was where his doctorate work was aimed. Howard and I met a short time later.

Howard was a 2nd grade teacher from a small village near the east coast of England, teaching primary school full-time and attempting to get his doctorate degree. He was a slight, greying man, about 60 years old, friendly, rather unassuming in manner, and he came with two armfuls of equipment including a large tape recorder, a smaller tape recorder, a microphone, the requisite cords, and boxes of tapes. Clearly, he wanted to show me what he had been doing in his research, not just tell me. First, he asked if he could tape our conversations. After I agreed, he took out the small tape recorder and microphone. Then he described his research, and how he got into doing it. Howard's class were currently second graders, but he had begun teaching them the year before as first graders. When teaching first grade, he had used a given list of mathematical words that children should know by the end of first grade and another list by the end of second grade. He showed the lists to me, and told me that early in the first year, sure enough, when he talked to the students about the words on the list, they were uncertain of the meanings. Since he had recently decided to get his doctorate degree, however, he thought he should do something a bit more challenging for the students than just learning these words, so he thought of a game-like activity they could do.

The first graders were put into small groups, each group at a different table. Howard gave each group a math problem involving concepts that they were not familiar with, and asked each group to work among themselves to solve it. He made sure that these were problems requiring concepts that the children had not previously seen nor solved, but that they might be able to solve together with

the few concepts that they did know. In the beginning, for example, perhaps a subtraction problem without them having talked about subtraction before, but knowing what addition was. He had also put a tape recorder on each group's table, showed them how to turn it on before they began their problem solving, and off when they were done.

At this point, he brought out some of the tapes he had gathered from the children's problemsolving discussions. I listened to a couple tapes with him, finding the young students fully engaged with each other, trying out explanations, arguing, sharing their thoughts, often building on each other's ideas, and working out different solutions until they were satisfied. I was also impressed that the seven-year olds knew how to turn the tape recorders on and off. (Today, of course, young children show me how to make recordings with my cell-phone.)

Howard then told me that he had transcribed all their taped discussions, and used the transcriptions to deepen his analysis. What was fascinating, he added with a new force in his voice, was how different the language they used in their math discussions with each other was from the mathematics language they used with him! The language they used in their groups, alone at the tables problem solving, was significantly more mathematically sophisticated than the language they used with him in his math lessons. In fact, early in the first-grade year, he had discovered that the words they used in their groups had covered not only the first-grade list of mathematical terms, but the second-grade list as well.

That became his research problem. How could he explain this result? Where should he go now? What should he do with his lists of mathematical terms? Expand them? What does this mean to his teaching of mathematics to young children? Or more important, what does this mean for how young children learn mathematics beyond the classroom?

I was stunned by what I had heard on the tapes, not because of their mathematical context, but because they had deep linguistic significance. Howard had evidence that denied current linguistic theories of how children used language to learn. You could hear them applying vocabulary from each other, exchanging communicative roles from informer to informed and back again, and through this process, integrating new concepts to solve the problem in front of them. What Howard had on tape, and had transcribed from his young students in a small village school in the broads of Norfolk, challenged the theories of Jean Piaget, at that time the foremost researcher and theorist on children's learning and their developmental uses of language in learning. The tapes made clear that children as young as six years old knew how to engage with each other about topics they had

not previously known or considered. Working together, they had found ways to solve new problems, ways that were different from, and apparently more effective than, what they were doing in class conversations with their teacher.

Piaget's research on child language development had focused on listening closely to and recording his own children from infancy through childhood. Howard's research was being recorded in an everyday classroom with 6- and 7-year-olds conversing without his immediate presence.

My mathematics background had almost nothing to do with Howard's study. But my linguistic background, basic as it was, did. I could introduce Piaget's work to Howard, pointing out how his data challenged Piaget's theories of why and how children developed capacities to learn sophisticated roles of language. I encouraged him to continue to do just as he had been doing. The only change was that he would be focusing on the data the children were providing that challenged the current terms, phrases, and concepts of Piagetian theories of child language development. His focus on the mathematics the children were inventing would provide the context.

Howard and I continued our discussions about every two weeks, with Howard bringing in new tapes he had collected for us to consider together. Every meeting was fascinating, beginning with Howard pointing out what he thought were unique concepts being brought up by individual children, and subsequently becoming common usage to those in the group discussions. We were both hearing a language usage that we had never heard before. Excited by what we were discovering, we animatedly discussed possible descriptions and interpretations of how the children were operating together. It began to seem clear to us, for example, that it was the social intelligence of all the children that we were hearing. It was the different ways in which they assumed both the roles of being knowledge holders and of being learners that they used to build their common understandings of new mathematical operations. What they knew was not the mathematics as much as how to build on each other's varied and incomplete understandings.

You could say that the discussions between Howard and me were similar to the discussions we were listening to from his first and now second grade students. Like them, we two were constantly moving back and forth between who was the informed and who was the uninformed as we tried together to explain what the children were doing.

The result was that Howard, by himself and through his open respect for the intelligence of the children he was teaching, had produced the data for a break-

through in understanding how children solved problems. To solve new problems in mathematics, the children used linguistic strategies that helped them build new knowledge. He continued his study with tape recording in the same manner as he had begun, while becoming more expert in the theories of child language acquisition and theories of children's construction of new thought.

This unassuming, quiet, reserved, life-long teacher of first and second graders in a small village primary school in rural Norfolk had made a giant breakthrough about young children's sophisticated uses of social language when solving mathematical problems on their own. I left CARE before Howard had completed writing his doctoral dissertation. When I visited a few years later, I asked how his dissertation had gone. "Oh, we thought you knew," I was told, "Howard got Alzheimer's soon after you left, and his dissertation was never completed." I became extremely sad for Howard who never got the recognition he had earned. But, I must also admit, I was just as sad for the education profession which had lost the breakthrough that his research had provided. Although studies of children's problem solving are now showing similar social intelligence, as far as I know, no one has followed up or referred to his study, including, until now, me.

a London dramatist redefines educational impact

When I got to the Master's degree program in Applied Research in Education at CARE, it was not large. It was a one-year program, with nine full-time students – all teachers or school heads except for one who was a dramatist from a London theatre group that played to many ages of school children in London. She came to CARE with a question related to her ten years of work as a dramatist and actor for school-children, having decided that a Master's degree in applied research in education might help give her an answer.

The dramatist knew that the children and youth for whom her group performed had always loved the theatrical productions of her troupe. They were excited, involved, and asked terrific questions after the shows. What she wondered was whether there was anything that they remembered, that stayed with them, from these productions? Or was it a kind of one-time experience, perhaps interesting or exciting at the time, but unremembered and insignificant in the long run.

Because of my previous study on residual impact, I warned her about the near impossibility of finding a real answer to her question. After all, I had found the residual impact of a learning activity to be very difficult to uncover through formal

inquiry, even after only two years. I strongly recommended that she not use her energy and time to pursue that particular question, since I was afraid her efforts would be wasted. There must be another question you can ask, I suggested, one that could help you unpack some of the ambiguities of theatre performance and audience response.

My powers of persuasion had no effect. She emphasized that she was not an educator, she was a dramatist, and this was her question. She came to CARE because she wanted to get an answer to her question. And she felt this may be the only place where she could do that. So, she would do all she could to find what stayed with her young audiences over time, even if it included, perhaps, nothing at all.

She won. She returned to London to do her inquiries, locating former students who had seen various productions that she and her group had put on over the past ten years. She interviewed many of these former London students, wrote up the results, and returned to CARE a few months later to present her findings.

Even ten years later, former students remembered details from many plays, such as Hamlet, A Streetcar Named Desire, or Waiting for Godot. They remembered specific scenes, specific lines, or sometimes even obvious mistakes such as flubbed lines, problems with a costume, or a malfunction in the scenery. They remembered some questions asked at the end of the play, and some answers to the questions. They remembered being moved by a play at the time, or identifying with a character, and why. They remembered feelings that stayed with them after they left the school, and they remembered talking with their friends about those feelings. Many told her the performance of a play not only stayed in their minds, but they had continued to enjoy being play goers.

Although the dramatist was not a teacher, as she reminded us, she certainly was a researcher of the mind. The research that she had designed and performed uncovered a variety of meanings of residual impact on students of differing ages. If she were a teacher, this would have been a breakthrough. It certainly was a breakthrough to me, and a study that has stayed with me ever since.

We all know that many processes of learning occur beyond education – maybe most of them. She provided proof of that. Good for her that she didn't listen to me, her teacher. Good for me, too. Perhaps we educators could have asked her more about how she located residual impact and brought it back to educational settings. For example, I never asked her how she would have designed the study I had done a few years earlier.

John Elliott, the dignity of teacher research

John Elliott is a quintessential educator, one who all his professional life has championed the role of the teacher as thinker. He is a thinker himself, one of the most foundational thinkers in educational research that I have known. Applying logic – going from premises to new understandings – was his specialty. It is, I think, how he proceeded so quickly to teachers doing research. Teachers teach in schools, and educational and school reform is about teaching in schools differently; university researchers do not teach in schools. Therefore, it is necessary that teachers do research on teaching if reform is to change teacher understanding and behavior. That is my interpretation of John's logic. It is not a quote, but he has always been direct, argumentative, and absolutely clear about just why he has emphasized the need for teachers to do research, and how they can go about that task, and do it well.

I met John Elliott quite early in his career, after he had gained his graduate degree and while employed on the Humanities Curriculum Project, headed by Lawrence Stenhouse, housed at the Centre for Applied Research in Education (CARE) at the University of East Anglia. I mentioned in an earlier section about having heard him speak at the AERA meeting in San Francisco in 1975, and being impressed by his examples of teachers doing research, as well as his rationale for that work. Later, we became close friends, respectful of each other, and enjoying the ways in which our two minds worked differently towards the same purpose. We both wanted to see the educational profession support more opportunity for intellectual leadership from teachers.

About five years after we had met, in about 1980, we met at AERA again and decided to team up for a day of presentations in order to ask questions together. Asking questions is something we both valued, feeling it part of our duty to get closer to what was being reported as educational research. At the end of that day, we were surprised by a small cadre of researchers who had begun to follow us from session to session because they wanted to hear our questions. We were both rather embarrassed. All we wanted was to see what we could learn together.

Near the end of the Humanities Curriculum Project, John began working at Cambridge University with opportunities to promote teachers doing research. He accomplished this task far beyond the shores of England. In the U.S., for example, his name became more closely associated with teachers doing research than it was in England. This was not only because of his many presentations in the U.S. or even his writings on the subject, but because he was a more singular

voice in the U.S. than in England, and he was similarly unique in some other countries as well. If I mentioned his name in the U.S. as a colleague and friend, my reputation increased with those who felt that teacher involvement in research was a good idea.

Eventually, John became a faculty member at the University of East Anglia, and the Dean of its School of Education. It was a well-earned professional reward, and a sign of the significance of his efforts over the years to support the intellectual work of teaching and teachers. It also was a rebuke of an initial judgment of his work when he was going through graduate school in England.

In his graduate school at that time, one did not enter into a doctorate program, one simply wrote a dissertation which would subsequently be judged to be worth either a Master's Degree or a Doctorate Degree. The choice depended upon the judgment of the student's graduate committee, with John's committee being in the philosophy department of the school of education. I am told his dissertation argued for the significance of teachers being involved in educational research, pointing out its strong relationship to action research in the social sciences, as well as to improving the practical understandings of teaching and learning in the classroom. His graduate committee deemed that his evidence, arguments, discussion, and conclusion were too related to educational matters and not related enough to philosophy, and thus awarded him only a Master's Degree.

John Elliott's life-long influence as a world-wide leader of teachers doing research, and of the role of the teacher in the intellectual work of educating students, has demonstrated the severe limits of his graduate committee's breadth of professional intellect.

No one now doubts that John Elliott worked diligently to include teachers and teaching into intellectual visions of professional educational work. That he did this at the edges of education is likewise not a matter of debate. He was an edGe-ucator from the beginning as he pushed for, argued for, guided, and supported teachers doing educational research of their own. Most teachers he encouraged to go into research became better researchers of education than we educational researchers were.

a Center focused on educational edges

It may by now be clear that I viewed the Centre for Applied Research in Education (CARE) as an oasis of educational thought and debate for many educators, worldwide. It is also the place where I began teaching research to teachers. The

founder of CARE was Lawrence Stenhouse, a unique educator with an active mind who, in turn, knew how to hire young, talented, similarly active minds into education. He founded CARE at the University of East Anglia with some of the staff he had formed in the Humanities Curriculum Project. The purpose of that project was to inquire into how a newly developed curriculum in the United Kingdom was being enacted in its schools. The aim of CARE was to promote authentic research approaches to the study of educational practice and school reform.

Sadly, in 1983, Lawrence died unexpectedly young of a massive heart attack. I got the message in a call from Rob Walker, appointed CARE's temporary Director, who was calling to ask if I would be able to come to CARE for six months to take over the teaching and other faculty responsibilities of Lawrence Stenhouse. With my step-daughters on their ways to their own individual careers, research support becoming harder to acquire, and me actively looking for a job with more reliable security, I thought this may be a good step. In early January, 1984, I arrived in Norwich, England, in a blanketing snowstorm. The six months turned into two and a half years.

One of the features of CARE that I appreciated and valued from the beginning was its active professional energy. There were many educational researchers engaged within and around CARE at the university, each of whom was practicing his or her own views of how to do good educational research.

Rob Walker, for example, was focused on classroom practice. He published one of the best publications I have seen on how to observe and analyse details in classroom teaching and learning. This explanation was accomplished almost entirely through photographs. Beverley Labette used tangible but unconventional records to learn about what was going on in schools, past and present. In one study, the only data he collected and analyzed were the crumpled papers he gathered from classroom waste baskets; in another study, about an early 20th century woman physical education teacher, he told her story through words taken from her personal diary, school records referring to her presence, and photos of her and her students and of her on her bike. No words from Beverley. John Shostak analysed the largely unseen features of social class that occur within educational contexts in a language he largely invented for the task, written in his own inimitable style. Charlie Hull was a favorite of mine, probably because he seemed to be the outsider. He was hesitant within the group, but a poet of education in his writing and in private conversation.

Jean Rudduck was the one who knew teachers and their work the best, and her research always showed that. She also was the most organized person at CARE, comfortable working effectively within an institutional setting, which CARE needed. Helen Simons, based in London, was one of a few women active in CARE from the outside. She often focused on the hardest parts of researching educational settings, such as interviewing students, or negotiating interviews with administrators. Her views and her quick intelligence on a variety of actions required to investigate challenging educational settings were often asked for and heard at CARE.

In my second year at CARE, a new faculty member was hired, Ian Stronach, from Glasgow, Scotland. Ian had a mind like no other I knew, facile with the nearly unintelligible (to me) social thinkers and philosophers of the day, such as Foucault, along with a unique creative spirit that extended these thinkers into the everyday of school practice, reform, and research. His playful way with ideas, words, and the insights brought on by his intellectual intuition made him the most unique educator I have known. And the most fun to work with, talk to, and search for better understandings.

Barry MacDonald was always a strong presence, as well as the primary acquirer of CARE funding for evaluating educational programs – from schools to police academies to music colleges while I was there. He had a sharp mind and a piercing, humorous wit that captured human character in a phrase or two. His wit was often biting, memorable and accurate, making his self a bit frightening to some. His eulogy at Lawrence Stenhouse's memorial service is still talked about by those who were there. Barry also wrote the most creative approach to teacher education I have ever read. He proposed that students of teaching use their four years of teacher training to study children and youth in their natural settings outside of school. Students of teaching, he suggested, didn't need to practice teaching; that could be learned quickly enough through their experience after they entered schools teaching full time. Educators, he argued, need to be curious about the contexts of childhood and adolescence. (I'm told his proposal was taken up by a teachers' college in Canada.) When Rob Walker left CARE, a year after I came, Barry naturally became the director.

Along with Barry MacDonald were a few young, unusually experienced researchers who worked on Barry's evaluation studies. They also taught in the Master's degree program. They were bright, creative educational researchers on their own, who had been uniquely trained in Barry's disciplined approach to interviewing and negotiating the interviews within and across institutions. More

than anyone else in CARE, they were the ones with whom I taught teachers to do research.

Early on, we gathered to talk about activities to engage the students in doing research. One of the teachers' first introductions to research, I was told, was for the teachers to perform a one-day study within a school. This included identifying a theme to study, then to observe and interview in the school, returning late in the afternoon to CARE to analyze the collected data and theorize from the results. "In one day?" I asked. "You'll find out," they replied.

A school agreed to be studied with a negotiated theme. The students decided what their interviewing and observing responsibilities were, and throughout the school day performed them. In the mid-afternoon, the students returned to CARE with their data, put it on blackboards, and began discussing the data. They critiqued and rearranged their interviews and observations, placed priorities on what data seemed most important, and created possible ways for their data to relate to their theme. Discussions were lively and interactive, full of loud voices, surprises, humor, and asides. They went to a pub for dinner, returned to look at the data again, and tried to arrive at a theoretical outlook that could aggregate features of what they had found.

All within a full day. The details of their work were left on the blackboards.

The next few days, the students and CARE faculty critiqued the one-day study that the teachers had accomplished, pointing out strengths along with limitations and weaknesses. The whole enterprise seemed to be a terrific introduction for the students to begin to experience what doing research meant.

I had now seen how those not experienced in research could produce a study in one day from which they could begin to understand what educational research was, and what it felt like to be in the hot pursuit of authentic information and explanation.

But my view of what I was learning about our students doing research conflicted with what the young researchers at CARE had learned. To me, this one-day study showed how closely the teachers could get to doing good research in a very short time. To the young researchers, this was a student experience that demonstrated how limited were the teachers' research skills, pointing to the extensive training that they had required.

From that day forward, I have always introduced doing research to teachers by emphasizing that there was no such thing as "baby research." To me that meant that they immediately had to apply the ethics of research by respecting the autonomy of those they were asking questions, listening to, and observing. To

my young CARE colleagues, however, it was "baby research," an exercise for the students to learn research ethics as well as research skills through their mistakes. The conflicts between us increased as we taught research skills to the teachers, such as those that related to interviewing and to observing.

As an example: when the students began interviewing by interviewing each other, I had noticed, and told them, that they seemed to be interviewing as if they were teaching. They asked questions to get answers they knew. That, I told them, was a terrible way to interview in research, but it also is a common mistake all researchers make. I reminded them that in research you ask questions because you don't know the answer. The people whom you are listening to - do know. So, if their answer is a surprise, or you aren't sure what it meant, or why it was given, you keep on asking until they have helped you understand better. In research, one listens to learn from the answer, not to get an answer you want. Although you may routinely question as a teacher in the classroom, it is often to see whether the answer is what you expect. If so, you go on. In research, if the answer to your question is not what you expected, then that is gold to pursue with further questioning.

I then demonstrated what I meant. I had in my possession many interview tapes from wellknown researchers as well as my own. I gave each student a tape, told them to listen to it, and find the places where the researcher made real mistakes in not listening closely to the answers, in not pursuing an interesting but vague answer with more questions, but instead moved on to a new question. As the students critiqued our tapes, many of my young colleagues believed I had made a huge error. Particularly because many of the tapes were from highly respected educational researchers, they felt that I was undercutting the professional nature of research in education.

Soon, however, the teachers were interviewing better than I had in my studies. And the teachers had evidence of that fact.

In observing, the opposite occurred: they were experts from the start.

Most teachers are better observers of educational actions than us educational researchers. Teaching in large groups is done with the eyes. They see more specific details of student behaviors in the school and classroom that we do. In crowded settings, they can focus on features of individual behavior with a rare clarity; in a moment they identify commonalities between observed individual behaviors. Even before the teachers had begun to learn research methods, they were expert observers of educational settings.

My recognition of the teachers' untaught research expertise caused a big problem – for the teachers – as well as for my colleagues. "If we can observe and

now interview better than you," students asked, "Then how can you teach us?" My answer was that when I was teaching poetry to 11-year olds who could write better poetry than I, but it didn't stop me from trying to teach them more. No matter what one's skills, there is always more to learn, often from another who does not have the skills you have in what is being taught. After all, even the most talented athletes can still learn something from a coach whose skills might not match theirs.

At my first graduation day at CARE, we met the families of our students. One of us asked the group if they had noticed anything new about their husband, wife, father, or mother over the course of the year? "Yes," one immediately answered, supported by a chorus of others, "he listens more." We teachers of research looked at each other. Success.

When it came to working at the edges of qualitative research methods, CARE was one of the most exciting places to be. I look back on my time working there, and realize that many of our conflicts came about because we were all edGe-ucating the teachers. We were actively promoting teachers to become more expert at the edges of research method than we ourselves were. I didn't recognize that in those words at the time, but many of the younger researchers saw and resisted that possibility. To those who learned their research discipline well, and had internalized the notion that researching was a set of skills acquired through considerable work, experience, and practice, any possibility that their students were becoming more expert than they were produced authentic conflict.

I never had that conflict with Barry, although he often suggested I tone my language down. He may have seen my views about learning to research similar to his own views about learning to teach. Both teaching and researching were professional disciplines that could be extended by applying personal experiences, understandings, and skills developed outside of their two respective professional domains.

Disagreements, however, were always worth the time at CARE. In CARE, trying to seriously understand education, especially educational practice and its many contexts, was worth the intellectual effort, and disagreements were a necessary part of the process. One public feature of CARE, for example, were its debates, which were high energy affairs, put on for public viewings. I am told the ones between Barry and Lawrence were always packed.

I will close this brief account of my stay at CARE by adding that, in the end, Barry was disappointed in me. He had hoped, he told me more than once, that I would help procure funds for new research studies, as I had done successfully in

the U.S. He also suggested that if I didn't do that, at least I could write something about CARE. I did that before I left, and titled it, "On the edge of the edge of the edge of the edge." I pointed out how Norwich was at an edge of England, and how CARE had been at the edges of educational research over the years, describing many of the researchers at CARE in similar terms of their work at the edges of inquiry. John Elliott hated what I wrote about him, Beverley loved the idea of edges, as did Charlie and some of my young colleagues. Barry told me he was looking for something more substantial.

"On the edge of the edge of the edge of the edge" became a chapter in a book length manuscript that I wrote around that time. It was titled, "Beyond Education" and was never published, but eventually evolved into ideas around edGe-ucating.

As I learned at CARE what teaching teachers to research could mean, the open, engaged, and questioning spirit of all at CARE pushed me further towards edGe-ucating without me yet knowing it. But it was just my passionate focus on how to engage teachers in research that was the primary disappointment that Barry was expressing. He, and CARE, needed more than that. Their Masters Degree program in applied research for teachers ended a few years after I left. For me, my work at CARE was also the primary reason for me to continue to be edGe-ucated.

Seven

teachers teaching me about research

vettvangsathugun, an Icelandic lesson about "research"

Around 1990, while living in Iceland, I taught a few courses at the Icelandic University College of Education and was trying to form a course for experienced teachers to do research. I was told, however, that I could not use the Icelandic word for "research," rannsókn, because no teacher would think that she or he could do rannsókn. In Icelandic usage, rannsókn refers to applying a specialized expertise that very, very few in the world have earned. So, a new word was invented for me to use as the title of the course, vettvangsathugun (sounding close to how it looks). Vettvangsathugun means field (vettvangur) inquiry (athugun). Any Icelander, I was told, knows they can do that.

I understood this Icelandic attitude to the word, "research." I had been encountering that attitude for years in most English-speaking research settings I worked in. Although I had liked the term "action research," for example, because it included the necessity of those doing the work to do the inquiry, the phrase also reduced the value of "research" by referring to an action that nonresearchers also did, and thus was not "real research."

In contrast to English speakers, Icelanders' have created a way to democratize their language through committees that translate specialized professional terms into Icelandic versions that can be understood by every Icelandic speaker. One purpose was to protect the language from extinction, but another was to have erudite terms be readily understood by all Icelandic speakers. A small group of experienced teachers signed up for the University College of Education course to do research (or at least "field inquiry"), and we worked together to see what kind they wanted to do. Some, as I had expected, wanted to investigate specific features in their own classrooms, with questions focused around the learning of individual children, for example. But four elementary school teachers together decided that they wanted to take on a different kind of question, one that they often heard in the teachers' lounge. Their question was, "Is there a hardest day of the week for those who work in schools?"

Although I had heard this question raised in nearly all teachers' lounges since I had begun teaching myself, the question might have had a special meaning in Iceland at that time. Icelandic elementary schools had recently changed to having all-day classes after having only half-day classes in elementary school, either morning or afternoon. Thus, the question may also have been a way to look into how that change was being felt by teachers and by students.

The four teachers also wanted to get a better sense of why teachers and students considered a particular day of the week to be uniquely difficult. They interviewed over 250 teachers, students, and school staff, and were surprised at the range of answers. It was not only Friday or Monday that were perceived to be difficult, as they had expected. And the reasons for why a particular day was considered difficult were likewise unexpectedly varied.

The four teachers presented the results from their interviews in charts, separating teacher responses from student responses and including percentages for each weekday. In addition to the charts were examples of statements made by teachers, students, and school staff stating their specific reasons for why some days were considered difficult. The sections that followed discussed the range of answers, especially those from the students.

The study then placed the many reasons given to particular days being tougher than other days into two categories: 1) reasons related to the students (like students being tired) and 2) reasons related to the school structure (like class schedules being too early or too late in the day). For the teachers studied, each of these two categories were mentioned 50% of the time. For the students, school-related factors were mentioned 75% of the time. For over 50% of teachers, the most difficult day was Monday, with only 3% saying it was Friday. For students, Monday was the most difficult day – but only for 37% of them. 22% of students felt Thursday was the most difficult, and the other three days had each been chosen by 12% of students.

One conclusion of the study was that the accumulation of stress and work over the week did not make Friday, the final weekday, particularly difficult for most in elementary school. Instead, each day had specific features that could make them difficult. Furthermore, the impact of weekends on the students was not only felt by students; it was also felt by the teachers even more so, likely through the students.

The study also showed that school heads and staff felt there were no differences in the difficulty of a school day; to them all days were the same. Because of this result, the teacher-authors felt compelled to discuss ways in which the school day

schedules could be revised to avoid some of the difficulties identified by teachers and, especially, by students.

Over the twenty-five years since that time in Iceland, I have been included in encouraging more than a thousand research studies by teachers, but this study by four Icelandic teachers was the only one published in an educational journal. Given the depth of discussion by the four teachers, and its appeal to a variety of educators, it deserved to be. But so did many hundreds of other serious studies authored by teachers that have had significant insights into professional understandings of how students learned or didn't learn, and why.

The educational profession could have been served better had these hundreds of other teachers' research been published. In Iceland, by the way, the request for publication of the teachers' inquiry came from Icelandic educators. In the other settings I have worked, it has been more up to me to look for publication, and that, as you may have surmised by now, is not a strength of mine.

teachers doing research through interdisciplinary studies

In 1992, at 55 years old, I was hired for my first tenure track university faculty position. The previous year, I had applied to over 50 positions in U.S. and Canada, interviewed in person for four and ended up at National Louis University in Chicago. National Louis University had been founded in the late 1880's for training kindergarten teachers and eventually had evolved by the early 1970's into a university with the second largest private graduate school of education in the U.S. It was situated in Chicago, but had Center sites in Wisconsin, Florida, St. Louis, and Washington, D.C. The program that hired me was called Interdisciplinary Studies in Curriculum and Instruction (IDS), housed in the College of Education, and was included in the sites outside of Chicago. It was a strange program, with features that many of the university faculty hated, and it was a wonderful fit for me.

IDS was a two-year Master's degree program. The same group of working teachers met one evening a week for four hours with a single primary instructor along with a part-time faculty reader. Teachers in each group could range from pre-school to high-school and teach any subjects. Each group met on the single weekday evening that they had chosen, normally at a school where a few teachers in the group worked and close by for others in the group. A group (usually between 15 and 20 teachers) could begin any time it had been formed, and it met nearly every week for about 22 months. Each group had its own schedule; the university schedule did not apply.

The IDS program had 11 courses, 32 graduate credits, in 3 grading periods, but it was called "interdisciplinary" for a reason. Generally, IDS program courses were not given separately because the challenges of teaching did not arrive in separated areas of knowledge. Instead, the course content was interconnected with, for example, child development, learning, curriculum, and instruction as appropriately applied to specific issues that teachers in the group were working with at a specific time. Thus, the program was centered not only on meeting teachers in their neighborhood and on their own schedule; but instruction was focused on the specific educational challenges which teachers in the group were meeting in their daily professional lives.

The IDS program had begun ten years before I had arrived, having been founded by Ethel Migra, a psychologist with a professional focus on group therapy. I didn't know her well because she had left the program before I arrived, having taken on an administrative position which she left soon after. I was told she was a task-master who had very definite ideas on how a group should be run, and how a group of teachers with conflicting views of education needed to be guided. The one thing I can say for sure is that Ethel Migra pioneered an educational program where all involved – faculty, teachers, and university – were working at the edges of graduate education for educators.

To those who feel that a Master's Degree program means it was scholarly, and that "scholarly" means delivered by a series of specialist professors performing readings, discussions, and exercises within specified professor disciplines on a university time-line, then IDS would not be considered a scholarly higher degree program. I felt otherwise. I found the IDS program to be one of the most thought-provoking educational programs I had experienced, seen, or read about. Others who assessed the program felt the same.

The idea of one faculty member being primarily responsible for a full Master's Degree program for 20 students might seem preposterous. IDS might appear not only non-scholarly but even look like a form of hubris by the single faculty member being responsible for all the courses. In practice, the program was based on the instructor listening to students, and was based upon individual student choice along with consequent student responsibilities for addressing one's own professional issues and engaging in professional dialogue with other group members. The aim was for teachers to develop new understandings and classroom approaches that better engaged their students in their contexts. To me, all of those features were primary intellectual challenges for any educator. The only courses that were given a definite sequence were the three action research cours-

es, one occurring in each of the three grading periods. In the first research course a teacher determined and wrote up the nature of the question they would pursue and why, and how they intended to apply a proposed solution in their classroom. The second research course was primarily aimed at investigating and writing up the range of literature related to that question, and to begin to document the adaptation of a solution. In the third research course the teacher was expected to continue to perform and document her reform, and to complete her report of what had been done by the students and learned by her in the process. All these processes were shared within the group, not only with the professor and reader.

There was an unfairness in this schedule. The effort required to complete the research and to write up a final report within the third semester was always extreme. Also, in addition to this third research course being the most intense course of the eleven, it was the only one that had only two credits, not three. Perhaps we can't always be fair to student work. Or to faculty work, either, since within the third semester faculty were constantly stressed responding to various drafts.

I have always thanked my good luck at having had a chance to work within this unique program that relied so heavily upon teachers' understandings and capabilities, challenging them to identify issues in their teaching, to come up with new understandings about their students, and to modify their practices to promote better classroom learning. Not only did the program present a new kind of challenge to the teachers, it was a new challenge to all us university faculty serving the teachers.

I got my first group within my first few weeks at the university, and was given two rules. The first rule was, "Don't show the teachers any of the research projects that had been completed by former graduates of the program." "Why not?" I asked since I had been reading and appreciating many of those projects. The answer was, "We don't want them to see anything they might copy." The second rule was, "Have the teachers write journals every week for you to read." I wasn't sure what they meant by "journal," and was told that those were personal writings describing their everyday experiences – for example a problem being confronted in the classroom or feelings that they were having throughout the week, whether related to teaching or not.

In my first meeting with my first group, after describing the program to the teachers, I asked them if they had any questions or any requests of me at that point. One request, echoed by all, was, "Yes, we would like to see what former research projects look like." So, by the second or third week of my teaching, I had

broken the first rule. No problem – the teachers realized how varied and personal and unique each report was, both in the question asked, in the study designed, and in the styles of presenting the action research project. Copying was irrelevant to the task.

Journaling weekly was a different matter. This possibility was new to me, and I found it to be a terrific addition for the teachers to practice their writing and to reflect on their work, and for me to learn more about each teacher. I read and responded to the teachers' journals focusing on the unique or interesting features of the issues raised by the teacher, including the feelings they were expressing, sometimes responding with my own stories related to their personal experiences. For the first six months of the program, responding to the teachers' journals was a large part of my job. I learned to appreciate much about the teachers, about their work, and about the issues they each were confronting in their personal lives, as well as in their work. It was also a way for me to introduce myself to each of them.

Being an instructor in this IDS program unexpectedly silenced me in the classroom. As teachers expressed and discussed their classroom experiences with each other, my professional experiences seemed to be unnecessary. What was most important were how their own experiences were being expressed, shared, and especially interacted with by the other teachers in the group. Most notably, their views were being constructed together as they heard from each other, and as they developed a wider understanding of the educational processes of schooling that were being experienced from early childhood through high school.

The variety of research projects produced by the teachers was extraordinary. Over 20 years, I read and responded to various drafts of many hundreds of action research projects. None similar. The primary lesson I learned from their work was how capable all teachers were at analyzing their professional actions. They could decide on a teaching-learning challenge that needed to be improved, do their best to work on that student improvement for over a year, and then in their own style present what was done, had been learned, and was still to learn. Furthermore, I discovered that this action research challenge could be satisfactorily performed and completed by every single teacher.

In fact, the teachers themselves were learning that they had more intellectual capacity than was generally assumed – by most educators (including often their school supervisors and previous professors), by those outside of education, or too often by themselves.

Since that viewpoint may seem preposterous to some, let me give a few examples of the action research projects that these teachers produced. There are hundreds and hundreds more. (The names used are ficticious.)

Edith was a fifth-grade teacher (10- and 11-year-olds), and had been teaching for over 25 years in a hilly, forested town about an hour west of Chicago. She had a strong independent streak with ideas of her own, polite but firm, and expressive in her views. One view was that "whole language" – at the time, a fairly new approach to learning that focused on interactive, projectbased learning – was worthless. In her terms, it was "pure fluff," with nothing useful to offer for students' learning. For her research, she decided that she needed to improve how she was teaching science, and she would begin by creating a new approach to teaching the children about the rain forest.

Edith did nothing half-way, and in the summer she and her husband toured the U.S. to visit museums and other sources to find more information about rain forests than she could find in books. We met late in the summer to discuss her plans for the students, and Edith excitedly told me about all the materials she had found, and how she had been working on her action research project all summer. Then her mood changed, and she was silent, looking off to the side for a few moments. After reviewing her plans, she went on, she had become absolutely shocked. She realized that what she had developed was a "whole language" approach to learning about the rain forest! Her back straightened, and she added that after realizing this, she had decided that she was going to throw away her design and start over, but then thought maybe she would bring her original plans to the group the following week and see what they might say.

Later in the fall, Edith invited the group to meet at her school one of our evenings so that we could see what her students were doing with the rainforest. Entering her classroom, we walked into a rain forest with paper and cardboard vines climbing throughout the room and along the walls from floor to ceiling and along the ceiling, a variety of paper maché monkeys and other brightly colored animals, birds, and insects were clinging to the vines, as well as to the tree trunks and on a variety of the green leaves and branches that filled the room. A large mural, not yet complete, was in the process of taking the rain forest into the hallway.

The students had not only performed the project along lines that Edith had planned from that summer; before the end of the year she had become the leader of the whole language approach in her school. On the last day of class, Edith admitted to us that she had never enjoyed teaching as much as she had during that year. We all learned that a teacher can change through discourse with other

teachers she trusts, as well as trusting herself to provide the expended energy that that may require.

Throughout the first weeks of the program, Rebecca constantly worried about her research project, telling me that she couldn't write anything over ten pages. "I will never write a research report," she moaned. She taught in a unique school far west of Chicago, filled with students from elementary grades through high school who had been kicked out of the region's regular schools. Within a few weeks, I could point out to her how her journals had been describing her daily school experiences in unusually interesting detail. "What do you mean you can't write?" I asked. "You've written over fifteen pages and we are only in our third week!"

Rebecca often captured the genuine interest and amazement of our group as she shared a variety of her experiences, thoughts, feelings, plans and disappointments. She described the students' anger, emotional outbursts, and physical and personal attacks, while also understanding the fears of many of her students, and of her own. I suggested that her research project could continue to capture what working in this unusual school environment was like, for her students and for her, along with what she was learning about her students within the educational system.

Rebecca's project became an exceedingly rich account of her trying to instil a kind of wholelanguage approach with her multi-aged, formerly expelled students. Her final product was fascinating in its detail of daily triumphs and failures, her own and her students'. Her work was also extremely instructive to all educators about settings which attempt to be educational for its students, regardless of the difficulties for both students and teachers.

At graduation, our last meeting, Rebecca told me that she had applied to a doctoral program in special education. She knew, now, that she could write as well as think.

Five elementary teachers from three different schools decided that they would like to create a research project together. I was told by my IDS colleagues that this was impossible, but since their topic was "developing a sense of community," it made sense to the teachers and it did to me, too. Within a short time, they had developed an investigative community among themselves. In their introduction to their project, they each described their different selves and contexts, why this topic was important to each and to their respective schools and communities, and how working together would be part of their study's focus.

After they had analyzed together what community meant to teachers, students, parents, and community members within their different communities,

they created a number of separate products that could be used for developing a sense of community. For elementary students, they produced video-tapes that could engage students in supporting each other in interactive ways that would promote a sense of community within the classroom or school. For parents, they produced a slide-tape show to discuss the nature of community of parent with parent as well as with their children and in parent-teacher meetings. For teachers, they produced a handbook of activities for promoting a sense of community within the classroom, school, and larger community. For community members, they produced a series of pamphlets about what businesses and community organizations could do to be more involved with school children and their teachers and schools.

The group's final report included a copy of each product along with a bound copy of their research report that included their introduction to themselves and their respective purposes for the project, a review of literature on developing a sense of community within schools, classrooms and communities, and a conclusion of what each of the five teachers had learned from this work. These products and the research report were included within a boxed briefcase.

The most difficult feature in accomplishing group research, they reported, was how to write a review of the literature as a group. They decided their review would be performed by recording their group's conversations after reading research articles related to developing a sense of community, in and out of school. Their conversations had gone well, with much interaction and ideas being expressed, and with all recordings being transcribed. But then a major problem occurred when one in the group wanted their conversations to be edited and proofread like writing. The others argued that then it would not be like conversation, since no one talks that way. Eventually, the majority won, and the result was an engrossing variety of interactive connections being made from the literature to their respective classrooms, schools and community contexts.

Kim was a kindergarten teacher, quiet, self-contained, and with a quirky turn of mind. She said that initially she had wanted to apply more creativity of childhood into her kindergarten, but then realized that her first challenge was how she was communicating with her five-year olds by constantly yelling to gain their attention or response. As she pondered solutions, she was also reading a picture book about sign language, and realized that that would be her topic. Kim decided that she would try to teach her five-year-olds sign language, and then see how sign language could be used across the spaces of the classroom. Signing was

noiseless, yet could be "heard," understood, and responded to in kind, whether given to the whole group or to individuals across the room.

Kim began with signing about directions, about making too much noise, for example, or bothering others, or to share more. She quickly realized that these signs also became how the students began communicating with each other. As she was learning to sign language herself, she became more aware of the variety of messages that could be communicated with her students, and for her students to communicate with each other, and with her. Signing, she realized, need not be limited to commands or directions, but could also include ways to engage in differing expressions of feeling and connecting. She reported to us the range of resources that she was able to draw on, and how she was expanding sign language with the students.

By the end of her research, Kim had increased the signing lexicon in her classroom to expand upon the possibilities for both her and her students to communicate. In fact, her class had not only used sign with each other as well as with her, but they were having a similar effect on adjoining classrooms as their friends in other classes asked for advice on how to sign. The increased quiet and order made it possible for more creative activities to take over.

Kim's project had focused on a communication issue that all teachers of young children encounter, yet few had taken it on and addressed it so simply. How does one control a classroom of young children without yelling across the room? Her research report was written like a how-to-book for other teachers of young children with suggested ways of introducing and sequencing lessons to encourage a fuller appreciation and use of signing in the classroom. It included wrong turns she had made in her journey, situations where she thought she could have done more than she did, and some where she had tried to do too much with signing.

Her research developed into the kind of success that caused quiet Kim to smile with accomplishment whenever she reported on how it was coming along, and what she was learning along the way. I hoped that she would find a way to broadcast her accomplishment beyond her school, but was no help to her there. I don't know if she ever did, other than with her immediate peers. I do know that she knew she had accomplished what she had set out to do, and that it was unique and extremely useful to her and probably could be to many others.

Bess produced an extreme example of action research built upon failure after failure. Bess was an early childhood teacher in a blue-collar community south-

west of Chicago with a considerable population of immigrant Latino families and their young children. She was a young grandmother and natural leader who had been recently voted to the local town council. I learned quickly that she knew not only how to identify real problems, but how to get things done to solve a problem: who to talk to, how to get others involved with the kind of organization that could ensure that actions were taken. These were also talents required for her research project. Bess's aim was to get more parents of her early childhood students to come to school parental meetings and to participate more fully in their children's schooling.

First Bess tried bringing food and drink to attract parents to school meetings. That didn't work. So, she tried to have school meetings after work hours, supplying transportation to school if wanted. Nope. Then she had the meetings at her house, thinking that the resistance was to the school itself. None of these approaches to making the meetings more accessible worked as she had hoped, so she reorganized what the meetings were about, thinking that presentations by persons the parents knew or respected may be attractive, perhaps with a topic that was related to their context as parent, rather than to school matters. She also tried meetings with more Spanish. No deal.

Bess tried more than a dozen different approaches – none of them successful. She described each approach in detail, including where and from whom the idea came, along with her planning for each event. That was accompanied with her descriptions of the event as it occurred, including the corresponding parental responses, ending with her analysis of the result of each approach and what she learned from the process. As I read the detailed accounts of each attempt, I could not believe the energy she had put into this research project, and the amount of organization and creativity represented. Bess kept trying, analyzing, thinking, and trying again but always with a different kind of approach.

In her conclusion, Bess wrote that what she had learned from these efforts was that she was addressing a deep issue, an issue related to social and community histories, values, and fears that she could not resolve as an educator. From her efforts as an early childhood teacher, she realized that a solution would have to be designed and addressed through non-educational settings with non-educational contexts. A lasting solution would probably need to come from a broader context than education, and be related to a fuller social and community acceptance of minority group parents and their children. She concluded that her next step would be addressing her problem through her part-time position as town council member, not as an employee of the school system.

I had learned how committed Bess was to finding a solution, and how capable she was in searching for and trying out as many possible solutions as she could find or think of. Not only was the amount of work her research demanded unique, but the range of failure she endured and learned from was extreme. She had demonstrated what can be learned from failure after failure.

These few examples are less than one-hundredth of the action research projects that I saw teachers accomplish within their two-year IDS Masters' degree program. Almost all were focused directly on researching their own classrooms.

Catherine, a high school history teacher, was one of the very few who didn't research her classroom. She had to argue with me vociferously for her to write a family history of her extended Ukrainian family. She and her family in the Chicago area had only recently become aware of previous extended family members who had been forced from the Ukraine to Siberian exile in the 1930's, and who were planning to meet for the first time with the few in the family who had been able to remain in Ukraine.

Her research report on her exiled Siberian relatives turned into two volumes, well over 300 pages, with parts written in Ukrainian from her interviews of extended family members from her visit to the Ukraine, along with the specific documentation that she had found. As a high school history teacher, this was her first foray into performing historical research. It was extensively documented with interviews and supporting documentation, along with occasional analysis by her, the historian. I shared it with a few historians I knew who judged it as fine historical work. I judged her study as a unique educational experience gained from research that she had developed entirely on her own. But it is clear to me now that she had edGe-ucated herself.

Although there are many more stories from IDS teacher research for me to refer to, each unique and each powerful in insight and ambition, my purpose here is not to promote action research. What I am trying to do, instead, is to illustrate the nature of what working teachers were able to accomplish through their personal inquiries. All teachers could find a problem in their work worth looking into. All could apply a variety of creative research methods to get better information about the problem they were facing. All could work out their solutions, and record features of the entire research process ending with better understandings of what had happened and why, and what could be done next. Those attributes of scientific intelligence capture the capacities held by every teacher, and, by extension, by all of us.

The educational edges of my experience teaching teachers research in the IDS program, however, were not limited to the quality of the teachers' research. That was not, even, the program's primary goal.

Rather, the intent of the IDS program was to support teachers trying to improve their professional work by using action research, dialogue with each other, and reading professional literature to help them along these lines. The educational edges of the program's intent included teachers gaining a self-confidence in themselves as problem solvers and thinkers on educational issues, and building a strong respect for the profession of teaching children of all ages through their interactions with other teachers. More than gaining self-respect, the program made it possible for the teachers to depend on each other for support, for ideas, for professional response, and for new insights when confronted with a problem for which they felt unprepared. The program, as designed, emphasized that the process would require them to do this kind of work primarily by themselves, not dependent on requiring the expertise of a professor or some other outsider to resolving the challenges being confronted within their teaching contexts.

At IDS, I was working in a university program that supported what working teachers needed most, professional listening, encouragement, support, respect and the opportunity to investigate one's own practice through discussing with other teachers the intellectual challenges of teaching.

The educational frontier at which we faculty and students met had been created by Ethel Migra (whom I mentioned earlier). She had found an edge in the educational practice of higher education that had been skirted by assumptions underlying the intellectual structures of higher education. It was her design which focused the teachers on using their and their colleagues' problem-solving skills and insights. Although Ms. Migra was not a certified educator, she had created a design for a unique higher education program that could be effectively applied with working teachers, regardless of subject matter content or grade level. Yet her achievement has never been recognized.

For example, the IDS program had begun in 1980, when I was working at a university about 100 miles away, and was traveling the U.S. to study teacher education. But I had never heard about the formation of this IDS program until I was in Iceland looking for a job in 1991. All of us professors in IDS could attribute our successes to the educational framework created by Ms. Migra for supporting the continuing education of teachers. Many of us recognized that as fact, but not enough to write that to our teacher education brethren.

Throughout my teaching teachers to do research in the IDS program, I couldn't help but recognize how each teacher was demonstrating how capable she or he were at the intellectual tasks required to do basic research. It seemed that the more I engaged with teachers reaching better understandings on how to achieve their primary educational aims through personal inquiry, the more they demonstrated how deeply embedded in our human condition were our shared human capacities for performing credible, expert research. Edge-ucating was being accomplished here.

Can universities work at educational edges?

As I worked in IDS as faculty member, department chair, and occasional chair of college faculty, I had learned that all teachers could accomplish credible research on their own educational edges of practice when given support. But then I began to ask myself a different question from my experience in teaching teachers to do research. To what extent was the university capable of working at its edges of educational practice?

The IDS program was clearly at an edge of practice designed for graduate educational programs. As occasional chair of the department and of the college faculty, I began to understand more about how universities worked from the inside. Within 20 years, the program had grown to 2,000 students, 25 full-time faculty and many part-time who primarily worked in schools. Throughout that time, the IDS Masters' degree program continued to be the strange two-year Masters Degree program.

As strange as its challenging set of program features continued to be, more of the educational faculty outside of the program were coming to us interested in the possible contributions of these unusual university features for improving teachers' instructional expertise and understanding.

The administration, however, was not interested in either the process or the potential outcome for teachers. Administrators had to deal with the program's organizational strangeness, which they found neither easy nor economical to manage. Forming new IDS groups required active recruiters who needed to bring news of the program to teachers within schools, and organize new groups within their common geographical areas. These recruiters had special talents that needed to be paid accordingly. Furthermore, IDS faculty schedules required additional attention (for example their pay for their summer teaching responsibility, expected in their program contracts, was considered "overtime," not salary). The

most difficult feature, however – and the most expensive from a university management perspective – was how to manage the two-year individualized schedules for each IDS group. Since IDS did not fit into the automatic semester schedules of the rest of the university, both students and faculty required special bookkeepers to record each group's progress through the two-year Masters' Degree program. Thus, while bringing in a large number of fees to the university, the IDS program required added administrative focus, talent, time, and expense.

The administrative management issue was always efficiency, with uniformity part of that computation. The program faculty issue was how to develop our professional understandings in order to apply the unique potential of the program design for the benefit of teacher education built on teacher research and professional dialogue with each other. Since none of us had experienced a program like IDS as students, we organized yearly retreats for IDS faculty from all the Centers to get together for three to five days to discuss specific challenges we encountered within our groups and ourselves, along with possible resolutions. What I and my faculty colleagues never did do, however, was take on a demonstration role for others. We never used formal inquiry to communicate to our administration (or to other university faculty) what we were learning about how these unique features were being successful in achieving the educational mission of teacher education, and why.

Over time, naturally, contextual changes occurred that compromised the IDS success. The first was positive. In 2002, a call came to the Education Dean asking for an on-line Masters' Degree program. The National Audubon Society had thousands of U.S. teachers who wanted to gain their Masters' Degree, if it were offered on-line. The organization promised to pay for all the expenses required to design an on-line program for these teachers. As chair, I was interested. After all, I argued, IDS goes to where the teachers are; if teachers want to learn on-line, we go there.

After making the decision, we faculty discovered, from the few successful on-line programs at the time, that an on-line program could be designed to be more effective in promoting student to student communication than most face-to-face programs. We completed our on-line design of IDS relatively efficiently, including its approvals (with university administrative help) by state and regional graduate school oversight agencies. Unfortunately, soon after we received official approvals, a new Audubon administration, affected by an economic downturn, withdrew the promise of their teacher members' involvement. The on-line IDS

program began quietly, and is still operating, but on a much smaller scale than had been expected.

The second change was more universal, but certainly not positive for teacher graduate education, including for our IDS Master's Degree program. An attitude grew in school districts which held that teachers did not need graduate degrees in education to be effective. Many school districts, feeling the economic pressures of funding public education along with a promise of less costly training approaches that they could control, reduced their support for advanced educational degrees for their teachers. Within a few years, the IDS program was reduced from 25 full-time university faculty to five.

Over my fifteen years experiencing the growth and then the decline of the IDS program, I had occasionally chaired the IDS Department or the College of Education faculty. Within that time, my view about a university's incapacity to deal with educational edges took shape. Although I have given some of the reasons for holding that view, and holding it strongly, it is not the view I hold now, six years after retiring. Now, I put more responsibility on me and my colleagues and less direct responsibility on the university administration.

We faculty did not appreciate that our role as institutional outliers meant we had more responsibility for communicating to our administration, and faculty colleagues, not less. Although the program's increased growth could be accommodated, the severe changes of reduction required a new integrated systematic response involving both administration and faculty, something we had not prepared the administration or ourselves to do. That was our fault too, not only theirs. We did not provide the administration with enough educational understanding of what made our program significant and successful. We did not broadcast to the teacher education profession, including schools, the complications involved in a university program aimed closer to teachers and their work than most programs. We also did not request for, or understand, the range of challenges that the administration had with the IDS program's unique features.

At the time, my answer to the basic question raised about whether our, or any, university had the capacity to deal with educational edges would have been a resounding "No." My current answer is much more qualified by the need, at that time, for more communication on all sides of the issue of continuing professional education for teachers: schools and their teachers, and the university and its faculty. The marginal organizational design of the IDS program had given an opportunity for the two educational institutions of school and university, in-

cluding their employees, to be integrated in a greater capacity. But the marginal context of the IDS program also left the program with no systematic institutional response that could protect its operational features. We faculty must take some responsibility for our part of this lack of professional integration between the teachers and ourselves.

My view now is that professional integration was a part of our professional faculty responsibility as educational inquirers and participants in the educational ambitions of our profession. But that professional responsibility required a professional viewpoint that is more edGe-ucational than educational. We IDS faculty had retained the distinction between our primary responsibilities as knowledge producers and deliverers of that new knowledge from the responsibilities of classroom teachers to teach students and their students to learn. We did not look for "outside" help or imagination to better integrate these two primary features of an educational profession.

Six years after leaving the profession, I am beginning to realize the significance of institutional responsibility and professional extension that we in IDS never did directly address. We were certainly not alone with that professional ineptitude, nor would we be now. Furthermore, what is most important to the theme of this book is that the institutional challenges brought up by edGe-ucating to all fields of inquiry are similar to the challenge that we IDS faculty did not consider. Our responsibilities as professional inquirers need to be better integrated within our individual, institutional, and community capacities for sharing our engagement with the questions that challenge our expert understanding.

butterflies

Occasionally, during my time at NLU, I taught a ten-week graduate course on doing research for master's degree students in education. It was a night class, a general course for working teachers in departments other than mine, such as science education, math education, reading, or language arts. At the end of one evening, near the middle of the course, a 2nd grade teacher, enrolled in the science education department, curious and highly engaged with inquiry as we were doing it, came up to me with a question. She apologized, saying it wasn't directly about our class, and then added that she was planning to teach her second graders about butterflies. She knew precious little about butterflies and had been looking in resources, but she wasn't satisfied with what she was finding. She wanted to have something more unique and more interesting than what the resources were providing, and so she had begun to look up names of expert butterfly scientists in

the U.S. She was thinking about calling them on the phone to ask for something more interesting about butterflies than there were in her resources. Her question to me was, "If I called them, do you think they would even talk with me?"

I responded that I wasn't sure how they might respond, but had a suggestion, if she were interested. How about asking these butterfly researchers if they could help you by identifying some of the unanswered questions about butterflies that they were hoping to answer in the future? Perhaps they could highlight some unknowns about butterflies that you could share with your young students. That question, I suggested, might capture more of a butterfly researcher's interest than what they knew. Her eyes widened, "that's what I have been looking for, something unique and interesting for me to try!"

A week later, she couldn't wait to tell the class what had happened when she called a few of the butterfly researchers on her list. After having introduced herself on the phone as a second-grade teacher, and referring to her interest in teaching her students about what was not known about butterflies, each butterfly researcher became so excited by her question and by the possibilities to bring the edges of their inquiries to young children that they went on and on and on. At first, that surprised her, but as they talked, each researcher emphasized the vulnerability of so many species of the world's butterflies, and how important it was for them to be able to answer their questions while it was still possible!

She realized that her challenge was not getting the butterfly experts interested in talking to her. Her challenge was going to be choosing what butterfly unknowns to share with her students, and how to share them.

What was also interesting, she added reflexively, is that her initial question not only seemed to have deeply touched the butterfly researchers; it seemed to her that they must have been giving some thought to her question well before she had called them.

In the few weeks remaining in class, she reported that she had experienced the same enthusiasm, passion, and interest from other butterfly researchers.

I cannot say how all this came out for her second-graders. After that course ended, I never saw her again. Being in a different department and seldom on campus, I never did learn how her work teaching expert uncertainties about butterflies was planned, performed and completed with her young students.

What I did learn from her initiative was that researchers can be highly excited by the possibilities of teachers working with young children to understand the edges of their respective fields. She taught me that what was not known in expert areas of research could be professionally exciting to a researcher or inquirer to

share with others, including with second graders. Perhaps especially so, if conditions for finding answers to their questions suggested that they may never be able to be answered without public interest. Of course, I knew that it could also be very exciting to the teacher. Thus, once more it became clear how an educator's enthusiastic and unique curiosity could be essential for initiating new work at the edges of educational practice and professional expert knowledge.

Simply put, there may be more potential than we educators have imagined for serious interest in edGe-ucating from expert researchers and inquirers. For varied reasons of their own, researchers and inquirers may find edGe-ucating in schools to be worth their time, consideration, and effort. As it is for studying butterflies, the continued development of much research and inquiry into specific disciplines of wonder and unknown may depend on it. Furthermore, the assistance of excited educators such as this second-grade teacher can not only be valued; it can be expected.

There may be more possibility for integrating the edges of expert inquiry from many inquiry fields into the public schooling of the world - children and adults – than anyone has yet imagined.

Eight

edGe-ucating begins to be a possibility

moving beyond education

If I were writing a screenplay, this would be a good place to introduce a dramatic change, a singular event that brought me to imagine the realities and new possibilities for edGe-ucating.

But it wasn't like that. Instead, it was a slow process.

Before I began teaching teachers to research, early in the 1980s, I had begun writing book-length manuscripts – none published – about the need to go beyond current educational tradition, both in practice and in institutional identity.

The first one, titled, *The Heart of Education*, showed how teachers' work performances in classrooms were being limited by university schools of education. The heart of intentional learning – that is – of education, I argued, was in finding ways to better understand the human acts of learning and teaching. I pointed out that as long as the responsibility for researching those educational actions was retained by university and research institutes, the development of teaching and the understanding of learning would be suppressed. I argued that such an institutional distribution of educational labor reduced teachers' potential to understand better their specific working contexts, while also reducing the quality and the usefulness of educational research and teacher education.

An early form of this manuscript had been drafted for the U.S. National Institute of Education (NIE) in 1983, as a response to their request for my suggestion on what areas of educational research may be most helpful for them to fund in the following five years. I recommended that they fund no research for three years and instead use their resources to develop capacities for all educational institutions to do research. After that, NIE could work out their research priorities in accordance. They told me they read it as an "interesting response."

I wrote *Beyond Education* in the later 1980s, It tried to do away with the assumption that the teacher was the "knower" and the student the one who needed to know. I referred to my experiences teaching grade school through graduate school, along with others' experiences in teaching a variety of skills and concepts

that demonstrated how ordinary student understandings often went beyond their teachers' understandings as well as expert resources of what was being taught. Most examples showed how an interactive intellectual engagement between teacher and student around the mysteries and uncertainties at the edges of the topics encountered could help students move beyond the teacher. I pointed out that when this happened, it appeared to be a situation that took both teacher and student beyond education as it is known. The same examples showed that when this happened, teachers could continue to educate students who were more knowledgeable than they in the areas being taught.

The Third Mind of Education was a book-length manuscript begun before 1990 and continued into the mid-90s. It started by considering the nature of edges, first noting how the turbulent recent times seemed to have hard edges collapsing. My examples were the Berlin wall, the San Francisco earthquake, Wall Street plummeting, Eastern European countries redefining their national status, Western European countries subsuming their sovereignty to make a larger union, and the head of the Anglican Church suggesting the Pope be the head of Christendom. This turbulence of borders being transformed seemed to come daily with our breakfast cornflakes. The only constant, I observed, seemed to be educators holding on to their own approaches to education, be they traditional, progressive, or oriented to social context.

Having begun to acquaint myself with a variety of analyses about the developing intellectual challenges being created by human borders being transformed or broken, I suggested that a new educational mind may be required in our changing world. Neither of the first two minds of education seemed capable of handling these new and growing challenges of intellectual turbulence.

The aims of the first mind of education, I suggested, focused on instructing students to learn the fundamental morals, skills, rules of behavior, and understandings deemed necessary for the survival of their group, culture, or society. That first mind of education was authoritative, moral, practical, and wise. The first mind of education probably began in very early days of human existence and had been applied over thousands of millennia. It has also continued to be powerfully applied in our present day by both educators and public, including, I pointed out, by its current critics.

I described the aims of the second mind of education as being centered on how students create, transform, and reconstruct meaning from their experience. The second mind was attentive to the processes of educating, including how learning occurred intentionally within education, but also often unintentionally

outside of education. The second mind of education aimed to provide students with more personal experience that could help the students deepen and continue their own creations of understanding, meaning, and communication. The second mind of education has often been taken up with more enthusiasm by educators like me than by the public. Many holding first mind views of education have argued that the second mind pays scant attention to the public knowledge and values that they consider significant for cultural survival. Contemporary social critics, on the other hand, emphasize how the second mind is considerably less effective as a strategy for changing traditional first mind aims than many proponents claimed.

Although the first and second minds of education have had a variety of educational accomplishments, I argued that neither the first or the second minds of education could successfully address the intellectual turbulences being encountered and anticipated to accelerate as we headed into the 21st century, giving examples of the more recent failures of each.

I proposed a third mind of education which aimed to extend students' experiences in reaching understandings not only beyond their teachers' understandings, but at and beyond the current borders of expert knowledge. If a third mind of education were applied, all citizens of the world would be better prepared to meet, begin to understand, and help to expand our responses to the everyday intellectual challenges being created by the turbulence at the borders of human understanding. I suggested that a third mind of education may be capable of being met within the 21st century because the edges of what was known and not known could be increasingly communicated to, and become more ubiquitously experienced by all citizens of the world.

My fascination with edges of education was expanding to include a variety of thinkers working outside of educational fields. These thinkers not only included scientists who referred to edges in their fields of expertise from physics to astronomy, biology to anthropology, geology to archaeology, but also other fields of intellectual inquiry such as history, philosophy, sociology, poetry, and the arts. I became engrossed by their varied descriptions of how the intellectual edges of their respective fields were being transformed beyond their fields' traditional understandings. I became interested not only in the nature of the changes they described at their edges of intellectual thought and analysis, but how the changes were being experienced by them and their colleagues. Fractals, for example, were an area in mathematics that fascinated me and I found they were also being applied more recently in the sciences. Fractals became especially appealing to me

at this time because they so quickly did away with the preponderance of linear metaphors for explaining change. Including learning.

"Boundary conditions" became a phrase that seemed to capture what was happening in a variety of fields, and also how change happens. Many fields, including mathematics, physics, astronomy, biology, and geology had been applying the term "boundary condition" to refer to new understandings of phenomena or concepts of unexplained dynamic diversity. Most often the term referred to interactive dynamics at borders where different phenomena, concepts, or expected behaviors, met. Although each discipline had given separate and precise definitions and meanings to a "boundary condition," together the term referred to clashes between unlike entities that produce exceptionally dramatic and unexpected change.

One biological example of a boundary condition is located in the Pacific Ocean, where there exists a green line more than a thousand miles long, many hundred meters wide, and some meters deep where warm ocean water meets cold. That boundary condition is where microscopic oceanic plant life, "diatoms," thrive and become so plentiful that they not only feed a great variety of ocean life, but the green line that their numbers create can be seen from outer space.

My readings had expanded to include descriptions of boundary conditions met within human experience. Clashes between intellectual borders have generated turbulence and uncertainties for our human minds to handle, such as borders constructed to separate social, cultural, religious, racial, or gender identities. Similarly, clashes at the intellectual borders of inquiry fields that I was reading about seemed to generate unexpected turbulence as old understandings were being denied and new forms were being tried out. Weren't we educators, I wondered, also meeting boundary conditions that had to be resolved?

The Third Mind of Education ended with how all institutional and professional roles of education would need to be transformed if we aimed ourselves towards a third mind. The role of student would be altered dramatically, along with the roles of teacher, administrator, and researcher, along with the institutions in which they worked. Admittedly, that may also include alterations in the cultures and societies in which they served.

I was, clearly, entering many areas I knew nothing about, which is what fascinated me. I was trying to write about a new way to think about education that did not function under the same rules of what I felt had dominated the debates I had been hearing for educational reform. I wanted to understand more; I wanted to investigate more.

I was probably lucky that these manuscripts were never published. Being not published but written, they could be retained but not defended or entertained by me. I could keep questioning to see where some of the ideas could lead me without them determining what I should believe. I remained uncertain, still looking for better understanding of my educational experiences, still questioning. In the years of writing book-length, unpublished manuscripts, I had put myself increasingly beyond the borders of educational reform as I had known them, beyond educational thought and practice, beyond educational inquiry, beyond educational aims. The natural consequence was that I was also leading myself away from education and into areas of inquiry where I knew little.

One could say that I was intentionally putting myself into being edGe-ucated. And that continued even as I was drawing myself further and further into university educational life teaching teachers research, and encouraging them to listen closely to their students as they conducted their work. I was trying to do the same, knowing it was not as easy as it sounded.

meeting examples of edGe-ucating

In continuing to look beyond educational borders, I began to find events in which the untrained were being brought quickly to the edges of scientific work, and doing well there. A few accounts appeared in the educational literature, but most were in sources like newspaper articles reporting unusual events. An early example did come from an educational source: John Jungck, a university professor of biology. Although he was married to an IDS colleague of mine, he taught at a university in a different state. Driving a few hours to talk with him, I discovered he had designed an unusual first-year college biology course which he called BioQUEST.

In BioQUEST, first-year college students were introduced to the nature of biological science by studying the unanswered questions of biology, the current mysteries in the field. The course was based on Jungck's view that the best way to begin to understand a scientific field was to engage with the uncertainties that fascinated the researchers in the field, what questions they were asking, why these questions were being asked, and how its researchers were trying to answer the questions. Within their first year of college, all students of BioQUEST were brought to the edges of biological science. At the time we talked, Jungck was also involved in the creation of a consortium with other biological researchers to offer this beginning course in biology to a variety of U.S. colleges and universities.

Over my years of looking for examples of untrained students being brought to the edges of an expert field of inquiry, BioQUEST has been one of the few formal courses I have found. Recently, it has also begun to prepare its students to work at rather than simply study the edges of biology. BioQUEST remains one of my primary examples of a course intentionally designed to edGe-ucate students.

A New York Times article from around the same time reported on a less formal way for untrained students to meet the edges of a scientific field of inquiry. In the early 1990s, U.S. high school students had been invited by world-famous Russian microbiology researchers to come to Russia for a summer to work on their research projects. These Russian microbiology researchers, each well-known and awarded world-wide, desperately needed money because, in the wake of the Soviet Union's collapse, they had received no pay for months. The summer training was offered to U.S. high school students for $10,000 each. Ten families, each wealthy enough to have sons at a private school in New York, decided this experience was worth the cost, including the trip to Russia. The article emphasized that their sons, the students, had no particular affinity or preparation for this work; they were not even the best science students in the school. But what made this event newsworthy, and exciting to me, was the shock the world renown scientists experienced about how quickly these ordinary students could understand the edges of their work, and how helpful they could be to the researchers.

About the same time as I read the article on the high school students, another New York Times article described a different path for the untrained to be working at an edge of expert understanding. U.S. military researchers are constantly looking for better ways for soldiers to carry heavy loads over long distances. After several years of studying, these researchers noticed that Luo women in Africa had developed their own style of carrying extremely heavy loads with apparent ease, using a system that army researchers had never seen. The Luo women's solution was related to their understanding of how to use the skeletal body and their sense of balance over the muscular mechanics of load-bearing. Once the women had shown and explained their solution to the researchers, it was applied by the U.S. army.

This example demonstrated to me how expert knowledge at the frontiers of a field can go directly from the untrained to the expert. Insight and practice by ordinary humans can reach beyond the edges of scientific inquiry. More importantly, the article also points to the untapped intellectual potential gained by the untrained within developing countries that can contribute to advancing scientific understanding.

Although later I will bring up more examples that demonstrate how edGe-ucating has occurred in practice, one significant example over the years has stood out among them all. I found this example in 2000, and it has continued to contribute to my deep appreciation of just how edGe-ucating has been and can be used to address unsolved problems of expert knowledge – everywhere. As described below, this example not only captures how edGe-ucating was accomplished with villagers from rural Thailand, but, the author argues, that it can be done more universally throughout the world.

David Cavallo: edGe-ucator

In 1998, Mr. David Cavallo, an MIT engineering graduate student (now a professor), started a research project in Nong Baot, a rural village in Thailand. Nong Baot is in the poorest region of Thailand with two harsh seasons: flood and drought. Mr. Cavallo's research was focused on how the citizens of Nong Baot could solve local problems that they had identified but that had mystified expert consultants. One specific problem was how to retain water from the region's deluges that could later be used for its regular periods of drought. A few expert teams had tried addressing the problem by building dams in the area, but without success.

Mr. Cavallo described how solving this water problem required "sophisticated mathematics, biology, engineering, physics, and computer science." The villagers, most with no schooling, a few with a year or two, had decided that this time they did not want to go to outside experts. Instead, the villagers wanted to be the ones to solve the problem, not least to gain new skills and knowledge that could then be applied to the many other serious problems they were facing. Relying on the villagers to create the solution, however, also required that the villagers be able to apply the relevant expert knowledge that needed to be integrated with their local knowledge. Cavallo's role was to engage the villagers with the expert knowledge that they needed to apply to complete their task.

Cavallo began by introducing the villagers to a computer, something they had never seen in person. The villagers went from learning to turn the computer on and off to playing computer games to using the device to map their topographical environment and to learn fluid mechanics. This training was done with the whole community together, from children to elders, helping each other to learn and then apply their new learning as they proceeded.

Cavallo reported that it did not take long for the villagers to come up with their first breakthrough insight. After a few weeks of helping each other with the

games and applying their topographical skills and analyses, the villagers realized two local features had not been addressed in previous attempts. First, they noticed that the previous dams, although situated at reasonable spots to collect water, had been placed too far from their village for their village water pumps to be fully useful. Second, the soils under the collected water were too porous, causing most of the water to drain away before it was needed. Armed with these insights, the villagers then looked for and located a more realistic spot for the dam and the path for the accompanying pipes to the village, which they proceeded to design and build themselves. It worked.

David Cavallo called this process of localized, complex problem-solving "emergent design." The phrase was meant to capture the process of how an untrained local population holding a range of required local knowledge could be brought to the edges of a variety of sciences that were also required for a successful solution. The assumption behind "emergent design" was that untrained villagers could solve a complex local problem themselves by connecting their local knowledge to the newly gained technical expertise and know-how.

His description of the details of the process fascinated me, including the nature of the knowledge held by the villagers that was necessary to solve the problem. One example, among many, was the mechanical acumen and creativity of one villager who had the habit of teaching himself how to adapt simple engines of motorbikes ("tuk-tuks") to a variety of multiple purposes. This talent, not entirely unique to the area, proved to be invaluable since a lasting, locally available mechanical means of transporting water through the pipes to the village was necessary. This individual also became quite adept at hacking software and adapting it to local needs. Other significant areas of local knowledge included: detailed understandings of local terrain; how to work with each other across generations; and an appreciation, deeply rooted in community tradition, of serious changes required for the survival and growth of the area and its population, such as improved irrigation and crop expansion.

I would have liked more detail about how Mr. Cavallo had trained the villagers in the variety of expert knowledge required, such as how to read topographical maps as well as applying fluid mechanics, but that is the educator in me. Also, since I am not good at either, his explanation would help me better understand what the villagers learned. Unlike me, Cavallo was a problem solver, an engineer and technologist, while also being a socially oriented change agent. Interesting to me was that he had also been mentored as an educator, where one of his primary mentors was Seymour Papert, the creator of "constructionism in learning." Pap-

ert was an idea man and technologist who emphasized that learning is most effective when the learner constructs a meaningful product. Unfortunately, I have seldom met an educator who has been influenced by Papert's work.

Mr. Cavallo not only gave much attention to Papert's views in his report of what he was aiming to do with the villagers of Nong Baot; his concluding statement of what he had learned from his research may be the most significant sentence about human learning that I have seen. Cavallo wrote:

> The latent learning potential of the world population has been grossly underestimated as a result of prevailing mind-sets that limit the design of interventions to improve the evolution of the global learning environment.

Perhaps, like me, you may need to read that sentence more than once to get its full impact, but his criticism is explicit. What is clear from Cavallo's work with the villagers and their success in solving their complex local problem – and consequently aiming to solve more problems with their new found knowledge and confidence, his conclusion is fully warranted and wholly earned. Cavallo suggested three features or conditions that should be considered essential to "emergent design." These are:

1) A respectful and observant eye for locating expert knowledge of the untrained;
2) The need for a solution to a local problem that requires knowledge and understandings that go beyond expert knowledge;
3) That the local citizens be equipped with a good grasp of the expert knowledge that may be usefully applied to solving the local problem.

It was that third basic feature of the process that was most immediately relevant to my notion of edGe-ucating. But Cavallo's first two features are also essential as they refer to the respect for the potential knowledge held by the untrained along with a respect for the lack of relevant knowledge held by the experts. To be successful, edGe-ucating requires all three.

Thus, it was a young engineer, trained to be a generalist in the sciences, a constructionist as an educator, and a universalist in his appreciation of the problem-solving capacities of all human beings, to be the most exciting actor I have found in edGe-ucating the untrained. These human qualities are not unique for

an engineer, perhaps they are not even necessary for those of us who are not engineers if we wanted to be a terrific edGe-ucator. But my main point is that qualities like an openness to human potential, a vision of intellectual excellence in nearly all others, and a belief in the human ability to work together to build something new –to create together what has yet to be created – may be required for one to become – or want to become – an edGe-ucator. Furthermore, these or similar human characteristics are not held by only a few. Nearly all, experts and non-experts alike have them.

Although he happened to be young and basically untrained himself when he went to Thailand, David Cavallo has since gone on to advance a number of fascinating ways to solve local problems in other settings by applying features of "emergent design." One was edGe-ucating thousands of high school students in Brazil to re-design the city of Sao Paulo through creating small group designs, titled The City that We Want. Another was as a member of the early 21st century project, One Laptop per Child, organized to design and provide a working computer cheap enough to be available to all children in the world.

Dr. Cavallo is an intellectual hero to me, for whom the notion of being a hero is one who has encouraged the intellect of others to be fully engaged in solving their own problems.

Another way for me to put this is that David Cavallo is not only an edGe-ucator, he is the ultimate educator. One thing he has taught me, for example, is that perhaps the two are not so distinct.

neophytes working at edges of the known

Around the time when I encountered Cavallo's work in Thailand was when the word "edGe-ucating" had been suggested to me by a teacher in one of my Masters' degree classes. In addition, as I thought about Cavallo's experience, along with early examples like the Ghanaian women or the high-schoolers going to Russia, the word "student" began to trouble me for reasons similar to those that led me to coin "edGe-ucating." Cavallo sometimes called the villagers "untrained," and other times, "learners." Both seemed appropriate but inadequate. I was looking for a word that was less oriented to schooling, or even to teaching or training. "Neophyte" seemed to work better. "Neophyte" suggests a beginner to an expert field, a novice. Being a neophyte in a field of inquiry could refer to someone who was highly trained in a different field, or to a person who had little educational background at all. I liked that ambiguity.

My curiosity, then, was beginning to take more shape as I had a new word, "edGe-ucating," for the process I was investigating, and a new word , "neophyte," for those who were being guided to work at an edge of expert knowledge, but could be considered "unqualified." Both words took me away from "education" with its implication that work at the edges of expert knowledge was only for those who were fully trained to do so. Instead, these two words together could allow for more detailed discussion and debate on the phenomenon of those with little or no previous experience being successfully involved in the processes of an expert inquiry.

With these two basic changes in terminology, I became more comfortable looking for, describing and interpreting the challenges of preparing "neophytes" to work at the edges of fields of inquiry. I also remembered the advice of the philosopher John Wisdom who pointed out that, when attempting to convince others, "always the final appeal is to cases."

It was mainly through chance that I found examples of neophytes breaking through expert edges of knowledge. Examples came occasionally through colleagues, more came from newspaper clippings, a few from educational resources, and not enough through public scientific articles. (I always felt there were many more examples out there because of the varied contexts of those I had found.)

I share a few of the examples below, but they are not perfect cases of edGe-ucating, just as the high school students going to Russia was fortuitous, not intentional, and BioQUEST was primarily an example of bringing neophytes to an edge, not necessarily beyond. Although the samples I found do hint at what is possible in edGe-ucating, few were what one might consider highly convincing "wow" examples – with the notable exception of Cavallo's work with Thai villagers.

Nevertheless, the following are individuals or groups who have shown themselves more than capable of intellectual engagement with the frontiers of experts than educators have assumed, or, it would seem, care about. They are sketches of citizens from a variety of contexts who found how to work successfully at the edges of knowledge – some with guidance, some without, and some who broke through assumptions generally held about their personal capabilities. Together they begin to underscore how limited have been the assumptions held within the design of formal educational institutions about the intellectual capabilities of citizens. Each is numbered for easy reference, for those who may want to return to them.

1. Gunter Wachtershauser was a patent lawyer in Munich, Germany who developed a new theory for pre-biotic chemistry, that is, chemistry that could

have led to life forming on earth. Mr. Wachtershauser pointed out how certain rock minerals could have been a likely surface upon which critical molecules for life may have initially formed, considering the earth's atmosphere in the early years of the earth's formation. Two New York Times articles refer to Mr. Wachtershauser's achievement. The first, in 1997, described his theory that life on earth could have started with molecules from the non-living chemical make-up of rocks. He pointed out that the special environmental conditions of the early earth, including high heat and a different atmosphere, could have generated chemical activity that was able to lead to life-forming molecules. In 2000, a follow-up article described Wachtershauser's experiment that mimicked the violent interactions of rock and gases that would have occurred soon after the earth had formed. This produced a chemical that is crucial for the metabolism of living cells, lending support to the theory. My understanding is that this theory is still being tested.

2. Geerat Vermeij was born in Holland, moved to the U.S. at 9, and has become one of the leading researchers on marine mollusks. He is a prolific field worker who is able to read from the ridges of mollusk shells the life struggles through which the creatures have passed. Mr. Vermeij has been blind since he was 3 years old. He was trained in paleontology at Princeton and Yale universities, and was the creator of the "escalation hypothesis," which concerns the energy an organism uses to fight the adaptations to which new environments seems to require of an organism. In fact, he showed that often those organisms that do not adapt immediately may more successfully survive a mass extinction event than those that do adapt quickly. (There have been five mass extinctions on earth, so far.) In the 1990s, Geerat Vermeij was awarded a MacArthur Fellowship along with a medal for meritorious work from the Academy of Sciences. He is included here because of the physical challenges he had to meet in adapting the senses he had to his learning of and performing expert inquiry. He clearly was encouraged by educators along the way, and recognized for the unique skills that he could apply to studying the edges in his field and arriving at new theoretical understandings.

3. As a child, John Horner discovered dinosaur eggs, embryos, and baby dinosaurs in the 1970s that challenged the beliefs of paleontologists. His discoveries showed that adult dinosaurs gave considerable parental care to their young, something that conflicted with the understandings of that time. He

grew up in Shelby, Montana, and found his first dinosaur bones at age eight. He attended the University of Montana for seven years, but did not receive a bachelor's degree because of severe dyslexia. He has since received a number of science awards for his discoveries, including the MacArthur Fellowship, and has been a museum curator, a university paleontology technician, and has had a number of dinosaur species named after him. He wrote an early script for the original Jurassic Park film from a book he was writing on how to build a dinosaur. The only degrees he has received were honorary doctorate ones, including from the University of Montana where he never graduated.

4. On the Monday of the week that 17-year-old Soo Yeun Kim was to turn in her work on the diet of the Neanderthal to the Westinghouse Science Award Competition, she was killed in a car crash. Beginning that night, and continuing until the end of the week, 16 of her high school friends completed Soo Yeun's two years of work, organized the data, and then wrote the report from the materials that she had gathered for her paleoanthropological study of the diet of Neanderthals, sending it in as Soo Yeun's final application to Westinghouse. In her application, Soo Yeun wrote, "There were days when my body ached from sitting under a bright light for hours peering at bone fragment after bone fragment." Soo Yeun Kim's entry won recognition as a semi-finalist in the national competition. Only two of the 16 students who had worked to complete this work for Soo Yeun had also entered the competition; neither won an award. The team of friends, which in a week's time completed and wrote her application, were "ordinary high school students" who had no preparation in Soo Yeun Kim's topic.

5. LeAlan Jones and Lloyd Newman were students at a high school in Chicago in 1994 when they started working on a radio documentary about the murder of a child in the Ida B. Wells public housing complex in Chicago. Their work expanded into a book from the many interviews that they had done for that study and other studies they had performed of their neighborhood, titled, *Our America: Life and Death on the South Side of Chicago*, with David Isay. In 1997, an article in the Chicago Tribune asks why only one of these two youth with so much intelligence and skills in investigative reporting seemed to be on the road to professional success. One answer among many is that the more possibilities for those two boys, and others like them, to work on the

edges of what is known may have helped them both to progress further with the skills, talent, and ambition they showed in their adolescence.

6. When Rachana Gupta was 13 years old, she saw a television news investigation of government poultry inspectors. "It was nasty and disgusting," she is quoted in a 1994 Chicago Tribune article. Deciding to check it out herself, she got a load of store-bought chicken to check the accuracy of the "USDA Approved" stamp. She tested her store-bought chickens for salmonella by soaking the chickens and putting the water on an agar surface, a gelatin plate on which small bits of bacteria can grow into visible colonies. The next year, she took her findings to a regional science fair, but was disqualified for two years because the judges didn't like her working so closely with salmonella. (She pointed out that they were touching and eating the same chicken.) Eventually, she did win awards, including for her developing a process for eradicating salmonella by soaking chicken in a vinegar solution before washing and cooking. Her father was a professor of microbiology, her mother a researcher in microbiology. Perhaps we should ask them how they edGe-ucated Rachana. I am guessing that their indirect messages to her may have been just as powerful, or more so, than the direct ones.

7. Matt Roloff has built a fantasy playland near Helvetia, Oregon, that challenges Disney in the style and fun that pirate ships, mine shafts, and western villages can bring. Mr. Roloff is a dystrophic dwarf, 4 foot 2 inches tall, and his entire 34-acre fantasy land is built for little people. Designers from the Disney Corporation, which has signs on their rides that limit the size (not age) of those who can enter, have visited Roloff's playland to see what they can learn from him. The story of Mr. Roloff is described in a 1997 New York Times article where he is quoted about creating his playland on his own, "I do have a plan, but it is all in my head and it keeps on growing."

8. Natalia Toro, 14 years old, was a student in Boulder Colorado, the youngest entrant in the 1999 Intel Science Talent Search. She was also the top winner of the award for her work on the oscillation of neutrinos. Neutrino oscillation is a quantum mechanical phenomenon where a neutrino can be measured to have different states of being at different times (called "flavors"). Such oscillation between different states of being have great theoretical and experimental interest, among other things showing that the neutrino has a non-zero mass

which required a modification of the standard model of particle physics. An example of the importance of neutrino oscillation was that two researchers, working independently, jointly received a Nobel Prize in 2015 for their studies on identifying the oscillation of the neutrino, each study being accomplished in extreme underground conditions, one in 1998, the other in 2001. Natalia Toro's research, conducted in 1999 with professor Edward Bertschinger of MIT, was described in a NYT article as having a potentially significant impact on the study of the oscillation of neutrinos. Her parents reported that they couldn't keep up with her interests.

9. When it comes to age, gender, and experience, the performance of the 1997 Mars expedition is informative. Brian Muirhead, the deputy project manager (at 45) estimated that the average age of the 500 people who designed, tested, and guided the spacecraft and its rover was in the low 30s. "I hadn't even thought about space until I got this job," said Rebecca Manning, 25, who joined the project right out of college, and tested the entry, descent and landing procedures for the Mars spacecraft. The playful nature of the Mars mission was captured in a 1997 NYT July 13 article about the Mars expedition website which described how to make one's own spacecraft. EdGe-ucating seems to have occurred at NASA at that time, with a very large group, including many neophytes, all aiming to accomplish a highly important, intellectually complex, and costly task.

10. Henrietta Swan Leavitt was a secretarial assistant to the astronomer, Edward Pickering at Harvard Observatory, at the turn of the 19th to the 20th century. Her job, called "computer" by Sir Edwin Hubble, the director of the Observatory, was to record thousands of photographs of the heavens that Hubble and his team had gathered, and to look through them for specific luminous features of the stars. As reported by Johnson in 2005, at the time there was a serious question, debated by top international astronomers on the size of the universe, with the greatest unknown being just how to determine its size. After observing thousands of photographs, Henrietta Swan Leavitt realized that the size of the universe could be measured through the star brightness data that she was documenting. On her own, she was responsible for edGe-ucating herself, and when her insight was proven correct, astronomers' understandings of the approximate size and complexity of the universe had been dramatically increased. Henrietta Swan Leavitt's solution has been one

of the major breakthroughs of modern astronomy. For years her discovery had been identified only by Hubble's name, but is now recognized with Henrietta Swan Leavitt's name as well.

11. Over the past few centuries, astronomers have generally been more open to neophyte assistance than most inquiry fields, partly because of the immense amount of potential data on the universe. "Galaxy Zoo" is a recent phenomenon sponsored by the Sloan Digital Sky Survey open to astronomers and untrained observers for their help in investigating and expanding the expert knowledge of our universe. Anyone who wants to participate in "Galaxy Zoo" can volunteer and then be tutored through a 60-minute video on how to classify images from the Hubble telescope circling the earth. Astronomers report that the findings by neophytes working with Galaxy Zoo over the past years have been extensive and valuable. One edGe-ucational question not yet answered remains: Can these neophyte astronomers also be trained to help address the theoretical uncertainties about our universe? Henrietta Swan Leavitt did that, but on her own.

12. Hedy Lamarr was a bombshell Hollywood actress of the 1940s and 1950s whose pin-up photo was kept in the helmets of many U.S. WWII soldiers. She also was an inventor of patents and developed a remote-controlled torpedo guidance system that could avoid electronic efforts to turn the torpedo off track. (The U.S. Navy didn't adopt this invention until 1957.) Her system was guided through a signal that hopped around the radio frequency spectrum, a precursor to the current technology of Bluetooth, wireless phones, GPS, and Wi-Fi. Hedy Lamarr had no training for designing this, or her other patents; she did them by learning on her own, and then working with others, including George Antheil on the remote-control process for protecting torpedoes. George Antheil was himself another neophyte on this project. An American composer who had thrilled and scandalized Paris in the 1920s with his avant-garde music, he later composed music for Hollywood studios, where he met Lamarr. The word for learning on your own is "auto-didactic learning," which happens often, maybe now more than ever through the ubiquitously available information technology. In 2014, she and George Antheil were posthumously inducted into the National Inventors Hall of Fame. Those who held her photo in their helmets may have been most pleased of all.

13. At Frascati, Italy, untrained high school students work directly with nuclear physicists on scientific frontiers at the Italian Institute of Nuclear Fission. These students, selected by their schools to work on the frontiers of nuclear fission, live with the scientists for six weeks of the summer, as well as work with them on their scientific investigations of nuclear fission. A report by Centioni, 2010, states that the students have not only learned much from the scientists about researching nuclear fission, but they have proven to be useful collaborators in the research.

This example of the Italian Institute of Nuclear Fission is a step towards edGe-ucating from which much can be learned about how neophytes can be assisted in a highly technical and theoretical field of inquiry. From an edGe-ucating point of view, however, I propose that the Institute may get a similarly positive result if all students were allowed to choose to live and work at the Institute. For example, in 1997, when Stevenson High School opened up advanced placement exams for all students who wanted to take them, 1,375 out of 3,300 students took the exams and 88% passed. Previously, 162 took the advanced placement exams. What would happen if the schools sending students to the Italian Institute of Nuclear Fission tried something similar?

These examples, and many more like them, became a fundamental stimulation for me to continue my personal journey into the potential and realistic possibilities for edGe-ucating everyone. Although they are not pure examples of edGe-ucating in action, they did provide me with glimpses of what can happen when edges become available to ordinary individuals or groups. Many of these examples were occasions where experts were close to individual neophytes (some by birth) which suggested to me that near random opportunities to gain access to edges may be an important feature for developing a capability to work on an edge.

communicating the frontiers of inquiry to everyone

You may remember that, when I began doing program evaluation research, I was not at all prepared for the work: I was a neophyte. Yet as I experienced hiring and working with other neophytes in the field, I began to realize that this may be a good thing. At exactly this time, one of the most well-known educational program evaluators, named Michael Scriven, was claiming that no one could become an expert in educational program evaluation without having done at least

1000 studies. That was quite a few more than the zero I had been considering, but I still felt comfortable building my ideas around neophytes contributing to expert knowledge.

I was not the only one noticing the limitations of commonly held assumptions about the degree to which extensive previous knowledge is required to do serious, expert science.

When I was young, I had been attracted to the ideas of Paul Feyerabend, a philosopher of science who argued that there were no final rules for doing science or for developing new knowledge.

At its edges, he pointed out, scientific inquiry broke all the rules of logic and rationality. It was, and had to be, a process where anything goes. Feyerabend used Galileo as an example of how revolutions in science occur through a variety of aesthetic, personal, and social features, not only rationality built upon previous carefully crafted experience. He also referred to the need to "democratize" the processes of scientific inquiry.

In an early year of me working on edGe-ucating, my niece who was studying comparative literature steered me to Michel Serres, another philosopher of science who argued that science should be considered a translation art, composed of various ways to express and account for experience, explanation, and connection. Hermes was his favorite image for science. In ancient Greece, Hermes was a messenger of the gods, moving quickly and surely between worlds of the mortal and the divine. Hermes was also a trickster who crossed boundaries at will, translating back and forth as he travelled between the two different domains. Serres' interest in this emissary image was in ensuring "freely accessible knowledge," but he also had a great scepticism about the role of education, where, as he put it, "the goal of instruction is the end of instruction, that is to say invention." A pretty fair definition of edGe-ucating.

Both Serres and Feyerabend were considered mavericks in the philosophy of science. Serres was initially trained in math, and, in particular, topology. Feyerabend was initially trained in music and theatre. To both, science is what occurs at the frontiers of knowledge, and education more often stopped you well before you got there.

When I discovered that Serres had been initially trained in topology, as I was, I began to think more of my own history with science. I realized that it was not the math that made science difficult for me; after all, I could understand many of the complex mathematical features of scientific explanation. It was the basic concepts that I could never fully grasp as intended. The edges were easier.

It took an historian of science, Barbara Strafford, however, who provided me a new base for considering that the frontiers of expert knowledge can be open to the participation of non-experts. Strafford pointed out that Western science, when first beginning to take shape in the 16th to 18th centuries had a different approach to the question of who could participate than we take today. When Copernicus – and then Galileo – were creating new scientific knowledge, for example, she pointed out that science was open to all. In mathematics, biology, physics, chemistry, astronomy, or geology of that time, anyone could join and participate with the international communities that were being created to communicate and engage with the new knowledge and its creation.

That changed, Strafford noted, as charlatans and fake inquirers began to surface, and subsequently became a significant problem to the continued conduct of serious inquiry and its intercommunication of results. The solution was simple and effective. Instead of relying on visual, graphic illustrations, readily accessible to all, as sciences had been doing, the solution was to create a new linguistic terminology in each scientific field, a terminology that required considerable training to acquire. Strafford pointed out just how deeply effective that solution has become in the past few centuries as current inquirers in many scientific and mathematical fields can now speak and be understood at the edges of their fields by less than a handful of other scientific experts.

Strafford also noted, however, that the recently enforced world-wide return to a visual culture through information technology and mass media may return the visual to science, and with a vengeance. That threat encouraged my sense that edGe-ucating may be more possible in the near future than it has ever been before.

Another voice that began to push me further into edGe-ucating was John Brockman's. In a book titled The Third Culture, John Brockman focused on the phenomenal public interest in purchasing books that explained the new, complex scientific breakthroughs in fields as disparate as sub-atomic physics, the birth of the universe, the Cambrian explosion of life forms, or the details of the genomes of all living creatures, past and present. These were not only books and articles by some of the most highly respected working scientists in these disparate fields; they were best-sellers. There was a public, obviously untrained in all these areas, who were interested in becoming more informed about the edges of contemporary science - expert language be damned.

Brockman's book was published in 1995, with the title playing on a well-known academic lecture by J.P. Snow. In 1959, Snow had proposed that there

were only two primary academic cultures – the humanities and the sciences – with a shared inability to communicate, or disinterest in communicating, with each other. Brockman, a literary agent for many of the researcher-writers he wrote about, pointed out that the frontiers of science were being communicated by the researchers working at the edges – and to an ever-growing population of readers. The subtitle of *The Third Culture* was "Beyond the Scientific Revolution."

A few years later, Brockman started a Web Page, still ongoing, called "The Edge." It was built for scientists working at the frontiers of their knowledge and generating new fields of understanding to communicate their work to other scientists working at other edges of other sciences. "The Edge" is also a place where anyone can enter who wants to engage with these digital conversations around the frontiers of many separate fields of inquiry. Sound familiar? It certainly did to me.

I began to think of edGe-ucating as an experience that many neophytes could experience more than once. I imagined neophytes who could become successful at the edges of one field, then leave that field to go and pursue and create new knowledge at the edges of another field of inquiry. I referred to these neophytes who moved across multiple edges of inquiry as "double-crossers." They could cross one frontier of a field of inquiry, and then cross back from that frontier to enter an edge of a different field of inquiry. In my imagination, there would be nothing to stop these neophytes to be multiple double-crossers. In fact, I began to envy them.

Nine

attempting to integrate edGe-ucating with educating

when the edges of science lost to educating

As I began to communicate my notions around "edGe-ucating" to my educational research colleagues, it seemed to me that I was gaining little of their interest. Then I came upon information about a similar battle that had occurred nearly a half century before. A significant battle had occurred between those who educated and those who performed at the edges of science. It may not only have been a precursor to my battles between educating and edGe-ucating, but a reason for the two fields to continue to remain so separate and distinct.

In September, 1959, at Woods Hole, Massachusetts, a National Academy of Sciences conference had been arranged for top U.S. scientists and top U.S. educators to work together to improve science education. The conference occurred two years after the Soviet Union had put Sputnik circling around the earth before the U.S. had. The charge for those at Woods Hole was to improve the serious faults in U.S. science education that were responsible for the country's loss in scientific prestige and the apparent failure in producing technical, scientific knowledge.

The co-directors of this conference were a scientist and an educator. The former was Jerrold Zacharias, a decorated experimental physicist who had been a member of the Manhattan Project during World War II, and, among other titles, was the Director of the Laboratory for Nuclear Science and Engineering at MIT. He had also recently become one of the leaders in designing an experimental high school program in physics. Jerome Bruner was a leading educator, a cognitive psychologist, learning theorist, and curriculum developer at Harvard University. The other thirty-two scientists and educators at the conference had similarly impressive credentials.

Accounts of the conference proceedings suggest there was at least one agreement between Zacharias and Bruner, and that was that the intellectual work of a research scientist and the intellectual work of a young child were essentially

identical. Nevertheless, that understanding did not suggest there was agreement in what should be done, or, as it turned out, what intellectual work even was.

I have read two accounts of what occurred when it was time for the two co-directors to get together to write up the proceedings of this conference. The educational account is that Jerome Bruner locked himself up during the last weekend of the conference, and wrote a seminal piece of educational genius, titled, "The Process of Education," initially published in 1962. It was modest in size, under a hundred pages, and has been considered, immediately and for decades after, a classic to be read by all educators. Bruner's published book identified itself as the Woods Hole Committee's final report, and listed Bruner as the only director.

An historian's account, written by Peter Dow in 1997, differed starkly. Dow included Zacharias' view of what had occurred at the end of the conference. Dow reported that, when the two codirectors of the conference got together to write the committee's final report, they could not agree on how to capture the conference proceedings and conclusions. In frustration, Jerome Bruner locked himself away to write his version, and in less than two days he opened his door and showed his resulting report to Jerrold Zacharias. Zacharias was shocked and unconditionally rejected Bruner's version as a committee report. In fact, Zacharias was so disgusted with what he read that he left the committee with no agreed upon final report.

The reason Jerrold Zacharias rejected what Bruner had written was Bruner's claim that "the scientific method" was composed of a few specific, sequential, universal steps that could be followed by any student of science to reach a successful conclusion to their inquiries, no matter what age or level of experience. Zacharias, by contrast, vociferously held and argued that, in reality, scientific inquiry at the frontiers, "loses all forms of traditional rule and principle."

I had met the educational view while a teacher in the early-1960's, but did not encounter the historical view until nearly 40 years later. As a teacher, I had great respect for Bruner's book because it so succinctly and clearly expressed why and how children could be trusted with doing science in order to learn science. But, even then, the linearity of his explanation of "the scientific method" never did seem right to me. I always distrusted linearity when used to explain any complex intellectual process, whether it was about learning or about intentionally breaking into a new insight or understanding – scientific or otherwise.

As I pictured this famous clash between celebrated scientist and educator, I began to understand more about what I was up against. There are deep roots of resistance held by educators to a researcher's claim that scientific inquiry at

the edges of knowledge often called for a necessarily messy conduct of thought, connection, imagination, and analysis. Keeping Zacharias' respect for the complexity of inquiry at the edges of expert understandings in mind, I continued looking for examples that could describe the various processes that might be used to edGe-ucate.

a manuscript on edGe-ucating for educators

The first time I used the word "edGe-ucating" was in a book-length manuscript, begun in the later 1990s and completed in 2003. Titled *EdGe-ucating*, the aim was to bring the ideas and potential of edGe-ucating to teacher educators, teachers, educational researchers, school administrators, and educational policy makers, people whom I had been working with for the previous 35 years.

The manuscript began with five examples. Three you have seen, two were imaginary. Imaginary examples were included because I wanted educators immediately to gain a sense of what edGeucating could look like in practice. Since most educators would never have given thought to the possibility of students working at the frontiers of knowledge, I wanted them to have images of "edGe-ucating" before they got to the how and why. Within the first chapter were examples added from my experiences as a teacher and educational researcher that began to suggest that edGe-ucating was possible in classrooms and other educational settings. The title of the first chapter was, "Leaping boundaries: edGe-ucating in action."

That first chapter included a variety of short essays, over 20 of them, some less than a page. These brief essays were on topics as apparently dissimilar as uncertainty, Plato, the genius of ordinary minds, new expectations for students and teachers, relationships between literacy and research method, and how borders have been significantly applied in learning theories such as those of Piaget, Luria, and Vygotsky.

A short essay on uncertainty, for example, quoted Bertram Russell as he referred to science and education near the turn of the last century. "Fallibilism," Russell said, "denies authority as the basis for truth," and he went on to doubt if education could serve that end. The essay pointed out that Abelard, a 12th century theologian, was more positive than Russell when he stated that the goal of education was to pursue the uncertainties in human understandings, not the certainties. A following essay referred to how students of edGe-ucating would demand to know what their teachers and resources did not know, as they would be inquiring into, investigating, and trying to understand the unclear borders,

not the coherent lucidity of the centers of specific fields of expert knowledge and understanding.

Referring to how borders had been essential to modern educational learning theories, one essay reminded readers that Piaget focused on the internal contradictions that can build up in a child's belief system and subsequently need to be transformed by the child as her experiences force her to create new understandings. Vygotsky referred to "zones of approximate development" to identify the range of uncertainties that individuals can feel at the borders of their personal understandings. Luria emphasized the roles of language and social context as mediators within these personal struggles as individuals meet their edges of understanding. Operating between the borders of the known and unknown were being understood as natural human processes of learning, especially in life, if not in academics.

The first chapter ended with an expressed disappointment that current educational debates were primarily about the centers of knowledge. The ever-present battles over "the basics," for example, seemed to assume that the duty of all educators was to aim students at what was known and valued, not at frontiers of the unknown.

I remember wanting the essays to be a challenging and fun read for an educator. Although the collage of kaleidoscopic topics may seem over the edge, I still like the idea of quick, multiple images when writing, and thinking, about edges.

The second chapter was titled "Dancing on the margins, leaving centers behind." The sections were longer and fewer; the essays in this chapter less a quick glance and more of a discussion around ideas related to edges. How, for example, at an edge unlike entities can often meet. "Punctuated equilibrium" was a term coined by biologists to describe a wild explosion in the variety of new life forms that developed on earth during the Cambrian Period. I pointed out that the phrase, "punctuated equilibrium," also seemed to apply well to our common experiences of adolescence, a time when we leaped periodically across margins of being and understanding, often including friendships along with multiple senses of self.

Another essay discussed how the fields of women's studies and mathematics shared commonalities in work at their respective edges. Newcomers were often the primary creators of new understandings at the edges of both fields, for example. Each field also valued personal intuition and private insight in the making of new discoveries. Both drew expert distinctions between what were the "centers" in their field and what were the edges, which often differed seriously from strong-

ly held public views of what should be a center of both fields. Although math had been part of academia for many centuries and women's study for a few decades, both disciplines experienced regular clashes with what the public valued about the discipline and what the discipline valued. For women's studies, some of these points are less true now than when I wrote this essay, but that is the point. I was writing with the present in mind, pointing out that in both fields the clashes between public and expert were about the importance of edges versus centers, they were not only about centers.

A different essay pointed out that Montaigne created the essay 300 years ago to wrest transient meaning from the mysteries swirling at the writer's personal boundaries of what is known and not known. That initial role of the essay to deal with personal edges of thought and meaning was then compared with the invention of the comic strip. The comic strip was begun by a Chicago newspaper in the 1880's to appeal to the city's new influx of German immigrants. Although the purpose of the essay had long ago been changed to being a form of persuasion, I suggested that the comic strip was a new style for Montaigne's essay, created to appeal to those caught in the gap between the old world and new, for those who, like Montaigne, had reached edges of meaning gained through their personal experience. A discussion on the significance of the "between" in comics led to raising the challenges of translating thought across languages, as expressed by modern writers like Milan Kundera and Elizabeth Hoffman.

"At the boundary, life blossoms," started another essay, as it focused this phrase from biology onto the turbulent transitional experiences of immigration, heresy, and sainthood. I also linked this phrase to Michel Serres' claim for the significance of prepositions in their role as they carried specific details of our movements over time, as we try to connect words and new thoughts together. As an example, he linked the Challenger explosion to the Polynesian sacrifices to the gods.

These essays may be a bit strange in topic, but I wanted to write a different kind of book about education. I needed something closer to Montaigne's notion of the essay since there was so much yet unknown to me about edGe-ucating. It was also important for me to state how the edges of understanding are just as present in our personal lives and individual experience as they are to formal inquiry. I wanted to point out that we humans are required to deal with our edges of understanding as we attempt to give meaning to who we are, to how we can exist more fully, and why. Edges in our belief systems are necessary to be crossed if we are to create better understandings in life, as well as in our formal

inquiries. I wanted edges to be fun, strange, worth our time to ponder, and to deal with intellectually. I also wanted to recognize the significance of uncertainty, with Montaigne's form of the essay being a necessary challenge to take on, along with education.

The third chapter focused on the role that edGe-ucating could play in transforming our understanding of democracy. The chapter emphasized that the educational questions being raised by edGe-ucating are whether ordinary citizens can be participating usefully at the edges of expert fields of inquiry without long years of preparation. The chapters' essays brought up how new strategies were beginning to be applied in a variety of expert fields that promoted participation by the untrained public in helping to answer unsolved mysteries in their fields. The chapter also discussed traditional descriptions of knowledge production, including "genius," "artificial intelligence" and "creativity." Post-modern science and the post-modern university were not left out. The title of this chapter was, "Double-crossing experts: the democracies of knowledge production."

By now you may get the picture. I was trying to display the similarities between our dances at the edges of our private thoughts and the dances created to go beyond edges of expert understanding. The point that I am making is that I wrote a full-scale manuscript to introduce educators to the notion of edGe-ucating. And in doing so, I forced a range of new connections and new possibilities for teaching and learning into the conversation. The connections admittedly went beyond most educators' experience, but also, I hoped, may be entertaining as fodder for new thought, for new educational potential. I have gone over about the first 100 pages, a third of the book. The last three chapters were more oriented to the aims of edGe-ucation that were more commonly shared by educators.

In the fourth chapter, for example, I focused on why edGe-ucating could accomplish more than education within developing countries, as well as in minority and disenfranchised communities in Western post-modern democracies. As Julius Nyerere, the president of Tanzania, said, "Education is not a way of escaping poverty, it is a way of fighting it." I argued that edGe-ucation may be a better way to fight poverty than education.

My main argument of the fourth chapter was that edGe-ucation could not only reduce the time to reach expert edges to fight poverty, but with considerably higher numbers of ordinary citizens working at those edges. Especially within developing nations and within minority cultures in industrial nations where these fights needed to be won. A related part of my argument was that edGe-ucating

would make it more possible for those marginalized to problem solve with their own priorities, using their better informed and newly created understandings.

I wrote recognizing my slim experience and understanding within these areas, referring to some of the most creative educational thinkers in the mid-20th century, like Julius Nyerere and Frantz Fanon in Africa, Paolo Freire in South America, and Ivan Illich in a variety of developing areas. All these thinkers were critical of "Western education," especially when it came to applying education to cultural settings with alternative values and needs for new knowledge. I realized there were many others with richer experiences and understandings of the unnecessarily slow pace and severe reduction of intellectual respect, opportunity, and advancement of the marginalized. I emphasized that this lack of attention could not be tolerated in education, nor continued. This chapter was titled, "Skipping past the knowns."

The fifth chapter raised and answered questions about edGe-ucating. Can specialist domains survive edGe-ucating? Why should we edGe-ucate now? How would professional expertise be identified and licensed? What can the arts teach us about edGe-ucating? What is the role of the university in edGe-ucating? The chapter ended with, Why hasn't edGe-ucating been thought of before? The title of this chapter was "Surfing unknowns."

The last chapter discussed what could currently be done in specific roles and contexts if edGeucating were to be taken further. This chapter attempted to be practical and aimed to action, thus the title, "EdGe-ucating between beginnings: What we can do now." Sections included what could be done in families, classrooms, schools, school curriculum, and teacher education. Discussion continued to what universities and research institutes could do. I ended with a note on the need to imagine more and better ways to edGe-ucate.

I never tried to get this manuscript published. It still needed more than the 32 single-spaced pages of footnotes that I had completed. That would take time. More important was I had to be more certain – my understandings of edGe-ucating had to be filled in with greater detail. That wish of mine to gain more certainty, of course, was a failure in understanding the work at the edges. I also had not yet given thought to how my previous educational experiences could be used, as I am doing in this book. Instead, I felt the manuscript required more wisdom, insight, and experience, if it were to be taken seriously. Obviously, I am not letting that stop me now.

Writing this manuscript was important for me. But I felt the effort to publish it would not be as efficient as continuing to pursue more possibilities for

edGe-ucating. Ironically, the work of writing a manuscript for educators pushed me, instead, to be more emphatic about my intent to go beyond educators and educational researchers to a wider audience interested in knowledge generation and knowledge creation. I began going to international conferences for researchers from many fields other than education. I was looking for their experiences related to edGe-ucating, as well as introducing them to where I was, while acknowledging a lack of contribution made by educators to the generation of new knowledge. I had more work to do if I were to understand better just what I was proposing as a new aim for a redirected education for everyone.

Brad Greenspan, edGe-ucating in high school

National Louis University occasionally had a day set aside to share what graduate students and faculty were doing. I would usually discuss why I was looking into bringing all students to work at the edges of knowledge and give some examples of edGe-ucating. I then would answer questions, some fascinated, many sceptical, and my time would be up. After one session, however, a young man came up to me, introduced himself as Brad, said he was a doctoral student, and that he had been searching for some time for a topic that would really excite him. He looked at me and said, "I think I found it."

What interested Brad, I discovered, was not only the challenge in the idea of expecting students to get to and help break through the edges of knowledge, and the risk in doing this, but that it touched on a goal that he had had for his students to create new knowledge on their own. It was also important to him that he do the same in his doctoral work.

As we continued to meet, I learned that Brad taught high school biology in a large suburban high school, that he was married and expecting a second child, that he loved his work, but had decided to go for his doctorate degree in order to keep excited about his teaching, about student learning, and about his field. After having looked into possible areas for his doctoral research, edGe-ucating immediately appealed to him. He came with two professional experiences that made edGe-ucating seem important. The first was that early in his teaching career he had created a new idea for a lesson on food webs that had subsequently been taken up by a supplier of science materials and delivered to teachers around the country. "Creating something new for others to use was something special that really excited me," Brad said with pride.

Brad's second experience came in the course of his Master's degree project, when he installed progressive methods of teaching into his high school biology

classes. Brad had asked each student to decide what she or he wanted to learn in biology, and then supported them in how to accomplish it, including sharing what they learned with each other. It actually worked pretty well, he said, surprising him and his high school students as well as his colleagues, but it wasn't as satisfying as he had expected. He had recognized that he had done nothing new in promoting self-directed learning in the classroom. Many others had done the same, he said, adding that he needed to accomplish more than that in his doctoral work. Just as important was that he wanted his students to experience the thrill of creating new information for others, too.

When Brad completed his doctoral research in 2008, what impressed me was how he had pushed forward my understandings of edGe-ucating, along with his own. In looking at his dissertation now, I am increasingly impressed with the perspective he used to analyze edGe-ucating and its natural conflicts with educating in his high school. Since these themes developed by Brad carry forward my story of how I became more edGe-ucated about edGe-ucating, I will briefly describe Brad's work with his students, the research he performed to illuminate the teachers' understandings, and the analyses that he applied to bring additional meaning into the nature of edGe-ucating in an American high school in the early 2000s. That was unique work beyond the edges of edGe-ucating and indeed beyond many edges of educating.

Brad's first attempt at integrating edGe-ucating into his classroom were really two different ones. This was Brad's way: if one attempt could aim students towards edGe-ucating, two would be better. Both were student projects organized by researchers located elsewhere. Both promised to include high school students in attempting to create new understandings by gathering and analyzing new data. Each fit what Brad wanted edGe-ucating to become if it were more intentionally applied in his biology classroom.

The first student project was an experiment in developing curriculum conducted by researchers at Harvard University. Students would not only be going through a new approach to learning by solving health problems of a fictional U.S. city in 1879; they were to be a part of the design team itself. The students would be responsible for analyzing what needed to be redesigned in this approach to curriculum design for its use by future students. Brad's students had never formally analyzed curriculum before, of course, but they knew what worked and didn't work from their own previous schooling. Now they were being asked to apply their understandings as they engaged with this new learning project. As designed, this was edGe-ucating in action.

The students enthusiastically analyzed and responded to features of the town sickness exercise, discussing and then sending in specific suggestions for making it more engaging and more useful. Brad described how animated and serious they were as they engaged with their new research responsibility. The Harvard researchers, unfortunately, never responded to the students' comments. Instead, all eventual changes made in the design of the curriculum project appeared to have been made by the Harvard team, with no reference to the students' suggestions. Student interest and enthusiasm turned to anger.

The second project, a Knowledge Web Project developed at the University of California-Santa Cruz, was quite different in its purpose and in the role assigned to students. The project was based on the book, *Connections*, where students would be identifying and then investigating specific inventions that connected to seemingly unrelated people, places, or events. An example in the book was the invention of the pencil, which was discovered to be connected to Thomas Jefferson, among others. After students found an invention that had a variety of unusual connections,, they would write a report, send it on for official approval, and then have it published on the web with the names of the students who discovered them, thus creating new information for others to apply.

The task of finding and making connections to the creation of specific inventions, however, did not attract much student interest. Although they completed the task with a few contributions even accepted and published, there was little excitement or energy shown by the students. Unlike the curriculum project, to them, these challenges did not carry much importance.

Initially, Brad was greatly disappointed in the results of both these student activities aimed at edGe-ucating. However, he quickly realized that a different way to inquire into edGe-ucating was right in front of him. Over the months when he had been working with his students, Brad had been talking with some of his teacher colleagues. He realized that they were rather intrigued by the notion of edGe-ucating, and perplexed at the idea that a teacher could be responsible for students working at the edges of knowledge. Why not do a study of teachers in his school around their views, their understandings, and their experiences of working with students at the edges of their respective fields? He could accomplish this research by interviewing teachers, and writing up their stories around themes of edGe-ucating. That would be new.

The investigative process Brad chose was "narrative inquiry," a qualitative research method aimed at understanding how an individual has created meaning from her or his experience. Brad's research included interviewing and recording

each teacher's understandings, views, and experiences of edGe-ucating, then writing up each teacher's story from the interviews. Initially, interviews were performed in four or five meetings of about 40 minutes each, the length of an open teaching period. Brad then wrote an initial draft on the apparent themes of a teacher's recorded comments, which led to a significant second stage where each teacher read over the written draft for accuracy, and then engaged in further discussions with Brad to capture any new thoughts about edGe-ucating that the teacher may have formed after the initial interviews. These second stage conversations were also recorded, and a new draft was written by Brad and shared again. The final result was a documentation of each teacher's story around various themes of edGe-ucating, with each teacher's final approval necessary for the narrative to be included in his study.

Brad interviewed six teachers, choosing those who had been voted as "teacher of the year" at his high school. The reason for this choice was to gain teachers of distinction, but also to provide a range of experience (10 to 28 years) and subject matter (physics, art, special education, biology, math, and orchestra). Although he wanted to get a balance of gender, it turned out that five of the six were women. Each teacher had her or his unique background of life and schooling, ways of considering students and learning, as well as how they considered student learning of their subject matter along with the meaning of "expertise" at the edges of their discipline. Their background experience, Brad noted, appeared to affect their views, understandings and recognition of edGe-ucating as a potential learning phenomenon.

Judging from excerpts from their narratives, the six teachers seemed engaged over their months of conversation on teaching, learning, students, education, and edGe-ucating. Each of the teachers articulated and questioned themselves on the complexities of teaching and learning in high school, and indeed their own lives. They appeared highly involved in conversing with Brad about the nature of edGe-ucating, often disagreeing with his views that it was possible in high school, expressing themselves in detail about why not, and occasionally came back to him with additional views as they thought more about students working at the edges of expert knowledge within their classrooms. The following will provide a hint of a few features of the teachers' remarks as they considered the possible role of edGe-ucating within their work as a teacher.

Each of the six teachers had initial resistance to the idea of bringing their students to the edges of knowledge in their respective subjects. The teacher of mathematics, for example, initially stated that there were no edges in mathemat-

ics, no frontiers of unknowns, no expert uncertainties. Later, she looked into the matter after Brad noted that an article he had seen that day discussed string theory and its ambiguities. In subsequent discussions she referred to why she had felt that. Although her claim was wrong, she admitted, she also added that she would continue to work with the edges of student understandings of specific mathematical topics, not with edges of mathematicians' understandings. As Brad knew from her students' written comments, she was an extremely talented teacher in being able to accomplish exactly what she intended with all her students.

The special education teacher talked about learning being like a ladder. If the bottom rungs were not sturdy, a student couldn't climb up. To her, the significant rungs for her students to climb were skills related to career and life, skills and strategies that helped make life more fulfilling and enjoyable. They talked about one of her special education students, Zev, who had also been a student of Brad's in his inventions course, and in his science topics class, a class for students with school difficulties. Although always having problems in school, Zev was a chef, had a cooking business and, in fact, had invented a food tape of gelatine, tasteless but able to hold together other foods like tacos or pastries. (Zev had looked it up, it had no patent.) To Brad, Zev was a hero for edGe-ucating as he had developed the food tape on his own. In Brad's inventions class, Zev became a leader for all the students and within the science topic class he had performed all the academic exercises required to record his accomplishment. When Brad walked into the special education teacher's office for their first interview, she was warmly congratulating Zev. Zev had just learned that he had gotten a full scholarship to a Chef school in New York.

The special education teacher appreciated Brad's view of Zev, but emphasized that all her students had unique ways of thinking and doing things. She then asked, "What is more important than breaking through one's expected limits for living? Is creativity in life of lesser importance than creativity in an expert inquiry field? Is edGe-ucating for all students? If not, which ones are you going to choose?" These became some of the questions that she left Brad with that he couldn't answer. Nor could I.

The physics teacher argued vociferously that his students did not work at any edges of physics, that was not his job, nor was it what learning in high school was about. He also kept pointing out that what students did to create new information may look to be new, like Zev making the gelatine food tape, but it was probably not new to an expert in the cooking profession.

Later, however, this physics teacher publicly praised one student, giving her a prized school reward for having solved a problem he had tried to solve over ten years, a problem in data presentation. Her solution transformed one of his traditional lab units by creating one data table for an immense amount of complex data instead of the three data tables that were the best he could create, or find, for the lab exercise. It was an approach to reporting data that he had never seen before. He added that after he used it, for the first time in 11 years of teaching this lesson, every student completed the lab and understood the underlying concepts. That was accomplished thanks to her unique data solution, he told the student audience when giving her the award.

In a later discussion, the physics teacher described in detail how he and a colleague from a different high school created an approach to teach students about kinetic energy and acceleration by having students take photographs of situations that reflected energy dynamics at a large amusement park. An example of the assignment for the students was to take a photo "of a place where your acceleration would be in the opposite direction of your motion." The students' excitement, learning, and discourse while discussing each other's photos were fantastic, he reported. He mentioned that the interactive process the two teachers had applied to create this new approach for students to learn a complex topic showed how teachers could work together to solve a common problem at an edge of teaching. He also emphasized how this took real time and engagement together, and would not have come from either teacher alone.

The art teacher argued with Brad about the differences between a new look in art and creating something new. Although the variety of student drums Brad saw in her art room were each impressively unique to him, each having its own style, she told him they weren't "at an edge of art" as Brad called them. Instead, she argued, the edges of creativity in art had to be something more basic than that. At the edges, creativity in art had to do with how you saw, not just what you made. She went on to suggest that originality in science might be similar. Creativity at the edges in science, she suggested, may be in a new approach applied in how one understands a common phenomenon, and then how one finds a new way to communicate that understanding. She then pointed to how much energy this kind of creativity at an art edge can take, often requiring tremendous focus and time, two qualities from her experience, she offered, few high school students had.

The art teacher also emphasized the need to recognize the role of student self-confidence and fear if one were expecting them to create something new in

art. Brad had earlier learned from her that critique was an essential part of art making, something many students had troubles dealing with. Thus, the risk required to create could be difficult for many students both in terms of the product made as well as in inventing a new process of looking.

Other teachers brought up similar concerns about the capabilities of their students to handle risk or uncertainty in the ways needed to work at the edges of knowledge.

Students may have time to re-create, said the orchestra teacher, but not the time to create. She gave an example of her students' reluctance to write musical compositions in her class. One "out-of-the box" assignment she would give to her orchestra students was to compose a 12-bar blues piece. She found that few could, or wanted to, accomplish that task. Her experience was that students resisted work at the edges of music; most, she said, were intimidated by that. She also kept emphasizing that the real success of the orchestra, and of the students' engagement in orchestra, did not require them to go to that edge.

Brad had reported that his initial discussions with the orchestra teacher did not go well. After the first couple of interview meetings, she had to confront him for continually asking her "the wrong kinds of questions." His orientation to music was the Grateful Dead, Phish, she said; hers was classical music. Each Grateful Dead concert being a new invention, an improvisation, was a universal goal of music to him, not to her. Classical music required other kinds of talents, she emphasized, like how to process and interpret a composer's meaning, say, from 300 years ago. He needed to listen to her and respect her music experiences and understandings, she emphasized. She was there to talk to him about her goals and understandings of students' engagement with music, not his.

As their discussion changed, she referred to teaching orchestra one year at the same time she was fighting breast cancer. She had invited her students to ask her any questions about her cancer experience, "whatever they wanted." And she answered all their questions as openly and honestly as she could. That year, she added, her students became fully engaged in learning, and orchestra became her best year of teaching, ever.

Like the other teachers, the biology teacher brought up the need for knowing "essentials" before getting to the edge. Although the biology teacher taught the most advanced courses and students, requiring each student to enter the regional science fair, she noted that the most creative and novel science projects they did were related to their everyday experiences. One entry for the fair was testing whether algebraic warm-ups improved the speed of learning new chess skills; an-

other was "the effect of perceived personal inadequacy on the hostility of internet journaling." Brad asked why all students couldn't do something similar, and her answer was, because they weren't yet fully capable of "abstract thinking."

Later, however, the biology teacher referred to an exercise she often gave students to create visual, 3-dimensional models for how chromosomes affect human genetics and the inheritance of human characteristics. She remembered a "typically average" student who came up with a model and a process that the biology teacher had never seen or considered before. The student's approach may or may not have been entirely accurate, she added, but the point was that the process that emerged from her image was new to the expert concepts of inheritance and genetics that she had seen or studied. She added that she will always keep her new and deep respect for this student who may have been at a creative expert edge in considering and in showing how genetics worked.

After reading these accounts from the six teachers and their reflective clashes with Brad and his views of edGe-ucating, there was no doubt that the teachers had brought an immense amount for him to contemplate. There were complexities to working at the edges of knowledge in schooling that neither he nor I had considered. There were many questions asked that required to be answered better than we were able.

An additional feature to Brad's research applied a perspective for analyzing the teachers' initial viewpoints about edGe-ucating and perhaps to some of the questions they asked. Brad used epistemology, a field of philosophy that considers the existence of competing understandings for what knowledge is. For philosophers and educational researchers, epistemology also focuses on who holds knowledge, how knowledge is gained, and how knowledge is made. One set of assumptions about knowledge, for example, could be that knowledge is fixed and certain, immutable and cannot be changed. A different set could include knowledge being temporary, but that the processes for gaining knowledge can be immutable and universal, such as knowledge being gained over time through specific, sequential steps of learning and experience. Each set of assumptions would have different answers to who may hold knowledge, how it is gained, and, especially significant to edGe-ucating, by whom new knowledge is made.

One epistemological question can be: Do educators and scientists have similar views of what knowledge is and of how new knowledge is gained? That question takes us back to the Zacharias and Bruner clash when Zacharias' experience of work at the edges of science would not allow him to accept Bruner's view of what the process of doing science should mean in classrooms. Much of Brad's

study demonstrates how the teachers dealt with similar clashes between the edges of their fields and their educational work. The differences between them and Zacharias and Bruner were that, with Brad, the teachers had considerably more time to raise, discuss and reflect upon their experiences and their respective views of intellectual edges. And were willing to do so.

Was Brad successful in his study? His doctoral committee said absolutely, they had never seen a doctoral dissertation ask so many essential and unanswered questions. Furthermore, most of these questions were asked by the teachers, each of whom were experts at educating, but made no claim to be edGe-ucators. That, in itself, was an example of edGe-ucating. Brad showed how edGe-ucating can occur through intense dialogue with mutual questioning stimulated by his elicitation and respect for the teachers' views.

What became clear from Brad's study was that edGe-ucating needed more questions, more educational ambiguity forced on edGe-ucating by those who were educating. Perhaps I was naïve enough to find that exciting. Brad's study was an honest, curious, personal, professional, and open appraisal of edGe-ucating from the minds of those teaching and learning in his school. Brad, also an educator, was focused and humble, a listener holding professional respect for those who spoke – additional qualities that were probably necessary for his study to have been so wildly successful.

I was both proud and humbled at Brad's accomplishment. I am sure that I let him know that his work took edGe-ucating into new territory. For a few years after he completed his study, we teamed together to give talks on edGe-ucating at conferences for educational researchers and teacher educators. We generally presented through dialogue, where we contrasted our two differing perspectives on edGe-ucating as gained from our two separate working environments. We had hoped to generate new energy from the contrast, stimulating more interest and more questions, but we were never quite as successful as we had wanted.

As I reflect now on Brad's study, I am understanding that my primary focus on edGe-ucating should not have been arguing on its universal potential in school classrooms. The real value in considering the existence and the nature of edGe-ucating experiences is in the interesting questions raised about education, along with the nature of human intelligence. I have always been trying to convince others to consider the potential and the realities for applying edGe-ucating experiences. But Brad's study suggests that the most important feature of edGe-ucating is how it directly asks us what educating can be and should be.

kids and bees

The following is from the abstract of a research article published in a respected peer reviewed journal, Biology Letters, in 2010.

> We came up with lots of questions, but the one we decided to look at was whether bees could learn to use the spatial relationships between colours to figure out which flowers [to visit]. It is interesting to ask this question, because in their habitat there may be flowers that are bad for them, or flowers from which they might already have collected nectar. This would mean that it is important for bees to learn which flower to go to or to avoid, which would need them to remember the flowers that were around it, which is like a puzzle. (Blackawton, P.S. et al, 2010)

This research about the way bees use color and space to navigate between flowers was performed, and the paper written, by 25 co-authors – all of whom were between the ages of eight and ten at the time. The 25 second-graders from the Blackawton Primary School in Devon, England, designed the experiment from the ground up, performed the research, and wrote every word of the paper, which has gotten multiple positive reviews by their apicultural colleagues.

Helped along the way by a neuroscientist, Beau Lotto (whose son was in the class), the young researchers' work was part of a science project, "i, scientist," designed to engage kids with hands-on science. They picked the question after trying on eyeglasses that helped them imagine how bees perceive the world, and they designed their own materials to conduct the experiment. These included a plexiglass cube filled with colored lights, each connected to a dispenser tube with either sugar water or salt water. The schoolchildren observed bees' behavior over several runs where the colored lights were switched on and off. In colored pencil, they recorded their observations of the variety of bee behaviors and the individuality of the bees' perceptive faculties.

The children's paper was not considered "ground-breaking" by the apicultural reviewers, but it was an addition to the research on bees' perception and behavior. Lotto first submitted the study to the science publications, *Nature*, *Science*, and *Current Biology*; all "loved the idea" but passed on the work. It did not have statistical analysis or any references to past literature. Lotto then asked four independent experts to review the paper, and only one questioned its scientific merit. He then sent it on to *Biology Letters* editor Chris Frith, who agreed to publish the

article after soliciting four more reviews, all positive, and asked neuroscientists Larry Maloney and Natalie Hempel to write a commentary to accompany the published paper. (For more details, see Yong, 2010.)

We can, of course, continue to ask just what the children did do to perform their research. Did they really choose the apparatus? Did they really write their report? Was it the work of all? What we know is that they all have their names on the work; that it was accomplished in their classrooms; that they were aware that they were working on a question that no expert had yet solved, so that uncertainty of outcome was certainly present; and that, as a group, they were trying to answer that as-yet-unanswered question. That is enough for me to say that this, indeed, was edGe-ucating in action that occurred in the second grade of the Blackawton Primary School.

In conclusion, there can be no doubt that, regardless of age or cultural circumstance, we can do better at guiding all citizens to the edges of our respective specialist understandings. Even more important, we can do better to prepare and encourage all citizens in helping us go beyond those edges.

Ten
dealing with complexities of edGe-ucating

How can edGe-ucating be done?

As an educator, I found the most interesting unknown about edGe-ucating in how it could be accomplished. I was hoping that I would learn from examples, but I knew that I was trying to understand a learning challenge that had seldom been encountered by educators – neither in their intentional practices nor in their educational theories. I also anticipated that guiding a neophyte to work at an expert edge may require some different approaches than those taken to educate.

Starting with the aim of edGe-ucating neophytes, one lesson that I have had to learn over time is that there appear to be two sets of answers to how edGe-ucating can be done. One aim is to have neophytes understand a particular edge of a field of inquiry. A different and more challenging aim is to prepare neophytes to work at a particular edge of a field of inquiry. The first aim can help lead to the second, but the two are certainly not the same, nor are they necessarily achieved through similar means.

I have often emphasized the second aim for edGe-ucating more than the first, mainly because I thought working at the edge of a known was more rewarding for neophytes, as well as for the fields of inquiry, than understanding alone. In addition, I considered that working at an edge of knowledge might provide a wider range of understandings about what creating new knowledge might mean. For both of these reasons, I will begin with the greater challenge for edGe-ucating, namely strategies I have found for preparing neophytes to work within specific edges of fields of inquiry, followed by strategies I have encountered for becoming informed about the edges of inquiry fields.

Strategies for neophytes to work beyond the edges of expert knowledge include: local problem solving, bringing experts to neophytes, embedding neophytes with experts, gaming, and neophytes working together on a challenge. These strategies are not necessarily applied separately, but can be and have been combined in overlapping and mutually reinforcing ways.

Local problem solving has been the most common strategy I have found for preparing neophytes to work at an edge of expert knowledge, and it is not new to edGe-ucating. I have previously referred to radical educators over the

twentieth century who focused on how the disenfranchised could be prepared to create their own unique solutions to their local issues. Paolo Freire, for example, encouraged the illiterate poor of Brazil to transform their lives through critical analysis and systematic action. Others, like Franz Fanon, Julius Nyerere, and Ivan Illich have pursued similar social aims within societies from South America to Africa. They were among the educational heroes of many in my generation for their attempts to raise economic status and opportunity for the oppressed and marginalized of the world through education.

Myles Horton was an American educator, trained as a theologian, who founded The Highland Folk School in 1932. For generations now, The Highland Folk School has been successful in addressing the reform of social, economic and political conditions confronting a range of Americans by bringing experienced social change agents to share their experience and understanding with local union and civil rights leaders from around the country, along with artists. You might even say that Myles Horton was a precursor to David Cavallo in linking expert knowledge with local intelligence.

Like Cavallo, Horton described his actions in encouraging local problem solving by the untrained, and, like Cavallo, Horton also had them working with expert information along with local knowledge and insight. Cavallo, however, may have put more emphasis on the villagers gaining technical knowledge for future problem solving. In addition to referring to some details of his engagement with the Thai villagers, for example, Cavallo listed three primary features of his approach. The first two features of his approach were similar to those of other radical educators: first, to identify a local problem that required going beyond the knowledge held by experts, and, second, to locate the relevant expert knowledge of novices that could lead to solving the local problem. The third feature of his approach was to ensure that local neophytes had a good grasp of the potentially relevant expert knowledge.

What action, I wondered, did that third feature require? Wasn't it, in a sense, calling for edGe-ucating?

As we have seen, Cavallo went into some detail on the actions taken for the villagers to gain expert knowledge: having the villagers become acquainted with the computer through computer games, then gaining information on expert fluid dynamics through computer simulations as well as through working on specific small-scale projects in the community, and accomplishing these tasks within one village group of all ages, from young children to village elders, helping each other through the learning processes.

Two educators, Ben Kirschner and Kristin Geil, directly brought in experts to prepare school-age children to identify and address local social issues, including working with local school boards, city councils, and other community forums. About the same time, Hall and Jurow called this approach "hybridity," referring to expert experience being combined with the young's creativity and energy to promote local social transformation. Hall and Jurow, for example, invited mathematicians to schools in order to show children how to apply specific edge-related mathematical approaches to solve local issues. "Hybridity" was similar to what Cavallo did with Brazilian teenagers designing a new Buenos Aires with a bit of initial expertise brought in by architects. Nyerere had done the same with agricultural reformers working with school children to develop new localized agricultural techniques in Tanzania.

Embedding neophytes with researchers was another way to successfully achieve edGe-ucating, as the nuclear scientists at Italy's Frascati Institute aimed to accomplish by having high school students both live and work with physicists through their summer (p. 172). The Russian microbiologists did the same with lesser prepared American high schoolers (p. 162). One could also anticipate that 14-year-old Natalia Toro's research on neutrino oscillation was successfully conducted through a continued interactive professional engagement over months with an MIT professor (p. 170).

Although these were temporarily embedded engagements between neophytes and experts, there were also considerably more extended periods such as Henrietta Swan Leavitt's employment under Sir Edwin Hubble where, during her long-term observations on the illumination of stars, she became the first to imagine how to measure the size of the universe (p. 171). Similarly, hundreds of largely untrained and inexperienced researchers were successfully engaged with the 1996 Mars expedition by being embedded with more experienced experts in highly specialized fields (p. 171). We could also anticipate that Rachana Gupta's research on salmonella in store-bought chicken was dependent upon her 13 years of life living with her two parents, each with microbiology research expertise (p. 170). The Mars exploration team's involvement with experienced experts was intentionally aimed for working at and beyond expert understandings, Ms. Leavitt's and Ms. Gupta's were not.

Another effective intentional approach for encouraging neophytes to succeed at extending expert knowledge is through gaming. Once again, it was a strategy employed by Cavallo with the Thai villagers, but gaming has more recently become an essential strategy for gaining citizen participation in a variety of research

studies, through a strategy that has become known as "crowd research." An example of gaming in this regard was applied by scientists at Carnegie Mellon and Stanford Universities as they were attempting to harness the wisdom of crowds for designing new RNA molecules through creative folding techniques. In a computer game called "EteRNA," for example, non-biology-trained players sent in their folding designs to biology experts who were looking for different ways to fold ten proteins into specific 3-dimensional configurations. When tested, these non-trained players handily beat leading software applications at that task.

As John Markoff has suggested, computer gaming is being used much more universally as a way to attract and engage a creative and capable public. Such a public may be "uneducated" by researchers' standards, but capable of supplying creative responses to specific highly complex tasks required to resolve researchers' uncertainties.

Andrew Chen provided a different perspective on gaming when he taught a course on gaming to undergraduates, while realizing that many may have more gaming experience than he, and knew more about gaming. He taught his course on gaming through gaming. Each student began the course by designing a game. After two weeks, the students chose which game designs would not be continued and which would be kept. Those students whose designs were voted out had to choose another design to work on. The choosing of designs to be dropped continued until, from the initial 50 designs, a final 9 were completed at the end of the course. Assuming that there would be experts and neophytes within the class, Chen made certain that they interacted as teammates, and also made it possible for the neophytes to be involved in producing a "winner," along with those with more experience.

Could Chen's approach produce similarly positive combinations of creativity and expertise within the work at a variety of edges of expert fields of inquiry?

Another strategy to encourage neophytes to engage with expert edges of a field is through extended, strenuous dialogue on the problem. An immediate example is the way Brad Greenspan and the teachers he interviewed achieved breakthroughs in understanding the explicit reluctance of his teacher colleagues to accept the possibility of edGe-ucating in high school. They achieved this understanding, including the whys, through their recorded dialogues, followed by Brad sharing a draft of what they had said, then reflecting in private and returning for more dialogue on the issue (p. 187). Engaged dialogue is also the way in which Soo Yeun Kim's high school friends responded as an interactive team when they took the deceased Soo Yeun Kim's notes, and together created a re-

search project report in two weeks that won a national Westinghouse research award, something none of them could have done alone (p. 169).

My favorite example of using intense dialogue as an edGe-ucating strategy is one described by Florian Barth and Matthias Luft, two German college instructors who had been co-directors of international award-winning security competition teams. One year, however, they had lost all of their award-winning team to graduation and had no experienced replacements. At first, they tried training neophyte hackers efficiently through lectures on adaptive knowledge and skills in technological adaptability, insight to unknown technological problems, vulnerability-oriented systems, team communication, and the ethics of hacking. That approach failed.

Barth and Luft then went on to design ten highly interactive workshops, engaging the neophytes to work together on hacking problems – without experts. That approach worked well. In a matter of weeks, the hacking neophytes became competitively creative in finding the vulnerabilities of technological systems, and winning awards at international competitions.

Barth and Luft reported that they have continued their workshop approach in successfully training new neophyte hackers. Neophytes successfully trained themselves in applying highly specialized knowledge, expert intuition, and meeting unexpected challenges that required both insight and risk-taking when confronting unknowns. These two are my new heroes as I consider how similarly conducted interactive workshops could be applicable for preparing neophytes to work at the many different edges of expert knowledge.

In addition to strategies for engaging neophytes to work at the edges of expert knowledge, a variety of creative mass media approaches have been used to make edges of specialist knowledge accessible to all. The following are a few examples of how video, literature, and especially the ubiquitous Internet have been increasingly applied in museums and other sites like science festivals, to bring edges of a variety of specialist knowledge to untrained citizens.

As described earlier, an increasing number of writers – like John Brockman (p. 175) – are writing popular books and articles that capture the work of researchers at the edges of their fields. Brian Green, for example, has written books on topics as erudite as "string theory" with its loops, snippets, and branes, along with other exotic topics such as the unresolved status of an inflationary universe and multiple universes.

John Durant has taken a different route than a literary one to informing the public. Dr. Durant began by designing museums for citizen participation in sci-

entific research, and then proceeded to form science festivals at a number of different sites throughout the United States. Brian Greene was a participant at one festival and reported, "We tried to inject the drama of science into these highly produced programs, and we heard the participants leaving the event saying, 'Wow, I didn't know that's what science is like!'"

In 2011, a singular event was designed for "amateur collaborators" at the Columbia University Library in New York City. One participant was David Hogg, an astronomer and physicist who has applied amateur and hobbyist images within his astronomical investigations. Another participant was Jane Hunter, the director of a large research network in Australia, who has promoted a variety of e-research methods and on-line tools for "citizen researchers" to engage with research networks across a variety of research disciplines. Dr. Hunter has, for example, developed visualization techniques to enhance collaboration and on-line data sharing to aid multidisciplinary projects for preserving modern art. She also has provided new data tools that can help integrate Australia's cultural assets for humanity and citizen researchers. Another participant was Rick Bonney, an ornithologist who founded citizen.org, an organization that has promoted public participation in scientific inquiries such as those in environmental conservation.

In astronomy, organizations like Galaxy Zoo and Zoo Universe have used social media to make the frontiers of their knowledge accessible to all. Traditionally, astronomers often have approached the general public with both respect and the opportunity to better understand newer edges of their field, while also preparing them to participate in gathering data to help increase their newest understandings. Like those described above, perhaps soon they may also create or adapt new ways for the public to be involved in working on the theories that create these understandings as well as helping experts by providing the data.

The range of strategies for aiming neophytes to understand and to work at the edges of expert inquiry fields suggests that there are a great variety of active educational imaginations that can be successfully applied to edGe-ucating. Current contributors to developing new processes for edGeucating include untrained citizens, as well as students, teachers and other educators, along with researchers, scientists, and problem solvers. My modest sampling also suggests that many more as yet unimagined approaches to edGe-ucating neophytes can be developed and applied. The ranges of who and where, why and how these strategies have been created seem to demonstrate that the need for edGe-ucating is here, along with opportunities for success.

What is NOT edGe-ucating?

The more I talked about edGe-ucating with groups of problem solvers, engineers, and information technologists, the more I was asked to describe what edGe-ucating was not. With educators and educational researchers, that was seldom an issue since edGe-ucating was far outside of their professional experience and theoretical understanding. To problem-solvers and researchers working in other fields of inquiry, however, edges of knowledge appeared to be a topic closer to their work, and closer to some of the questions they were asking about the training of their students, as well as communicating their fields of inquiry to the general public.

I realized that responding to their question could also help my own understanding of edGe-ucating. Most of the examples I had of edGe-ucating did not represent the full potential of what could be done to edGe-ucate. By answering what it was not could perhaps make finer distinctions for what could be considered edGe-ucating, and why.

I can start answering the question by referring to an early mistake I made. Most of my early work on edGe-ucating was inspired by the thought that edGe-ucating should be defined as aiming for neophytes to work at the edges of knowledge. I began by assuming that bringing neophytes to the edges of knowledge was not, in itself, enough to qualify as edGe-ucating. But I now consider that assumption to be unnecessary. Once a neophyte comes to understand a frontier of expert knowledge, there is no reason why she or he should be left out of the work at that edge. BioQuest has learned that lesson after working with first year college students for many years (p. 162). An inquiry enterprise like BioQuest, one that successfully brings neophytes to an active edge of a frontier of expert knowing, will recognize that those same neophytes can also be guided to contribute to the work at that edge.

Knowing that successful engagement at an edge of inquiry is possible, however, does not mean it will be done. All inquirers know that. But now, with so many more citizens being able to reach the edges of expert knowledge through a variety of media technologies, we can be more confident that edGe-ucating – neophytes participating at and contributing to the edges of expert knowledge – can be made more accessible than it has ever been. That possibility leads me to accept edGeucating as including both separate aims: getting to understand an edge of a knowledge frontier, and working at an edge of a knowledge frontier with the intent to help break through that edge. With that supposed integration of the two

major aims of edGe-ucating – understanding an edge and contributing to that edge – the following is now my answer to the question of what edGe-ucating is not.

It is not edGe-ucating when neophytes perform routine tasks of data gathering. Many data gathering tasks can be done, and done well, with little understanding of the theoretical contexts of the study for which the data are being gathered. Being edGe-ucated is becoming capable of participating in analyzing new data, and in seeing the theoretical structure of the question that provides specific interest to the data being collected. Being edGe-ucated includes recognizing why the data may promote, deny, or suggest a better understanding of specific phenomena than is currently held by experts in the discipline.

In the sciences, for example, participating in lab work is not enough. EdGe-ucating requires the preparation of neophytes to understand the intellectual and conceptual challenges at the frontiers of a field of inquiry. In becoming edGe-ucated, a neophyte must understand the specific conceptual features of a discipline that are being questioned at a particular edge of a field of inquiry.

An example from my work in a physics lab as an undergraduate looking at the trails of subatomic particles captured within a spark chamber might be useful here. For that work, I was given a clear and explanatory six-page article from a Princeton alumni magazine about what the sub-atomic particle paths that I was looking for were, and why they were important to a better understanding of sub-atomic physics. Although I imagined at the time that I would also have been capable of understanding the nature of the questions being raised about the paths I was documenting, that was not my job. I was not included in, nor was I prepared for analysis of the data. I had not been trained to understand the nature of the competing theories being investigated; that was the researchers' job. I was not being edGe-ucated.

Perhaps I could have operated a bit more like Henrietta Swan Leavitt (p.171). She was much more imaginative and observant of related details external to her observations, and she was more aggressively curious than I. Her achievement at reaching beyond the edges of astronomical knowledge was accomplished by being active enough to listen for and become aware of the theoretical issues being raised, as well as pursuing and aggregating the full details of her observations. She went well beyond the observation task that she had been given. She edGe-ucated herself. I did not.

To continue with what edGe-ucation is not: preparing an individual for long term participation and engagement in an expert field is not the same as prepar-

ing a neophyte to engage with a particular inquiry at one edge of an expert field. Apprenticeships or internships are not edGeucating – at least without an intent aimed directly at the work and the questioning that are occurring at a particular frontier. Many features of becoming a member of an expert inquiry profession are not necessary, or even desirable, for edGe-ucating. EdGe-ucating is the act of preparing a neophyte to engage intellectually with work at a particular unknown at the edges of a professional inquiry. An edGe-ucated neophyte is not expected to be a professional practitioner within that expert field of inquiry, but is expected to be able to understand and then contribute to one particular edge of the field.

In summary: some, perhaps much, of what is done to prepare individuals to become professional inquirers within a field are not edGe-ucating. Although edGe-ucating can be part of preparing a professional inquirer in a field, to edGe-ucate on its own would be ineffective as an entry into the profession of any field of inquiry. EdGe-ucating would not be broad enough or deep enough to prepare for further unanticipated theoretical work, or for performing many of the everyday details included in an inquiry profession.

Rather, edGe-ucating is a way for those untrained in a profession to understand an edge that is being investigated, and to help that work along. Continued involvement in that inquiry profession is not expected, and would in fact require an entirely different kind of preparation.

The question as to why to edGe-ucate, then, must be answered with a different response than that it is a way to train for life-long involvement in a particular discipline of inquiry. From the beginning, I have argued that becoming edGe-ucated is first an intellectual adventure worth having – and not only once. It is also the best way I know to gain a deeper sense of what professional work with the edges of uncertainty is like. It is a way to recognize the various ways in which we humans operate with our rational and intuitive engagement with unknowns, and of the significance of human interaction and fierce disagreements in trying to reach a new understanding. EdGe-ucating is not a step to continued employment.

Finally, I must concede one more point about my view of edGe-ucating. The yes-no feature I have used to answer the question of what is not edGe-ucating leaves me uneasy. EdGe-ucating, like all intentional actions taken to inform others through new experience and understanding, has a large variety of possibilities, many not yet imagined or tested in action. This discussion was not intended to reduce those possibilities, but to shed some light on actions that are currently

being taken to educate that would not satisfy the aim of neophytes to understand and engage with the expert edges of what is known.

unexpected enthusiasm

After two decades of presenting edGe-ucating to educators, I received a surprise in response to a proposal I had sent to the International Conference on Integrating Research, Education, and Problem Solving (IREPS) for their 2012 conference in Orlando, Florida. Included in their acceptance of my proposal was an invitation to address the full conference in a plenary session. That meant I had an hour plus question time with a potential audience of all conference participants, not the customary 15 or 20 minutes in a small group. I was surprised, and a bit shaken, having never had that kind of upgrade for a conference presentation. It was a relief when I realized my plenary session was scheduled towards the end of the conference which meant that I would have a few days to get a sense of who the participants were, and their interests: particularly important as I had never before gone to this conference.

Many of the sessions I attended before my talk interested me, and some were also highly related to edGe-ucating, although they didn't refer to that term. You have read about some of those presentations in the section beginning this chapter. One, for example, was about using gaming to teach students who had more experience in gaming than the professor (Chen, p. 198). Another described how a team of neophytes learned best about working on technological security problems through the group solving problems together, without experts, so much so that they won international competitions (Barth & Luft, p. 199). There were other conference presentations that I have not yet mentioned, such as one about conducting bottom-up research through a process that started with simpler challenges and going to more complex ones, while integrating students into the investigative process, along with professional researchers from different scientific disciplines (Pierre et al., 2012). They called their research process "emergent research," describing it as a robust way to approach unpredictable phenomena, a process dependent upon continual feedback. Although they initially referred to chaos and complexity theory, the image they used was how ants discover food by first taking many different paths, eventually leading to the most successful result. I noticed not only that the term for their research process was similar to David Cavallo's "emergent design," but the research process itself.

In my plenary address, I was able to refer directly to a number of the presentations that I had attended, noting how, as I was, those presenters were also

working on issues related to who can work successfully at the edges of knowledge –and why and how. I titled my presentation, "Addressing the unsolved through edGe-ucating, or Can IREPS promote democratic knowledge production?" I had redesigned the talk every evening, integrating the conference examples I had heard into my presentation, and tailoring it for conference participants, many of whom were none-native speakers of English.

The hall was nearly full, and the conference members seemed to be engaged throughout my presentation. The variety of questions asked at the end, and the subsequent individual talks I had with a few participants from different work settings and countries, reinforced my view that this audience was a unique one for discussing edGe-ucating. Many of the small conversations we had afterwards related to their experiences close to edGe-ucating, experiences with a variety of ordinary people, mostly in non-school settings. They thanked me for bringing up the reality of these possibilities happening, and referring to the greater potential of increased citizen participation at the edges of inquiry.

After my talk, I was invited to lunch with the conference organizers, about six of them, a few near my age, the others considerably younger. Although the meal was long, food was made irrelevant by the passion of our interactions. Questions were asked and arguments made around scientific knowledge, uncertainty, research, communication, and wider participation in research, as well as about education. They wondered why they hadn't heard me before, or had read my work, and they suggested that I use one of their publications to reach a wider audience. One of the members at lunch was T. Grandon Gill, who was the editor of one of the sponsoring journals. He later formally invited me to write an article in his journal, *Informing Science: the International Journal of an Emerging Transdiscipline*.

My article was published in *Informing Science* the next year, 2013. Many of its special features, like side-bars, came from suggestions from T. Grandon Gill, the editor. It was a scholarly article with references but no footnotes, and it related most of the points I had made in my plenary address.

I wrote the article as a kind of summary, a "swan song" that identified major themes of edGe-ucating that I had been inquiring into and developing over some time. It was also a bittersweet moment as I was also preparing to retire, at age 78. The recognition of edGe-ucating as a common issue shared by problem solvers and educators was unexpected, and a very encouraging surprise near the end of my professional work on edGe-ucating. I could not help but wonder if, in different circumstances, I would have pursued the possibilities this recognition raised

with the requisite initiative and energy required to go further. Perhaps this book will encourage others to continue the inquiry.

edGe-ucating is too elite

Within my university was a unique and highly honored doctoral program run by the department of Adult Continuing Education (ACE), housed in the College of Liberal Arts. ACE and its doctoral program stood at the margins of its college, as did IDS, my masters' degree program in the College of Education. We faculty from these two departments in two different colleges often got together to share the issues our two programs confronted with our unusual educational approaches, including the conundrums those approaches seemed to present not only to the administration, but to other faculty.

In fact, I had been asked to work as a faculty member in the ACE Doctoral Program because my Master's degree program was being reduced to near zero - and ACE was in a similar situation. It, too, had lost most of its small number of faculty to the university's downsizing efforts. The entire ACE department was scheduled to end in three years, at the graduation of its new and final group of doctoral students. Similar downsizing was a condition that many university programs were undergoing then - and still are.

Since its inception, ACE had had an internationally honored, mostly minority faculty, along with a diverse student enrollment, especially in its doctoral program. It had been created a few years after IDS and was unique to any other program in the university, including IDS, in its aim to address diversity directly in terms of students and faculty through its scholarly, educational, and programmatic design.

The reason ACE was not in the College of Education was that they could not enact their doctoral program – extremely important to its mission – within that college. I understood their concern. Within my first year at the university, I had recognized how tied the College faculty leaders were to a very traditional university model (with, for example, a variety of prerequisite courses required by all doctoral students). Having seen other models of doctoral programs, such as those in England, it was difficult to accept that a progressive College of Education would not consider alternatives to that traditional (U.S.) model.

In the ACE doctoral group that I worked with (the ninth of the three-year doctoral groups to pass through the program), the majority were African American, two of whom had long experience in the military, one stationed in Washington, D.C., the other in St. Louis. Another had some years of experience in a federal

low-income housing agency; another was a dramatist teaching theatre at a local college; yet another was a recent Masters' degree graduate with ambitious ideas on how to promote more awareness, interest and involvement in African American communities. The term "African American," did not accurately describe the then current mayor of Kingston, Jamaica, who had received her Master's degree some years before in Cuba. It also doesn't refer to the minority identity of the Latina woman who taught a range of urban women trying to improve their economic status in the U.S. through local college education; or the Muslim woman who had immigrated to the U.S. from India as a young child with her mother, and later married a rancher in Montana, where she taught mathematics at a local community college. The only speaker of Swahili in the group was white, a young man who lived and taught in Tanzania for some years before moving near New Orleans, in Bayou country, to teach potential students – mostly Black – how to pass entry examinations to community colleges. Another white man in the group was an Information Technology expert who was teaching and had a leadership role in advising faculty within a local university, as well as a retired electrical lineman who wanted to show himself that he could earn a doctoral degree.

ACE conducted their doctoral program with such a wide dispersal of students by holding intense monthly meetings at the university from late afternoon Friday to mid-afternoon Sunday. Continued activities with students working together were accomplished through available social media. It was a highly individualized program in terms of student choice of specific topics to be covered, as well as being a considerable team effort, accompanied with energized confrontations and celebrations within the group of students and faculty. I was invited to work with three ACE faculty, all of whom I knew: two were regularly employed faculty, Dr. Tom Heaney and Dr. Randee Lipson Lawrence, and one a professor emeritus of the university, Dr. Scipio Colin III. I had often worked with Dr. Colin, whom I had always valued as a passionate educator and scholar, and colleague. It was she and I who had occasionally arranged departmental meetings between our two programs in order to discuss our shared challenges of operating at the margins of the university as well as of our respective colleges. We supported each other, and occasionally wondered if each of our programs would be more secure if we had joined together.

It took only a weekend meeting or two for me to get to know the ACE doctoral program much better than before, including its challenges. Although I had already respected the ACE faculty as professional colleagues who asked tough questions about what a university education could be, my respect grew even

stronger the more I understood the program and the challenges they had created for the students and for themselves.

I began working in the full group meetings as I had done in my master's degree groups, primarily by listening and asking for their views and experiences. That seemed appropriate, not only because I was teaching adult education, an area for which I had never been formally prepared, in a program that was different than any I had seen, but also because of the variety of backgrounds. From the beginning, the doctoral students were wrestling with issues of race, gender, equality, fairness, social justice, identity survival, and the building of a new and better society through more than education. I may have encountered these issues in different work settings and individual backgrounds in my previous work, but I had to listen closely to these students and faculty fully in order to understand the points each were making, and the experiences they were drawing from.

Listening was not good enough, however. At around the third meeting, one student pointed at me, and directly told me to get more involved. "Tell us more about yourself," she said. "Don't hide; we need you with us."

The most natural way for me not to hide was to bring in my views of research and the experiences from which my views had come. Research was often a common topic, as it is for all doctoral programs, and I knew my rich research background might be quite different from my ACE faculty colleagues. I pointed out that my view, not held by many academics, was that anyone can do research well with minimal training. I told stories that showed how I learned that from working with differing research methods, styles, and persuasions of inquiry with a variety of others in many different settings. I also knew that this message might not be one that doctoral students wanted to hear, since research was a big piece of the respect that gaining a doctorate degree provided. Included in my oft-repeated message was the view that what really mattered were the ethical responsibilities in doing research, especially to those from whom they were trying to elicit information and trying to understand better.

I also admitted that my view put more pressure on the students as researchers, since I expected their research not just to reflect past research of recognized experts, but to go beyond them. I expected their approaches to be better thought out and conducted than I or others had done to get at the specific themes and questions that they were asking. Following others was not going to cut it.

These were occasional bursts that, in a short time, they could probably recite themselves. But the primary method I used to show my respect for their work was expressed in my writing as I responded to theirs. Whether I was responding

to their critique of others' research, or to their written proposals and accounts of their own inquiries, I read what they wrote carefully and responded in detail. Seldom were they editorial suggestions, unless of course students asked for them. Instead, I responded to specific details, like how a point they made stimulated a connection for me, or raised an interesting new concept for me – say a possible new connection in what they were reporting. It was always important to me to show respect for student intellectual work by writing about how their work was affecting me, and why, including how I was understanding their aims as they were being described. I made sure that I showed that their work was always worth talking about.

My responses, they joked, were often as long as and more varied than the papers I was reviewing and responding to. For that, I always apologized, saying that it would take me much more time to reduce my responses to a reasonable length. What they were getting were my immediate responses as I read and thought about what they were saying. I wanted to ensure that what they understood to be coming from me was that what they had done, said, wrote, understood, created, thought about were worth their time, and mine. An intellectual engagement was what their work deserved. Always.

Although they joked that my responses could be nearly as long as their papers, they often added that what they received was an unmistakable interest and respect for them as intellectuals who were worth the time to listen to, to try to understand, to respond to and to encourage in going into directions that made sense to them. It was their ambitions that were number one here, not mine.

Rather quickly, I think, we learned to appreciate each other as searchers. I felt my role was to search through what they were trying to say and the insights they were trying to pursue as they used the tools and opportunities being provided within the inquiry enterprise.

Once, later in the program, we reversed our roles, where I was asked to present what I was doing in my research. I talked about edGe-ucating, imagining that this would be a topic that could draw their interest and respect. Maybe they would provide some new perspectives. My presentation to the students was never completed, however, because they kept interrupting me and challenging me for taking away the freedom of neophytes to choose their own inquiries. "What bullshit," one said, "this is just doing research controlled by the expert. Nothing new there!" I was shocked by their shock. And I was unprepared for their charge that I would be so authoritarian as to rely on "expert research" as the benchmark, not on what the neophytes wanted to research. They were throwing my views of

their inquiries back at me, but in a form I had never considered. Instead of being moved or stimulated or even interested in my concept of edGe-ucating, they felt it was only another form of the academically favored taking control of public intellect. They certainly did provide a new perspective on my work. Ten years later, I am still trying to come up with a helpful response.

By the end of the three-year program, each student developed work that was exemplary to their respective aims. One in the military worked on gaining individual PTSD stories, and connected those to making better military policy, better care, and better understanding. Another in the military wrote a play relating personal details of sexual abuse and its aftermath, including the unquestionable need for more military recognition and the on-going development of appropriate responses, with her play performed and designed to be continually presented to military audiences. The federal housing assistance manager focused on specific stories of those being "served" by the agency. In her work, their voices and experiences were so fully expressed in their own words, and subsequently heard by a researcher who was astounding in the critical lessons she was drawing from them about context, including how their experiences contrasted with much current "expert" academic analysis. The actor initiated, engaged in, and reported about the theatrical training he conducted with prisoners expressing and acting in their own stories within the State prison system. Included in the account were his stories about the difficulties he had to "get into" the prison system to do this work, and his efforts to make this theatrical work a future part of the state prison system.

The Kingston, Jamaica, mayor recorded how three different strategies she designed for promoting more community participation in problem solving worked so differently from each other, including the participants' interactions, leadership, power sharing, contexts, and outcomes. Her analyses led to a better and more real understanding of the complexities of local democracy in action. The Muslim mathematics teacher from Montana not only formed a team to change her college's mathematics curriculum, but gave extensive attention and analysis to institutional contextual features through case studies of her college, as well as other community colleges in different cultural settings, to come up with a better understanding of how community college curricular reform can be achieved. The Swahili speaker wrote chapters, all in the first person, each one describing his experiences teaching adult students in one of the two differing cultures: Tanzanian African, and Louisianian African-American. He always left it up to the reader

to make any strong links shared between these two cultures, especially including how each dealt with the formal approaches to adult education that the students had to confront, and the experiences of the students as they each tried so hard to make that education work for them. This dissertation became a form of literary art as well as of scientific critical analysis. His doctorate assessor, an internationally acclaimed professor and educator from Great Britain, called it the best damn doctoral dissertation he had read in his 30 years of advising doctoral students.

I was deeply impressed with them all. In their own ways, they each had extended understandings well beyond previous academic inquiry in adult education. I had learned from the ACE doctoral program and its students that I, as an educator but neophyte in their field of inquiry, could find ways to advise and encourage these students, initially untrained in research, to make real breakthroughs in their diverse fields of adult education.

I felt proud of what all these doctoral students had accomplished. As I draped the doctoral hood over the shoulders of those doctoral graduates who had been my primary advisees, my congratulations were genuine. My goodbyes to each and all, were sad.

Unlike other goodbyes at graduation, my sadness has remained. My 30 years in CARE, IDS, and ACE had not only ended, but so had the programs. Each of these three programs, revolutionary and aimed at professional educational reform in higher education, were effective in educating their students through their involvement in serious research within their respective professional settings. All three programs had challenged commonly held assumptions about what students could accomplish through their own inquiry; and all three felt they needed to re-arrange administrative university schedules and routines to do so. For different reasons, they were not able to continue.

Regardless of any possible explanation for their demise, the sadness was real. But so was my feeling of personal good fortune to have been an educator when I had been. I began teaching at a time when it was possible for me to try to engage children more actively and directly in their learning, and with parental support. I had entered educational research at a time when new approaches were beginning to be created and applied to understand education and educational change better. I had the opportunity to adapt and apply these research approaches with a federal program that seriously attempted to improve the teacher education for minority populations in the U.S. I was given opportunities for similar educational work in different cultural contexts outside of the U.S. And I was able to participate in

three extremely creative graduate degree programs that were trying to imagine new ways for graduate education to be experienced by educators. I left education as a very lucky educator.

You could say that I felt like every educator saying goodbye to her or his students. I knew I could have done more for them than I had done. But they had to move on. So did I.

towards a last edge

In 2015, a few weeks after the ACE group graduated, I retired and left for Iceland. My wife, Anna, had purchased our new home in Reykjavik, a small fifth floor condominium across the street from the ocean. I left with the IDS program as an on-line program with a few groups each year. Almost all my IDS faculty colleagues had left the university, as had my ACE colleagues.

Like my colleagues, I left the university and the profession with much experience, some of which had become irrelevant. Some insights drawn, however, held a greater understanding of what had been lost in education and some about what may be gained. I felt edGe-ucating could become a new set of academic expectations that would extend the potential of higher education, both public and private, with their shared capacities for raising public intellectual engagement with expert inquiry.

I arrived in Iceland, knowing that I had to leave behind my educational background. My first priority, if I were to live on this North-Atlantic island for the rest of my life as planned, was to learn Icelandic. Six years later, it still is – except I did take more than two years away from my Icelandic classes to write this book. Perhaps I did not leave behind my educational identity and experience as thoroughly as I had thought.

Eleven

on becoming edGe-ucated

uncertainty

The more I have immersed myself in trying to understand how we become edGe-ucated, the more uncertainty has been highlighted. Wanting to become edGe-ucated, for example, means agreeing to step onto a trail leading into what is not known, into what is not certain. What can make that trail frightening is the surrounding tangle of human explanations and "knowns" that have created the uncertainty we have chosen to meet.

To become edGe-ucated requires skills of re-imagining those explanations, of looking for or weaving in new, competing explanations that better capture the understanding of an unknown. To take on an expert unknown is to focus on the specific features of an expert's understanding that have become uncertain or ambiguous, and that appear to block further understanding.

In becoming edGe-ucated, one is focused, then, on what is not certain, on what is not known or seems too ambiguous to know well, accompanied by an added desire, sometimes need, to understand better.

From what we have been told by those working at the edges of expert knowledge, dealing directly with expert uncertainty and ambiguity is not an easy task. The intellectual work required is intuitive and unpredictable, and can include unique processes of imagery, connection, and curiosity, along with continued discourse with others and with oneself. It is not a rational activity, not predictable, not rule-governed, not logical. The only known in such a search is that the hardest task will probably be to throw away a certainty.

Almost all processes for breaking into new edges of knowledge require acknowledging the weakness in a certainty. As the theoretical physicist, Zacharias, and the educator, Bruner, tried to integrate modern science with modern education at Woods Hole in 1959, it was the significant role of uncertainty at the edges of scientific inquiry that irreconcilably separated them (p.129). It is a tension that still exists today.

There are reasons that make it difficult to integrate the processes of education with work at the frontiers of science and inquiry.

The processes of becoming educated have generally focused on the known, on what may be considered not only certain, but significant and useful to know in the foreseeable future. In becoming educated, we appreciate, look for, and apply effective means to process and retain authoritative certainties.

In becoming edGe-ucated, on the other hand, we must appreciate, look for, and apply effective means to approach, take apart, and deal with expert uncertainties.

In becoming educated, meeting uncertainties or ambiguities is often tantamount to being a sign of error, possibly failure.

In becoming edGe-ucated, meeting uncertainties is fundamental, oftentimes requiring the replacement of a certainty with uncertainty, but supplemented with richer understanding of the complexities involved.

Although edGe-ucating has different aims and may require applying different intellectual processes than educating, it is the role of uncertainty that creates the greatest separation between these two learning processes. Acknowledging this difference between edGe-ucating and educating is required if we are to honor the reasons why both these processes for knowing and understanding need to be engaged in by us all as we try to use the full capabilities of our human minds in these post-modern times.

As an educator, I have been learning about the significant role of uncertainty in edGe-ucating for nearly 25 years. For more than twice that long, I have been learning about the significant role of certainty in educating.

While teaching grade school children, for example, I quickly learned that comfort in gaining new certainties identified those who were successful in school. As I described in chapter two, for example, about the middle of my first year of teaching public grade school, I suggested that students bring all kinds of non-living matter into the classroom in order to argue over and demonstrate their views about what matter could be in the very very small. I wasn't sure what would happen, but found that the uncertainty encountered in answering that question seemed to be extremely uncomfortable for the students who had been good in school, especially in school science. For others, who often were not doing so well in school, however, it was not only an interesting challenge, but one they took on quite successfully.

When I undertook teaching students in this manner, I wasn't sure if this kind of challenge to rely on one's own observations, thoughts and analyses, working out new ideas with others, were skills that could be learned, skills that could overcome, for example, the habits of school success. Eventually, however, all the stu-

dents did become comfortable with uncertainty. After similarly unconventional activities over my five plus years of teaching children, I realized that meeting the challenges in dealing with uncertainties could be learned by ten-to-twelve year-old children – including by those who had found learning from authoritative sources more natural, and rewarded.

When I began directing educational research projects, I likewise found young, untrained grad students to be fully capable of doing field research – observing, interviewing, and questioning others while also integrating the varied experiences of these others into a coherent account. They were more capable, it seemed, than were their more knowledgeable professors. The professors immediately put what they saw and heard into conceptual schemes that they had already formed, rather than trying to find new ones that might better fit the experiences they were studying.

But the professors, too, later did become more comfortable in acknowledging and dealing with uncertainty. After writing a full account of the training from the grad students' voluminous observational notes, interviews, and end of day discussions, for example, the learned faculty began to doubt expert assumptions that they had held about how to educate teachers. Their summary and study conclusions were a series of questions focused on how teachers develop, including questions about the appropriateness of their own practices for educating teachers.

Once again, I learned that it is possible to become more comfortable with uncertainty when one is immersed in inquiry, even adults with years of professional expertise in creating, and sharing, certainties of their own.

In addition, I found that those managing federal education programs, often with no research or professional educational backgrounds, could entertain more possible explanations for what may be occurring with students in teacher education than many educational researchers. Why was that? I think it was because the bureaucrats found the uncertainties within the educational enterprise immediately interesting enough to consider and to play with. When I showed the staff of a federal program a chart of a dramatic change in student teachers' attitudes to teaching, a change made at the end of the students' first two weeks of training, the room erupted with, "Why? What happened?" Animated possibilities came from all corners. I knew then that our continuing study would retain genuine interest within this agency. Uncertainty had made the study attractive. Dealing further with these uncertainties was their job.

And, of course, we researchers were being paid to help them do that.

In Iceland, I found that a variety of professional colleges that were trying to change their institutional and programmatic focus to university status were especially fascinating in their "in-between" state. Yes, they were neither the college they had been, nor, yet, the university they were trying to become. Yet at the same time, the educational roles within the institutions, their programs and approaches to educating their students during that in-between time, were not only unique, invigorating, energetic, and more substantial than they had been previously, they were also more educationally substantial than the university norm that they later achieved. The uncertainties that had to be confronted in their unique institutional in-between state produced new educational arrangements that, evidently, were not capable of being continued within their achieved university setting.

In England, at CARE, I realized how unusual were the public debates as faculty and staff argued passionately among themselves over values, missions, goals, and consequences of their processes for researching educational practice, and for educating their students. Those debates remain in my memory even though the program, the staff, and the audiences are no longer there. What I noticed then is that they all had become very good at the exchanges as they considered and dealt with their differing professional viewpoints with passion, humor, and respect. I have always wondered how. One answer may be in how they treated their own educational and research certainties with a professional doubt that respected other, competing, views. Another, perhaps, is that they were never so certain.

When it came to teachers doing classroom research in their Interdisciplinary Studies Masters' Degree program through observing, listening to, and often interviewing their students, all while sharing doubts and questions with each other, by far the hardest time for them was in the beginning of the program. It was a new way to consider learning. This was school, after all, but there were few right answers about how to "do" it. That they quickly became very good at field research, with few given answers but with much personal observation and analysis, it became clear to them that this kind of inquiry and personal analysis had also been required not only in their teaching, but within their personal and family lives. Once they realized how natural doing this field research was to them as adults, they became especially sensitive researchers of educational practice and student learning.

Just as important for reaching their research proficiency was how the teachers began to request and use each other's perspectives and differing experiences and imaginations to improve their analyses of their students and their teaching prac-

tices. By the time they finished their studies, they could all have been exemplars to expert researchers from a variety of inquiry fields. What made all the difference was that they were able to bring their rich life experience with uncertainty into their mutual engagements with classroom inquiry.

Brad's high school teachers stated directly that introducing their students to expert ambiguity and uncertainty was not their job. They all emphasized that the purpose of teaching high school students one's particular subject matter was to ensure that their students received and internalized specific professional knowns. That focus on certainties was not only their professional responsibility, it was required if the students were to be capable of continuing their studies. To focus on expert unknowns was not part of high school teaching, and would not be serving the students well. Some eventually recognized that very occasionally students did get to an edge of expert thought, but meeting those edges, much less encouraging students to go beyond them, was not part of the schooling experience. It was enough for students to meet and build upon their own edges of knowing with the certainties that were being provided.

For the ACE doctoral students, uncertainty was an entirely different matter. For many, such as members of minority populations in the U.S., their everyday lives contained uncertainties that most others had no idea were being encountered. From driving a car to going into a bank to watching entertainment, uncertainty had always been a common feature of their public identities. They often expressed the fact that they had placed themselves in the doctoral program precisely to reform the inequities and unfairness of that reality, but also to extend their personal identities even further beyond the expected. With edges and marginalization being confronted every day, there was nothing special or unique about me emphasizing that classrooms encounter professional edges of expert understanding. They had been doing that their whole lives without the need of experts. Others in the ACE doctoral group also had encountered their own features of marginalization, for example within their work settings.

When I presented my ideas around edGe-ucating to this doctoral group of adult educators, they reacted strongly against the notion that edGe-ucating had any importance. Their collective aim was to go beyond expert knowledge, but they could and would all do that on their own, as they had for most of their lives. Respecting professionally agreed-upon uncertainties enough to try to improve them was not for these individuals. They wanted a more equal role – a reasonable demand, I think.

I have been concentrating on uncertainty because it is central to edGe-ucating, but there are other reasons why it may be worth our time. Recently, I have been encountering many analyses and studies of the increasingly fundamental role of uncertainty in our public and private lives. These analyses have been stimulated – as so many other aspects of our recent lives have been – by the prevalence of social media and information technology, from birth for many adults and all the young. The ubiquitous challenges of our current lives provide us with new reasons for focusing on how we learn to deal with uncertainty.

A century ago, philosopher and educator John Dewey argued that the Enlightenment views from the 18th and 19th centuries had held an erroneous notion that "the quest for certainty" (the title of his book) was shared by science. In 1929, he argued that the scientific quest is and always has been for reflection on experience in order to gain better knowledge, not more certainty. In fact, he argued, science often did away with past certainties. Dewey had formed his arguments through principle and rationality. Current research goes beyond Dewey as it focuses on the roles of uncertainty within human experience, not only past and current but also anticipated.

One set of psychological experiments, for example, has demonstrated that the uncertainty of an anticipated electrical shock is more stressful than getting the shock itself. Those who had been told that they would be getting a shock sometime later experienced more stress than those who got the shock by surprise. It was the anticipation of a potential unwanted occurrence that caused the stress, which may explain why the anticipation of unwanted events such as recession, fire, or flood can cause deeply felt stress in our post-modern lives. We are built to deal with shock through action. Dealing with the uncertainty of when a shock may occur can be a bigger problem. We all know that social media is a key difference between Dewey's time one hundred years ago and now, or for that matter between 15 years ago and now. Nearly all living humans currently experience constant streams of information through a variety of social media technologies. Dewey had no idea about such "sources of knowledge."

Social media are making it possible to stream information only from resources that will increase, not decrease, our certainty. We can now choose only those sources that will provide what will help us retain what we (believe we) "know." Studies from various fields of inquiry and analysis have begun to uncover more of the effects of the phenomenon of "over-knowing," of individuals and groups building on and retaining more certainty, not less, when faced with a potential uncertainty.

Uncertainty, then, has begun to emerge as a newly established challenge for understanding the increased tensions underlying post-modern human lives. This is becoming clearer through psychological experiments – through sociological studies of childhood, adolescence, and adulthood – and through socio-political analyses of emerging anti-democratic movements in established liberal democracies. Studies are increasingly suggesting that the human mind seems to have been built over eons to retain its certainties. Research highlights how and why we humans appear to be naturally ill-at-ease at not knowing, with us humans having built a natural aversion to being unsure.

Most important to me as an educator, however, are recent inquiries that are indicating the value of us adaptively dealing with the uncertainties that we do not like. These studies show that, although dealing directly with an uncertainty can take time and effort, it can also slow down our natural rush to judgment as we take another look and search for a better answer. Simply fearing an uncertainty, many studies are showing, can make us prone to rigidity, anxiety, and a closed mindedness to our own experience. William Hogeland (2021) has shown how this has happened in expert research as well as in everyday life.

Being unsure, another study points out, can be both a signal for danger and a provocation to investigate what's different, wrong, or missing in what we know. Uncertainty can be informative; it can point us in the direction of what we do not know, and, with support and encouragement, to replace that uncertainty with something more real and more helpful. Daeyol Lee, Yale professor of neuroscience, has concluded from his research, "We only learn when there is uncertainty." There are recent studies of medical practice, for example, showing that many doctors can be uncomfortable when they meet patients who have symptoms of which the doctors are uncertain.

They then either over-prescribe or do nothing. Related studies, however, are showing that it is possible to train doctors on what to do with patients who have symptomatic complexities that make treatment uncertain. Doctors who are uncomfortable with uncertainties can be taught that uncertainty is not their failing, that it is a natural feature of medical knowledge, and that uncertainty can be dealt with, with just as much medical care, understanding, and skill. As one recent study concluded, doctors can now be "trained to be open to not-knowing, not to resist it but to seek it out. Ambiguity is not threatening. We can learn from it."

Especially germane to understanding the role of uncertainty is a study of 104 German CEO's views about the intent to expand the European Union in 2004 to include many former communist countries into the EU. A few months before

the change, the CEO's were asked to predict what would happen. One group was sure that this would bolster their companies' successes; another group was sure that it would hurt their companies' prospects; and the third group was unsure, its CEO's having no idea what would happen. One year later, the big surprise was that the group with deep uncertainty was the only group that had considered and applied a wide number of responses to the developing new EU situations, including eliciting more diverse voices to be heard and taking on more novel actions. Those most uncertain of the possible effects of the change were much more successful with how they responded than those who had been certain. Uncertainty seems to affect how we learn, argue, and solve problems. The more we shy from uncertainty, the more we tend to engage with rigid thinking. As Richard Feynman, a highly decorated theoretical physicist has said, "I can live with doubt and uncertainty and not knowing. I think it is much more interesting to live not knowing than to have answers which might be wrong … In order to make progress, one must leave the door to the unknown ajar."

Perhaps edGe-ucating is not as weird or unconventional as many educators think. It might be helpful if we were all engaged with the expert unknowns through our public educations. Becoming edGe-ucated may provide us with more experience, more understanding, and more awareness of how uncertainties are being directly addressed, lived with, and occasionally resolved through inquiry and public analysis. As we become edGe-ucated, we may learn not to fear uncertainty – neither our personal uncertainties nor those that are shared with large publics. Education does help us gain the knowledge that human cultures identify as significant for its members to understand. But it is also becoming clear not only that most human minds are capable of accomplishing the complex intellectual tasks required to work with expert uncertainty, but that our continued development and existence as a species may actually require that that is made ever more possible.

One certainty when considering our collective need to engage with uncertainties is that edGe-ucating will never be a common experience for all students without the engagement of more scientists and problem solvers. More possibilities must be created for scientists and other inquirers to gain wider assistance in communicating their respective frontiers.

In the following, I will suggest how this professional challenge to edGe-ucate more widely may be resolved. Instead of going around the professional boundaries created between educating and edGe-ucating, I will raise a possible solution for how edGe-ucating can be installed within our educational systems and re-

lated organizations. Like all proposed solutions at an edge, success is not guaranteed; it may not even be hinted at. But I will give this a try, even though I am doing it alone: generally speaking, the most useless way to proceed.

combining educating with edGe-ucating

It is only as I have been writing my stories that I have begun to recognize the many ways that educating can support edGe-ucating. Perhaps you have seen that yourself along the way. When looking back on teaching children and teaching teachers, and on observing a variety of classrooms and their approaches to teaching, what impresses me are the variety of creative ways that many teachers have invented for students to work effectively with uncertainty while being educated within their classrooms. Even if the teacher-developed strategies are not yet generally seen nor acknowledged by an educational profession or by the public, their potentially high number provides a strong reason to be hopeful that edGe-ucating can become better integrated into schooling within the near future.

Early in my teaching, I had decided to start each class of 6th graders with students discussing what they thought matter was in the very very small because I wanted the students to be able to use that experience to be more aware of, more interested in and appreciative of the explanatory powers of the atomic and molecular theories that they would meet soon after. I found that they all became more capable of dealing with these uncertainties than I had thought they would.

When I had students write their private thoughts later in the school year, I wanted them to begin to recognize both the power and the limitations of language as they tried to capture and share their thought and experience in words on paper. In putting on a Greek play, I wanted them to get a deeper sense of the emotions and values shared by humans of very different cultures across thousands of years. When I had them remove textbooks from the classroom, I wanted them to feel the responsibility of finding and forming their own information from sources they could locate and trust or not trust themselves. Regardless of my educational intentions, uncertainty became a primary feature of their education. And, again, in each challenge students produced more edge-work than I had thought possible. All students, I found, could deal with uncertainty.

Most important, of course, is that I was never the only educator who was, is, and will always be thinking of ways to expand the processes of student learning by having them engage with uncertainty. Even the high school teachers who were explaining to Brad why they thought edGe-ucating should never be entertained

in high school also related assignments and lessons that they had developed for their students to engage with uncertainties. This included the orchestra teacher who required her students to compose a 12-bar blues piece, and the biology teacher who, every year, asked her students to design a physical model to explain concepts of inheritance and genetics – and remembered one "ordinary" student who came up with an explanatory approach the teacher had never seen before in her biological research texts.

Like me, these teachers had time to focus on challenges that increased uncertainty within their students learning. Like me, they felt that facing uncertainty was related to their responsibility in educating students.

What I realize now is that many similarly teacher-designed activities aimed at uncertainties can also lead students to appreciate and engage with the edges of expert thought. My 11-yearold students proved that to me when a physicist came to talk about his work on sub-atomic particles with them, and he told me that they asked better questions than his doctoral students. Or when another class of students decided to study children in their school in order to get a better understanding of the present. And after describing the children, the students decided to integrate their findings by grade level, and then created new scenarios for schooling that they felt would fit better into the children's lives than what they had observed. Going into uncertainties leads students not only to ask more questions, but to provide possible new answers.

When I was teaching teachers research, nearly every single new method that the teachers developed and tested out with their students ended with similarly complex aims, such as the kindergarten teacher who taught her students to learn sign language. Her initial intent was to develop a quieter learning environment, but what she inevitably produced was a class of students who had learned a new language for communicating among themselves, and for reorganizing their young lives together in better ways because of that. The young students also began teaching sign language to their friends from other classes. I am guessing that they still may be connecting sign language within their lives now, 15 years later, but in new ways.

One lesson every teacher learns through her or his experience is that learning is not linear, and that learning is not as sequential and intentionally accumulative as many textbooks seem to claim. Almost no learning is like a tunnel; it acts more like a street light and what it illuminates over time is never controllable, predictable or even logical. There are too many connections that can be made, some perhaps accurate, many not. The same is true about becoming. Educators'

experiential understanding of learning is why they can have much to add of value to those who plan to edGe-ucate.

Nearly every educator who has taught children, adolescents, or adults has had to discover unique strategies to engage students with complex, sophisticated understandings. While that is being accomplished, teachers discover that what engages students must include promoting a variety of possible connections among the students. When the high school physics teacher who, with his teacher colleague, designed a way for students to use photography at an amusement park to study kinetic energy and acceleration, it was an assignment that went beyond the expected, and beyond any expert educational advice that the two teachers had been given. Nevertheless, it had the students engaged in imagining, and then testing, various connections that could be made between movement and energy, all by themselves.

When observing high schools, it surprised me and the other educator observers studying high schools that the classrooms where the most uncertainty was confronted by students happened to be in the industrial arts and home economics classes. Students were told to extend a motor beyond its capacity, to document how the motor broke down and then try to analyze and explain why it broke down. Or students were told to try out various combinations of cooking ingredients, and see what happened to the mix when combined, cooked, or baked, to analyze what heating did to taste and form, and explain why. We educator observers realized, by the way, that many of the teachers who designed such activities had never had an education course.

Ron Berger, an elementary school teacher who has systematically applied construction learning within his classroom, describes how he has had elementary school children draft their own precise blueprints in architectural detail before they build a house together. Educators like Berger who promote learning through construction, focusing on students developing skills of precision that can lead to expertise and near perfection, know that getting to that point of expertise requires dealing directly with the uncertainty. Trial, error, and analysis predominate as primary learning tools for successfully constructing complex understandings and skills. "Ready, fire, aim," as many entrepreneurs of problem solving say. Uncertainty has to be a part of the creative process.

Given the recent school challenges that began with the Covid-19 epidemic, these same educators and teachers, world-wide, have had to adapt their approaches to uncertainty with students online. They now join other specialists applying on-line education, many at universities, along with professional edu-

cators such as Sal Kahn who started the Kahn Academy on YouTube nearly 20 years ago. Mr. Kahn has made his fame by enabling students around the world to understand some of the more complex topics in school science and mathematics through a variety of online strategies. And now there are a significant percentage of teachers who have also accomplished similar successes in constructing new strategies for creating learning activities that can prepare untrained citizens to deal directly with the challenging uncertainties of expert knowledge. Unfortunately, however, many of those teachers remain unidentified.

My first suggestion is for schools to recognize these teachers for the talents they bring to educating through uncertainty, and to reward them accordingly. What this would do for edGe-ucating is that every researcher who intends to edGe-ucate within their expert field of inquiry could identify those school teachers who may be potential valuable resources.

My second suggestion is that researchers and inquirers who work at the edges of their respective fields of inquiry actively elicit ideas from those teachers who are working with uncertainty, and then appoint those teachers who seem to have potentially useful approaches to edGe-ucating as part-time members of their research teams.

The basis of my first two suggestions is that the current talents of those teaching in schools can help support expert researchers to edGe-ucate, and that that can be done successfully throughout the world. Teachers anywhere could choose to apply their educational attention to uncertainty to the specific needs of experts working at edges of fields of inquiry. Teachers could be included to help bring the work at the frontiers of expert knowledge to neophytes, and to help prepare these neophytes to assist in specific edge inquiries. Such teacher assistance would include being paid for the work, as teachers gain a foothold in the professionalism of edGe-ucating while continuing to hone their skills with students dealing with uncertainties in their classrooms.

As uncertainty becomes more recognized as educational work in schools, supported by both the educational and research professions, other teachers may wish to learn more about teaching their students through engaging with uncertainty. Over time, edGe-ucating may become a more basic feature of schooling, everywhere.

What has struck me over my 20 plus years of teaching teachers research are the answers I got when I ask the teachers if they have ever run into students who knew or understood more about what they were teaching than they did. Elementary school teachers often did, high-school teachers never. Working with

uncertainty can begin to break through some of the attitudinal barriers that exist between the different levels of schooling, as well as between schooling and higher education. Conflicts between research and teaching, uncertainty and certainty, may then become recognized as being integral within all educational intentions.

The desire to learn is not only a desire to know, it is also a desire to engage with the unknown, with what is not certain, with what is not known.

An additional potential advantage in respecting the large number of teachers already addressing unknowns is that most schools could become involved with edGe-ucating without drastic changes in personnel, mission, or structure. The primary adjustment needed for schools to support edGe-ucating is to recognize, support, and reward those classroom teachers who are currently engaging students with uncertainty. That support could leave open other needs for restructuring educational opportunities for the young, including revising student experience through developing new aims, missions, and curricula of schooling.

I conclude that there are essential features of what school teachers do now that can provide assistance in edGe-ucating large populations. If schools provided more recognition, encouragement and support for many of their teachers' current talents in introducing uncertainties into student learning, and allow those teachers space to assist research teams to edGe-ucate at the edges of expert knowledge, then edGe-ucating world-wide populations of citizens can be made more possible. In that way, schooling itself may become more consistently exciting for students, teachers, parents, and even expert inquirers.

placing edGe-ucating into science and inquiry

It will take the participation of scientists and inquirers from a range of disciplines for edGe-ucating to have a chance of succeeding. To bring the public to the edges of expert knowledge and encourage the extension of those edges, professional participation by nearly all scientists and other inquirers who work at the frontiers of expert fields of inquiry would need to be supported.

This may not be as daunting as it sounds. The primary action necessary for science and other inquiries to support edGe-ucating is to publicly communicate their edges, and that has long been a hallmark of the scientific tradition. Science began with scientists and other inquirers taking on a role in communicating the edges of their fields to the public. Many scientists and inquirers still are, and their numbers are continuing to grow.

In addition to communicating their edge-work, nearly all expert fields have been gaining new experience in and new understanding about how to tap the

potential of working in large, interdisciplinary teams of researchers. Many of the processes of post-modern research and inquiry performed at their respective frontiers have been accomplished through complex investigative teams. All fields of science and inquiry are becoming more comfortable and more effective in working at edges of uncertainty by enlisting complex backgrounds of other inquirers. Might that also include active minds from outsiders? Indeed: it already has.

For centuries, we have been blessed by creative, focused, bright, articulate, widely informed and successful researchers who have written books and given talks addressed to those untrained in their fields. Their purpose has been to provide a better understanding of what their professional uncertainties are, and what is going on as they continue to inquire into those uncertainties. A recent example is the book *Fundamentals*, subtitled, "Ten Keys to Reality," written by Frank Wilczek, a Nobel Prize winner in physics. Professor Wilczek takes his place in a long line of theoretical physicists who have communicated to a reading public about the unsolved questions of their times. Like Einstein, Oppenheimer, or Feynman before him, Wilczek has thoughtfully used his scientific and literary talents to digest the nature of current understandings of physics and related sciences while also focusing on explaining the nature of the unknowns at their frontiers.

Two messages are often expressed by those scientists and other inquirers who communicate the edges of their fields for neophytes. All express their extraordinary wonder in what they have found and are finding. The other message is their increased appreciation – and sometimes surprise – for how capable our human minds have been in building useful and increasingly more accurate understandings of natural wonders, understandings that go way beyond what we experience or sense individually. In addition to the "wow" of our universe and its ways of operating, their writings frequently express the "wow" of how our minds can imagine and work together to share that understanding to the point where new and ultimately more effective understandings can be constructed. Both of these exuberant "wows," they say, are why they write for the general public.

Wilczek for example, suggests that combining a scientist's wonder of nature with a deep respect for human intelligence demonstrates that a scientist's work is a spiritual quest as well as a scientific one. In his account, all scientific inquiries, past and present, lead the scientist not only to a deeper appreciation of the grandeur of the universe we inhabit, but also to a deep appreciation of the mind we humans have developed over eons, the very mind that allows us to recognize the reality of that grandeur and to engage with its mysteries, religious and other-

wise. Einstein said much the same. Most researchers and inquirers I read refer to a similar awe of the mind that emerges from the work at the frontiers of what is known, including the challenge to throw away their certainties as they proceed.

We are lucky that there are human beings, scientists and inquirers like Professor Wilczek, who take their time and energy to communicate their demanding and life-affirming inquiries to us untrained neophytes. What these scientists and inquirers seem to recognize is that there are many neophytes, of all ages and circumstances, who are capable of understanding the struggle with uncertainties at the frontiers of what is known. Scientists who write for the general public want to share that struggle and the occasional triumph of creative analysis with us. There are surely many additional inquirers working at the edges of their respective fields who would not only enjoy sharing their work, but be extremely good at it.

As I write here in Iceland, we have had more than a year with Covid 19, as all on this earth have had. In Iceland, however, Covid 19 has also been accompanied with thousands of earthquake tremors centered about 20 miles from Reykjavik, the capital city. The news over this time, broadcast several times a day, has been filled with questions of and possible answers from a variety of scientific experts on contagious diseases and on volcanic eruptions. And what is the primary message about these two natural phenomena that the scientific experts have given to all of us on this island? Uncertainty. Day after day, the experts repeatedly tell us that they do not know the answers to many of the important questions. Instead of answers, they share why they don't yet have them, along with what they do know, and discuss with us – the general public - what still needs to be done to know more. We public can and do deal with that, even as masks are worn and books fall off our shelves. All people can learn to accommodate and respect uncertainty, and expert inquirers and researchers can continue to become better at the art of describing what they do not know to the general public.

We all recognize, as well as experience, how current forms for communicating to the public have been expanding through information technology and its media. Writing is not the only way we receive information, as some have noted with dismay. Educators have known this fact, of course, even before writing was invented, and many have continued to work hard to find better ways to communicate through the technologies and strategies made available over the past few decades. Every scientist and inquirer now working at the edges of expert fields of inquiry can recognize that professional assistance is available from experienced communicators of complexity and uncertainty, some of whom will certainly be educators.

Although communicating to the public is not a new professional expectation for scientists and other inquirers, a new variety of increasingly available media strategies can now be applied to the task. Sharing the frontiers of one's inquiry through a variety of new communication tools and to ever greater public audiences could with time become an expectation for being a professional inquirer. That communication, admittedly, will still remain hard work.

One reason that communicating the edges of knowledge to the untrained public is hard work is that the languages used at most edges is so separate from our everyday languages. Those who do write well about their work at an edge are highly praised because the communication task, the translation of the languages used by expert inquirers to the languages of ordinary conversation, of metaphor and story, is never easy. Such communication represents an individual's strength at the edges of science and inquiry, but the challenge also points to a weakness in the profession. The challenges occur because the linguistic components of expert inquiry are so unique that they require additional professional skills in order to communicate outside the profession. Can the effort required to communicate the edges of their field be worth it for more scientists and inquirers?

Erwin Schrödinger, a Nobel prize-winning physicist who shaped the theoretical and physical features of quantum physics near its inception a century ago, consistently argued that every theoretical scientist needed to be able to explain their frontier-breaking concepts to non-experts. Schrödinger was the imaginer of the famous "dead-cat thought experiment" which explained to the non-physicist the fact that all possible states of a particle can simultaneously exist until it is observed. He repeatedly insisted that explaining the frontiers of science to the general public benefited science as much as it did the public. Along with other scientists and inquirers of his time, he emphasized the indebtedness of their breakthroughs to interactions with non-experts. Some of his colleagues based their arguments for communicating with the public on the need for social change; Schrödinger gave three technical reasons why a two-way interaction with the public was valuable not only to society, but to research at the frontiers of science and inquiry itself.

First, Schrödinger noted, such conversations often forced him as a researcher to reflect on his motivations for engaging in science, which brought up unexpected linkages in his mind. Second, a non-physicist's response to the scientific language he used often forced him to reconsider the thought underlying that language, leading again to a change of his tack to the problem. Finally, he pointed out that science at the edges required much more than technical expertise; espe-

cially at its frontiers, science was a subjective experience of discovery that can be stimulated by struggling with the unexpected variety of everyday curiosity.

That was nearly 100 years ago, in a Europe steeped in anti-Semitism that nevertheless pretended to honor objectivity. As far as I know, few scientists and inquirers since then have echoed this respectful approach to two-way communication at the frontiers of what is known between experts with non-expert neophytes. Nevertheless, as we have seen, there have over the past decades been many new approaches to inviting non-experts to contribute their creativity and outsider knowledge to solve specific problems at the edges of a field. A recent example is through gaming. We can only imagine how excited past scientists would be today with our current information access, transfer, delivery, and connectivity. Actually, we do not need to imagine; we can look to those who have begun to work out ways to "harvest distributed intellect," as Daren Brabham said in 2008 about an additional technique, called "crowd sourcing."

"Crowd sourcing" is applying information technology to invite a variety of people outside of the research to self-select and work on a given intellectual challenge. One example of crowd sourcing that was used successfully to break through a frontier of knowledge was a study of brain functioning by over 200 neurological scientists around the world who undertook the imaging of 21,000 human brains and accompanying genes. (The large sample was required because of the variance of brain size and specialized brain regions between individuals.) The response to this study from other researchers was an extreme appreciation for what had been accomplished. "What was really new here," said one who worked on this crowd-resourcing brain research, "is it gives us a power we have never had." Dr. Paul Thompson, one of the leaders of the study said, "It means sharing your data, pooling everything, and this is not usually how scientists work." Although the immediate reference here is to intellectual property, it is also suggestive of the potential of crowd sourcing to include neophytes in inquiry at the edges of expert knowledge.

Earlier approaches to stimulating new thought and connections at the edges of inquiry have included strategies to promote unplanned interactions between researchers in one expert field with researchers in a different field. Bell Labs, one of the most innovative scientific organizations in the U.S. from the 1920s to 1980s, encouraged informal interaction across specialities that helped create new fields such as digital communication, communications satellites, cellular telephone systems, and the silicon solar cell. The significance of the potential for unplanned interaction is further indicated by a recent Harvard medical study that showed

that the best research studies (defined by subsequent citations) were performed "when scientists were working within ten meters from each other." Most scientists may interpret this as expert-to-expert interaction (as some institutions have tried with little success). I suggest that it may instead be a more general combination of mutual respect for those working in contexts of uncertainty with the potential for wider questions being asked, heard, and examined – a respect that can be directed to all, not just to other researchers.

Disciplines which have applied similar approaches to unplanned interactions are the MIT Linguistic department in the 1950s (that included Noam Chomsky) and the Pixar animated movie company that placed meeting rooms, coffee bars and bathrooms in the same atrium. These experiences in expanding inter-communication between differing expertise, perspective, background and daily work have been shown to be directly related to increased diversity of innovation and thought. Current successes of inter-communication between differing forms of expertise, perspectives, and backgrounds also suggest that the potential power of inter-communication between expert inquirers with neophytes may be possible throughout the world.

Many current researchers and inquirers have learned how to do their work more successfully at the edges of what they know with a variety of other minds that come from differing professional and experiential backgrounds. In the past few decades, that inclusion has begun to include gender. The fundamental feature required for such intercommunication is mutual intellectual respect, often built around appreciation and admiration for those who work well with uncertainty.

What I am proposing is that all scientific and other inquiry fields recognize that most human beings, of all ages and backgrounds, have strengths in working at the edges of the known, of dealing with uncertainty. Although many may not have been prepared to apply these talents through their education, they have had to do so in a variety of other aspects of their lives, some more than others. An absence of respect for the public's intellectual capacity to work with uncertainty is primarily an attitude rather than a rational or fact-based decision: more a habit or an emotional fear than a considered viewpoint. But a perspective drawn from years of a formal education that emphasized what was certain does not reflect the reality of what most humans can perform well, and can learn to perform even better. Linked to that reality is the fact that there is much untapped potential in the talents gained by teachers and other educational professionals throughout

the world who have worked with engaging a variety of minds with uncertainty, both children and adults, often those with minimal formal education.

Perhaps edGe-ucating could be encouraged if a new form of professional recognition were created for all fields of inquiry. What would happen, for example, if a Nobel-type prize were awarded to recognize significant work of teams in the sciences and other inquiry professions that have included neophytes in their development of new understandings? Such an international prize could publicly identify, honor, and reward those who have worked to edGe-ucate as they have engaged in their significant discovery. It would also highlight edGe-ucating as another human intellectual achievement of life-enhancing work, a valuable success achieved by the inquirers, including the neophyte inquirers, by the particular inquiry profession rewarded, and by our shared human nature.

In summary, there is no need, whether in the sciences or other fields of inquiry, to insist that engaging with an untrained public can only be accomplished through an informing or top-down role. There are currently a variety of effective strategies for engaging neophytes in the processes of inquiry, and prospects for eliciting and inventing many more. The effectiveness of current strategies demonstrates that non-experts can be successfully engaged in investigating at edges of expert inquiry. Furthermore, additional educational assistance is almost universally available for help in preparing neophytes to engage with professional uncertainties through a range of recently developed means for interactive communication.

In the following section I will suggest a research study that may help illuminate the extent of our shared human intellectual capacity to engage with expert uncertainty and to assist with inquiries aimed at extending expert understanding.

proposing a study of the mind

Having once made a living by writing research proposals, I know that a proposal is seldom accepted when it initiates the proposed research idea. (At least in education.) But I am not asking for funding. Rather, I am asking for a consideration of a study to investigate the human potential to work and play with intellectual challenges that stump experts in their fields of inquiry. The aim of this proposed study is to improve neurological understandings of the human mind when it is addressing expert unknowns. In addition, the study may demonstrate how neurological research could be applied to edGe-ucating and how, in turn, edGe-ucating could be applied to neurological research.

I start with the idea that a neurological research study on how our human minds process uncertainty could begin to explain why the ordinary human brain is likely capable of dealing with edges of expert knowledge. It could begin to explain how the experiences reported by me and others about neophytes successfully performing at the edges of expert knowledge might be made to occur more generally.

It is of course possible that the results of this research study may instead suggest a different conclusion. For example, even if neophytes may seem to understand what is being done by experts at the edges of what is known, perhaps their responses to uncertainty will suggest that they could not be expected to contribute towards extending those edges.

Like all research proposals, my proposal needs to identify significant issues related to the question raised in this study. One issue is how little is known about the intellectual potential of' those around the world, including those who have had little formal education. As noted above, the engineer David Cavallo concluded from his work in villages of Thailand and, later, in cities of Brazil:

> The latent learning potential of the world population has been grossly underestimated as a result of prevailing mind-sets that limit the design of interventions.

There are two parts to Cavallo's claim that will be addressed in this proposed study. First, the proposal responds to "the latent learning potential of the world population" by focusing on what brain processes are used by ordinary individuals around the world when trying to understand and work with situations of expert intellectual uncertainty. For this study, "ordinary individuals" would need to include individuals from a variety of differing world populations, including differing cultural environments, economic circumstances, educational experiences, and linguistic backgrounds. I suggest that performing the research in five cultural settings of the world may begin to provide wider understandings of the capabilities of the human mind as it performs at expert edges of uncertainty.

The second part of Cavallo's claim is that there is little acknowledgment of this latent learning potential "as a result of prevailing mind-sets." That claim is a serious one, and will be addressed directly in this study by applying a process of inquiry that will include edGe-ucating. Local problem solvers, teachers, and other educators will be invited and guided to advise and participate with the

study teams according to a process that will be described in more detail later in this proposal.

A neophyte like me proposing a neurological research study may appear foolish, but it may also prove fruitful. I have found it fascinating, for example, that understanding how our minds deal with uncertainty has recently been of considerable interest in neurological research as it is to edGe-ucating. Feeding this neurological interest is the discovery that the brain's response to uncertainty is closely related to how the brain and body respond to stress. Research has shown that the hippocampus of the brain can interpret an uncertainty as a danger that requires immediate attention, stimulating an increase of dopamine for an anticipated need to focus, decide, and act. Some neurological studies show that this kind of automatic response to uncertainty can be accompanied by fear and a corresponding lack of decision making and action. Other studies show that, as uncertainty increases attention and focus, it can also increase learning, memory, and creative choice of action.

The difference between the results of these neurological studies primarily depends on their definitions of uncertainty, or more precisely, in what feature of uncertainty a study undertakes to understand better. Studies that focus on the dangers of the uncertainty being met highlight the perceived potential of risk. The stress can be experienced as existential, originating in the hippocampus, as for example when deciding whether the snake in front of you is poisonous or not. These neurological studies focus on how the mind deals with the probability of a potentially dangerous outcome, and the mind/body stress that occurs in making a decision to act.

One recent neurological study on uncertainty and the brain by a Tel Aviv team of researchers had individuals play a game by deciding when to pick up rocks which may hide poisonous snakes. It required individuals to make quick choices to pick up a rock - or not - and getting a shock when there was a snake underneath. One conclusion from this study was that the brain responds more intensely to failure than to success (a result shown in other studies as well), and especially to failures produced by the individual's choice. One interpretation from this and similar studies is that, as failures related to uncertainty accumulate over time, they can lead to an excessive avoidance of uncertainty, which is a damaging psychological condition.

Other neurological studies focus on intellectual uncertainties, not on potential dangers but on what was previously known; for example, where the mind can compute the probability of what may happen if an action is taken. When

neurological studies focus on the mind's interest in predictive uncertainties, the results have been provocative about the mind's attention to certainty and uncertainty. The more the outcome of a situation seems to be nearly certain, positive or negative, the less attention a situation is given. However, the more the outcome of a situation seems uncertain - maybe positive, maybe negative - the more attention is given to the situation, with the pre-frontal cortex becoming stimulated to be more involved in analysis, decisionmaking, and action. "We only learn when there is uncertainty," Daeyol Lee, Yale professor of neurology, concludes from these studies.

It is not our certainty that promotes the brain to learn, but rather the volatility of the environment. "The adaptation of learning and decision-making," Dr. Lee goes on, "might depend on regulation of activity in the pre-frontal cortex." The learning brain can decide to learn – or not – based upon the degree of uncertainty being confronted.

Both of these kinds of studies may contain information important to edGe-ucating. Studies focused on uncertainty as a danger may suggest to educators that neophytes working at the edges of expert knowledge pose a danger to educational practice. Studies focusing on the interest created in the brain by the uncertainty of possible outcomes, however, may alternatively begin to explain what could happen when an untrained human mind meets and works with an expert edge of the unknown.

One reason why my neophyte status may be important rather than a hindrance to the design of a study on the mind is that, up to now, little of the research on the brain has shed light on educational practice. Years ago, I used to attend a variety of presentations on brain research at educational conferences, but found little that spoke directly to educational practice or to educational thought. In fact, most of the presentations that I heard on brain research at that time started with a disclaimer that: "There is nothing here for educational practice." That was in the last century when neurological studies were beginning to show where specific intellectual actions took place in the brain, like where music is processed, and the paths that could connect from there to a variety of other areas, such as from music to emotions and memory. Reading was another brain activity that was being shown to be a very complex activity, one that occurs in many different specific areas of the brain and then connects to many other areas. As an educator, I will note that, although reading is one of the more complex tasks accomplished by humans, it has been proven through centuries of practice that nearly all human brains can learn to read – and to speak more than one language.

Last century, when I was listening to neurological research at educational conferences, I thought that what the researchers were really telling us educators was that there were no educational questions that interested them, or their funders, other than where certain actions like memory, language, creativity, and reading occurred.

Fortunately, that view is now being proven wrong.

In preparing this proposal, I have found that two significant limitations of early neurological research on brain activity are now being addressed. Both former limitations have been due to the equipment used to measure brain activity. Functional magnetic resonance imaging (fMRI) is done by an instrument that can take images of immediate actions in specific areas of the brain by locating, imaging, and measuring the blood flow of a functioning brain. It is a machine that requires one enter by lying down, head going in first, head encased and body necessarily at rest. Interaction with anything but a voice through earphones is difficult. Thus, one limitation was that there was little an fMRI could do to capture complex interactive processes such as educating or even talking face to face. Previous studies on certainty and uncertainty in humans using fMRI studies have had to depend on a brain's responses to external interventions like electrical shocks. The second traditional limitation to fMRI research studies was the inability to study brain activity over time. The information technology used to capture and interpret the information supplied during an fMRI required the capture to be of an immediate action within the brain, actions that lasted for considerably less than a second. Recording a brain's activity over time – for example in a discussion – required more storage and interpretive capacity than information technology could then supply.

In addressing these two technological limitations, recent neurological research has begun to produce much more information about the actions of our minds in more natural settings, and over time. That means that a proposed study on the actions of the human mind as it deals with expert uncertainties may be more possible than ever before.

A recent neurological study has applied both advances by using a cap with sensors, rather than requiring subjects to crawl into a machine. and a technology that is capable of reading from a cap on each of two heads simultaneously and over real time. Below I describe this neurological study of two minds interacting because it begins to suggest how my proposed research study could apply both technological advances in order to provide new evidence of what happens when brains engage together with the edges of what is known.

Using a cap with sensors to measure brain activity by applying functional near-infrared spectroscopy, this particular study monitored the brain activity of two interacting humans. One human was an infant (that is, pre-verbal) and the other was an adult. Each wore a sensor cap as they played with toys, sang songs, and read a book together. Each cap could collect and send information in real time from 57 channels of the brain that are involved in predicting future events; in language processing; and in understanding the perspectives of others. These particular brain activities of both infant and adult were able to be monitored and recorded simultaneously over time as they interacted and communicated with each other.

The study was performed by an integrated team of Princeton University researchers from the university's Neuroscience Institute and the Baby Lab. The findings from their research were new to the neurologists and fascinating to the research psychologists. One great surprise was in the brain activities of the twenty-one pre-speech infants, 9 to 16 months old, who participated in the study. During the face-to-face sessions, it was found that several areas in the baby's brain involved in high-level understanding were synchronized with the same areas in the adult's brain. The strongest coupling, for example, occurred in the prefrontal cortex, which is involved in learning, planning and executive functioning. This area was previously thought to be quite underdeveloped during infancy, but the study suggested otherwise. In addition, added Dr. Casey Lew-Williams, the director of the Princeton Baby Lab and a co-author of the published paper, "We were also surprised to find that the infant brain was often 'leading' the adult brain by a few seconds, suggesting that babies do not just passively receive input but may guide adults toward the next thing they're going to focus on: which toy to pick up, which words to say."

The brain activity recorded from the infant and adult suggested that their communication seemed to form a feedback loop. The adult's brain seemed to predict when the infants would smile; the infants' brains seemed to anticipate when the adult would use more baby talk. Both brains tracked eye contact and attention to toys. When playing together, their brains influenced each other in dynamic ways. This interactive process is called "neural synchrony," a term used in neurological research. Dr. Elise Piazza, the first author of the study and an associate research scholar in the Neuroscience Institute, noted that this study was the first to show how early "neural synchrony" was displayed in the minds of infants.

My proposed study on how we humans process challenges at the edges of expert knowledge could apply a similar dual-brain neuro-imaging system. For ex-

ample, this proposed study could record at least three types of dual brain-pairing activities: 1) between expert and expert as they address a problem of an unknown, 2) between a trained neophyte and an expert addressing the same problem, and 3) between two trained neophytes addressing the problem. Comparisons of the brain activities between these differing coupled pairings may begin to provide some insight into how individuals with differing backgrounds of expert information interact and address a specific uncertainty in an expert field of inquiry. There are, of course, other interesting pairings. The kind of questions that may be addressed by this general approach could include some of the following.

How do we humans use the knowledge we have to create new understandings together?

How do experts talk about the uncertainties in their field with those who are not experienced in the anticipated related concepts?

How do the newly trained try to discuss edges of inquiry fields with an expert?

Does the process of interaction between expert and newly trained neophyte create new potential paths of connection within both brains?

What are the connections being made by newly trained neophytes as they are trained by experts, as they engage with experts in problem-solving at an edge in the field, and as they engage with each other to solve the problem? How do these processes of engagement differ?

Do the connections being made by experts in the field change depending upon whether they are talking with another expert or with a trained neophyte?

Are there suggestions to be gleaned from this study about a possible role for neophyte minds when looking for help to solve a problem at the edge of a field of inquiry?

What are the interesting neurological results about the actions neophyte minds take when analyzing and discussing the edges of knowledge with knowledgeable experts?

All these questions would require advice from expert neuroscientists before this proposal could be more than imaginary. For now, my sketchy research design draws primarily on my own interests in the role of the human mind in edGe-ucating. Without a doubt, it requires more discourse with neurological scientists about issues of design, as well as the focus of the neurological questions. In addition, advice from scientists in a particular expert inquiry field would be required, for example in theoretical physics. The advice would focus on an edge in that field that could be the aim for the training of neophytes, and for the nature

of the discussions of field experts with the trained neophytes as they consider looking into possible strategies for resolving the unsolved issue.

Even as I consider the limitations of this study as proposed, I get excited by the possibilities for improving our understandings of the human mind when meeting expert uncertainty.

For example, I suspect that recent technical advances that can be used to study the processes of the brain will be expanded. That could mean the capacity for recording brain activity can soon be capable of recording more than two interacting individuals, and new "caps" will be designed to be less restrictive while also being capable of reading more varied and focused areas within an active brain. Technical advances like these would help promote a greater range of questions to be addressed by those investigating how our brains operate with and learn through uncertainty. And the research could be performed in settings closer to educational settings.

One neurological researcher who seems to be pursuing new technological approaches to studying the active brain is Dr. Uri Hasson, a professor, cognitive neuroscientist, and psychologist at Princeton University. He was also one of the authors of the research study on infant and adult interaction described above.

Dr. Hasson has been focused on studying the underlying neural processes that allow the brain to integrate information over time as well as the processes that facilitate human communication. His research has been conducted under ever more natural conditions, over increasingly longer lengths of time, as subjects have engaged in more complex tasks. In describing his approach to neurological research, he says, "We're starting from the complexity and messiness of real life and slowly trying to strip away some of the dimensions." By contrast, most neurological research, as he points out, begins from controlled situations, then to increasingly complex ones. In addition to working with teams that study how the brain accumulates and integrates information over periods of time, Hasson also conducts research focused on human social interactions, another complex set of brain activities that are difficult to examine under a controlled laboratory setting.

Most significant to my proposed study are Hasson's references to how two minds communicate. With regard to the categorization of speaking and listening as two different brain functions, Hasson referred to analyses that identified a subset of brain regions in which the activity in the listener's brain often preceded the activity in the speaker's brain, thus suggesting that the listeners were actively predicting the speaker's upcoming utterances. This suggested that the ability to predict speech may also be tied to how well people understand each other, Has-

son said. "The stronger the coupling between the speaker and the listener's brain responses, the better the understanding," he added. "Sometimes when you speak with someone, you get the feeling that you cannot get through to them, and other times you know that you click. When you really understand each other, your brains become more similar in responses over time."

My proposed study is to see to what extent this "clicking" may hold when expert researchers describe the edges of their research to a neophyte.

Just as significant to my proposed study is that Hasson is beginning to make it possible for others, less trained than he, to do their own studies. Hasson's interests, focus, and research creativity not only inform us about processes of the mind in human-to-human interactions; he is also sharing his research processes with those who have considerably less experience in research or in neurology. In fact, Dr. Hasson has been teaching a course that encourages undergraduate students to do their own neurological research studies using the fMRI machines. Through this course, Hasson is demonstrating how research on the mind can be opened up to lesser trained neophytes. His introductory course covers expert areas including brain physiology, experimental design, and imaging physics and analysis, so that near-neophyte undergraduates can understand the foundations of fMRI before they design and perform their own research studies.

One question I raise here for Dr. Hasson and for researchers in all fields of inquiry is whether he, and they, could be doing something similar with citizens of the world. Beyond Princeton students are many who may be interested in, and capable of, inquiring into the intellectual processes used within the human mind. That could include educators to apply the new research approaches developed by Dr. Hasson and others that can illuminate the inter-human processes used to edGe-ucate and to build new knowledge, as well as illuminating the processes used to educate and inform.

In summary, this incomplete outline of a proposed study is designed to address two areas in brain research that need considerably more attention if we are to understand edGe-ucating as a set of intellectual processes capable of being performed by nearly all human minds. First, this study will use the most current non-invasive technologies for measuring and recording brain activity, making it more possible to study the brains of individuals engaged in group-oriented intellectual activity. The aim will be to see how differing regions of the brain are activated as expert uncertainties are engaged through varied interactions between experts and neophytes. This primary aim seems closely related to other themes of cognitive research.

A second aim of this research study has been missing from current brain research, and it is even more essential than scientific equipment or research technique. That second area is to include others who are not neuroscientists, such as teachers and other educators, as well as untrained public, in asking the questions and in raising new possible interpretations in understanding what the evidence means for humans to be certain or uncertain. The inclusion of non-experts in brain research would be accomplished by bringing them up to specific edges of the research and then inviting them to participate in dealing with the unknowns, asking new questions and offering new possible causes and effects and interconnections. The expectation is that including neophytes in the research may enrich this study, both in terms of the diversity of the investigation and in the possible explanations given, including the linkages being made to potential educational actions. What I am proposing is a study that applies edGe-ucating within its choice of a team that performs the inquiry.

An important cautionary note to the multiple studies that make up this proposed research is that they be done in a variety of distinct cultural settings with as great a variety of ages, races, cultural settings, social standings, genders, religions, spiritual orientations, work experiences, and family arrangements as can be realistic for an initial study. What is important to realize is that the more identifiable are the possible features that may affect the nature of the brain's activity in addressing uncertainty, the more illuminating the initial results may be.

Managing this proposed research composed of five connected studies, each with a variety of expert and neophyte participation, would be retained by the organizations that normally support neuroscientific investigation. The costs could also be taken up by professional organizations and government agencies that sponsor educational research, including those that support international inquiries. Additional private funders could also be important to the funding of the cost of managing, aggregating, and communicating the process and results of this research that applies an edGe-ucational approach to research. This could include potential funders who are looking to support the attempt to gain deeper understandings of the world's human intellectual potential, as well as how to respond to engaging this potential through educating, edGe-ucating, or other forms of intervention, guidance, and communication.

As uncertain as the outcome of such a research study may be, we would have more questions asked and potentially answered about uncertainty and education – and about the nature of human intellectual innovation, learning, and problem solving – than we currently have. Importantly, these new questions and

understandings would be dependent on specific neurological study from varied world locations.

In addition, by applying edGe-ucating in the investigative process, there would be a greater influx of educational imagination, experience, and thought into understanding of the roles of uncertainty in the brain. Education would be served through new information on human intellectual capacities, more than a little of which may have already been suggested, promoted, entertained and considered by educators.

Finally, there could also be a variety of new questions raised about human engagement with uncertainty from research perspectives such as those of anthropologists, sociologists, palaeontologists, biologists, historians, economists, gamblers, and philosophers, as a short sample of additional expert perspectives. Each expert field of inquiry could conduct their own research into understanding better the nature of human engagement with expert uncertainty. Each research team could include their own sub-group of assisting educators and neophytes. The intent for collecting this group of varied studies would be to see to what extent the uniqueness of each perspective could be compared and contrasted in order to provide a deeper, fuller, and richer understanding of human intellectual engagement at the edges of the known.

As Dr. Hasson has said about research on the mind, "Understanding the brain is a communal effort."

a new becoming

The most important lesson about edGe-ucating that I have received occurred to me while I was preparing my research proposal above. But it was not focused on the potential of neurological research and its new research strategies. Instead, it was news that a new context for edGe-ucating has been applied within an institution of higher education – applying a strategy that could be appropriated to all levels of education. This new stage for becoming edGe-ucated is being developed by university students, graduate and undergraduate, who are studying in a variety of inquiry fields (but not, so far, education). Each of these students has decided on their own to communicate to the untrained how they met edges of their respective fields of inquiry and then how they each tried to resolve or extend that edge. They each decided to edGe-ucate on their own, and support each other, because they thought that was possible. Nothing I have said or wrote played a role here. And, perhaps appropriately, the students happen to be doing that work where my initial stories began, at Princeton University.

I found this new beginning for edGe-ucating in a half page article in the Princeton Alumni weekly, which I had chanced to pick up from a pile of magazines in my small living room as I was writing this final chapter. The article reported how, in April, 2020, Addie Minerva, then a second-year doctoral student in the Princeton Neurological Institute, reflected upon an assignment she was given to write a short review of her research study in a style that would be scientifically accurate but appeal to a wide audience of those who had no training in her field. After completing the assignment, she began talking to her friends who were studying in other research fields, and she realized that she knew nothing about what they were doing for their research. She is quoted as saying to herself, "Hey, this would be a really cool opportunity to share ideas and research that's going on throughout departments."

Within a year, Ms. Minerva had encouraged 50 writers to publish 28 reviews of current ongoing research from 9 different departments, including biology, economics, neuroscience, physics, and sociology. The reviews of their research are contained in an online publication, Princeton Insights, available at insights.princeton.edu. At first, the purpose was to present research to the Princeton research community. "But," Ms. Minerva said in the article, "we've grown beyond that, hoping to expand within Princeton and to the broader public." This on-going description of research studies being performed at the edges of a variety of inquiry fields is growing and continues to be run by students who have also created a podcast, "The Highlights."

There can be no better way for me to end my stories about edGe-ucating than to refer to current university students, undergrad as well as graduate students, who are carrying edGe-ucating further – originating not from me, but from the place of advanced inquiry where my stories had started. When I was there, over 60 years ago, I had no idea where my stories would go, and certainly not where they would end. But I tend to think that Ms. Minerva and her colleagues may know more about their possible futures than I did then, as they consider the potential in the experience they are gaining. What is significant to me is that they each have decided to engage in the challenge of communicating their research to the untrained within the early stages of their becoming an expert in their respective inquiry-oriented fields.

They are not calling what they are doing "edGe-ucating," but they are showing that they realize that the frontiers of knowledge they have met, and are actively engaging to expand, may be understood and appreciated by nearly anyone. More important, they are taking the time necessary to communicate – to edGe-ucate

and to expand their engagement with those edges with untrained others. They are doing this not because this task is required, but because the task is important to their own sense of curiosity to see how it can be done. Furthermore, it shows a respect for the human potential of engaging in professional inquiry, along with their personal belief that intercommunication can meaningfully occur between expert and non-expert.

On their own, regardless of whether the students' current research advisor and potential employers may have wanted them to do so, they have begun to edGe-ucate at a reputable institution of higher education. As these students continue their intent to communicate their edge-work to all, it may not be long before many of them will see the educational, social, and scientific potential for edGe-ucating all ages in all settings. Perhaps they have already noticed that what they have done is invite every expert inquirer to edGe-ucate from the frontiers of intellectual inquiry – and for social, existential, educational, and professional purposes beyond the scope of their inquiries.

The Princeton students are not proposing that readers become engaged in their research. Not yet, or not as far as I know. But they all are beginning to have a working knowledge about what it means to inquire at edges of expert knowledge in a variety of inquiry fields, and to communicate to each other and to the public about what that work is. That is a wonderful start to becoming an expert inquirer, as well as an edGe-ucator.

As Ms. Minerva and her colleagues continue to talk to each other while communicating their research to neophytes, some may also begin to realize how valuable and exciting it could be if they were to include interested untrained others to work with them in their research activities – and perhaps, even, inviting educators to do so.

If that happens, then unintended and before they know it, they may be changing the educational assumptions for engaging in expert unknowns. In fact, they may not only be changing these educational assumptions at Princeton University, and not only in higher education in general, but in all institutions of learning throughout the world.

So, my stories around edGe-ucating end, as all educational stories do, with only uncertainty about what may happen next as these Princeton students, and possibly others, become further edGe-ucated through their individual and group efforts. We all may have a stake in how their stories of edGe-ucating continue to develop.

Appendix

Notes to Chapters 8 through 11

These notes start with chapter eight because that is where I begin to discuss more of my research on edGe-ucating and make direct reference to others' work that I consider related to edGeucating. The sources I have used are listed page by page, within chapter and subheading. My intent for the following notes is that they may provide both the sources I used as well as offer additional sources for reflection by newcomers to inquiry along with expert inquirers from many different fields. It is a style that is suggested by a primary theme of the text: that it be open to, and encourage, any reader who may want to consider the potential of edGe-ucating, including to critique and go beyond what I have done in this area.

Eight edGe-ucating begins to be a possibility

moving beyond education

157–158 As for my old educational manuscripts mentioned here, I have my 165-page report, titled, "Why the work of teaching, teacher education and educational research must be redistributed," commissioned by the National Institute of Education, (NIE), Washington D.C., dated January, 1984. The Heart of Education, written in the early 1980's, remains only in notes that refer to the manuscript, along with the 1984 NIE report that applies much of its focus. I have not found the Beyond Education manuscript, although it is described, numbered, and provided in my documentation for professorship in 1996.

158 I have the publishers' proposal for The Third Mind of Education, including three chapters (totaling 55 pages), and the prospectus, table of contents, descriptions of the remaining chapters, and potential resources.

meeting examples of edGe-ucating

161 Along with my talk with John Jungck, my description of BioQuest was from BioQUEST notes. Volume 3, number 2 (1993), The BioQUEST Curriculum Consortium. Beloit Wisconsin: Beloit College. One reference to John R. Jungck is from "Ignorance, error, and chaos: Local learning/global research." *Journal of Contemporary Philosophy or Modern*

Thought, 24(11), 363-376 (1996). There are many more references to Bio-Quest on the Internet.

162 The newspaper article describing the high school students who went to work in Russia with top microbiologists was written by M. Specter in the *New York Times*, July 25, 1994.

162 The article on the Luo women teaching the U.S. Military how better to carry heavy loads was in the May 30, 1995, *New York Times*.

David Cavallo

163–166 The primary source I used to describe the work of David Cavallo in Nong Baot, rural Thailand, was his 2000 article, "Emergent design and learning environments: Building on indigenous knowledge." *IBM Systems Journal*, 39(3/4), 768–782. The quote on page 163 came from that article, page 769, the quote on page 165 was from page 782. There are many additional sources for Cavallo's later works in Brazil and elsewhere.

166 neophytes working at the edges of the known

167 Recent searches for "edGe-ucating" can bring up a variety of entries, depending on the search engine one uses, and also whether it is given as a verb or as a noun, or from what country. Educational consultants seem to prefer the noun, "edge-ucation" in some form. Sites in England include a variety of differing contexts, including the Duke of Edinburgh's Award (DofE) for the achievement of personal skills. One American site has copyrighted edgeucation.com. The verbal term, "edge-ucating," has become more popular now than it was in the mid-1990's when I began applying it, but not in the context or purpose that I am using the term.

167 Examples always help; as the philosopher, John Wisdom wrote, "Principles and laws may serve well. They can help us to bring to bear on what is now in question. They help us to connect one thing with another and another. But at the bar of reason, always the final appeal is to cases." John Wisdom, Paradox and Discovery, Philosophical Library, New York, 1965, p. 102.

167–168 Both *New York Times* articles on Gunter Wachterhauser were written by Nicolas Wade. The first, April 22, 1997, the second, August 25, 2000.

168 Geerat Vermeij's memoir, *Privileged Hands*, was reviewed by Carol Kaesuk Yoon in the *New York Times*, February 7, 1995. In that article, palaeontologist Dr. Stephen Jay Gould, describes Dr. Vermeij as having "an

uncanny way of perceiving correlations between shell forms and environment. He's noticed things that other molluscan biologists never did, even the most minor changes in the shapes of shells."

168 John Hornor's book, *Dinosaur Lives: Unearthing an Evolutionary Saga*, was reviewed by paleontologist Philip Gingerich in the *New York Times*, October 12, 1997, titled "Beyond Jurassic Park."

169 Soo Yeun Kim and her friends are described and quoted in a *New York Times* article by Barbara Stewart, January 14, 1995. The title was, "After a teenager's death, her friends fulfill her dream."

169 LeAlan Jones and Lloyd Newman are described in a *Chicago Tribune* article, June 1, 1997. Their book, written with David Isay, is titled, *Our America: Life and Death on the South Side of Chicago*.

170 Rachana Gupta and her parents are described in a *Chicago Tribune* article by Glenn Glaslin, 1994.

170 Matt Roloff is described in a *New York Times* article written by Timothy Egan, September 30, 1999.

170 Natalia Toro was described in a *New York Times* article written by William Honan, March 9, 1999.

171 Information about the age, gender and experiences of the 1992 Mars Expedition is written by John Winford in a *New York Times* article, July 14, 1997.

171 Henrietta Swan Leavitt is described in detail by George Johnson in his book, *Miss Leavitt's stars: The untold story of the woman who discovered how to measure the universe*. New York: Atlas Books, W. W. Norton & Company (2005).

172 Galaxy Zoo can be reached through a number of sites at galaxyzoo.org that describe the project and provide information on how one can join.

172 An extensive description of the inventions and character of Hedy Lamarr can be found in the book by Richard Rhodes titled, *Hedy's Folly: The life and breakthrough inventions of Hedy Lamarr, the most beautiful woman in the world*. New York: Doubleday (2011).

173 The program for Italian students to live and work with scientists at the Italian Institute of Nuclear Fission in Frascati, Italy is described by Centioni, R. (2010) in Laboratories on stage: Physics education programs, a presentation at the International Conference on Science in Society, November 13, 2010. (Laborator Nazionali di Frascati dell'Istituto Nazionale de Fisica Nucleare).

173 The change in the number of students enrolling in and passing the advanced placement courses in Stevenson High School was reported in a 1998 article in the *Chicago Tribune* by Jeffrey Bils. It included a quote from the principal, Dan Galloway, "The concern is that if you allow more students in, your scores will go down, your percentage of honor grades will go down, and that will reflect poorly on you. In some schools there's an elitist attitude that advanced-placement courses are only for advanced placement students. We don't subscribe to that philosophy."

communicating the frontiers of inquiry to everyone

174 Feyerabend, P. (1975). *Against method*. London: New Left Books.

174 Serres, M. [with B. Latour] (1995). *Conversations on science, culture, and time*. (R. Lapidus, Trans.) Ann Arbor, Michigan: The University of Michigan Press.

174–175 Strafford, B. M. (1994). *Artful science: Enlightenment entertainment and the eclipse of visual education*. Cambridge, Massachusetts: MIT Press.

175 Brockman, J. (1995). *The third culture: Beyond the scientific revolution*. New York: NY: Simon and Schuster.

176 Brockman, J. (2008). The new humanists. In J. Brockman (Ed.) *Science at the edge: Conversations with the leading scientific thinkers of today* (pp. 11–18). New York: Sterling Publishing Co.

Nine attempting to integrate edGe-ucating with educating

when the edges of science lost to educating

178 Bruner, J. (1960). *The process of education.* Cambridge, MA: Harvard University Press.

178 Dow, P. (1997). *Sputnik revisited: Historical perspectives on science reform*. Staff seminar presented at the National Science Foundation, Washington, D.C., February 26, 1997. In that paper, Dow quotes Zacharias as he discusses the great error of Bruner and education in general to focus on process and structure in the conduct of science, including: "Scientists are usually having their greatest sport when the structure is fuzzy, ambiguous, inadequate, or possibly just plain wrong."

a manuscript on edGe-ucating for educators

179 In 1995, I presented two papers referring to education at the edges of

knowledge. The first was, "Turbulence at the edges, sharing our boundary conditions of knowing and being," presented at the 1995 JCT Conference, Monteagle, Tennessee. The second was, "On the nature, processes, and challenges of education at the boundaries of what we know," presented at the 1995 American Educational Research Association Meeting (AERA), San Francisco.

179 The word, "edGe-ucating," was first used by me in a presentation paper delivered in 2003 to the American Association for the Advancement of Curriculum Studies (AAACS) meeting in Chicago, titled "Creating a democracy of knowledge production by eDge-U-cating."

179–184 Specific references within my unpublished manuscript on edGe-ucating will not be provided in these end-notes. The point of my brief review is to show what I was reading and thinking about during these times as I considered the role of education at the frontiers of expert knowledge.

Brad Greenspan, edGe-ucating in high school

183–192 I first met Brad in 2004, and he completed his dissertation in April, 2008. I am not including my references to his doctoral dissertation within these end-notes because much of what I am writing here is how I remember his work and our discussions. They are not direct quotes from his dissertation. Instead, I hope this brief introduction to his work is an invitation for you to read it. Brad Greenspan's doctoral dissertation is titled, "The Challenge of EdGe-ucating: Narratives of Knowledge and the Making of Breakthroughs in the Classroom." It is a wonderful read for its insight into both edGe-ucating and educating, especially from the teachers' viewpoints and experiences, and it can be accessed from the National Louis University library.

kids and bees

193 The reference to the published article by the second graders is: Blackawton Primary School et al. (2010). Blackawton bees. *Biology Letters*, published online 22 December, 2010. It was retrieved by me on March 11, 2013. http://rsbl.royalsocietypublishing.org/content/suppl/2010/12/21/rsbl.2010.1056.DC1.html

193–194 Yong, Edmond (2010, December 21). Eight-year-old children publish bee study in Royal Society Journal. Not exactly rocket science. Retrieved 10 May 2013 from http://blogs.discovermagazine.com/notrock-

etscience/2010/12/21/eight-year-old-childrenpublish-bee-study-in-royal-society-journal/#.UgAv6m1BKmA Edmund Soon-Weng Yong is a science journalist. Early in his career, Yong created and wrote the now-defunct blog, Not Exactly Rocket Science, published as part of the National Geographic Phenomena blog network. Currently, he is a staff member of *The Atlantic*. In 2021, he received a Pulitzer Prize for a series on the Covid-19 pandemic.

Ten dealing with complexities of edGe-ucating

How can edGe-ucating be done?

196 The Long Haul, Myles Horton told his story about The Highland Folk School, with J. Kohl and H. Kohl, published in 1998 by Teachers College Press.

196 David Cavallo emphasized two features of expertise that the villagers had that were significant to solving the problem that other experts had failed. One was their technical expertise and innovation related to small motorcycle engines that were being ubiquitously used throughout the region. The second was the extent to which they understood their topographical context. Both were previously unrecognized as fields of expertise that could be used to solve the engineering problem at hand. (Cavallo, 2000, p. 780.)

197 Both pairs of researchers, R. Hall and S. Jurow, and B. Kirschner and K. Geil delivered papers at the 2006 American Educational Research Association meeting in San Francisco. The Hall and Jurow paper was titled, "Hybrid interactional practices: Expanding the disciplinary expertise of a middle school mathematics classroom;" the Kirschner and Geil paper, "Access points between youth activists and adult policy makers."

198 The EteRNA folding game is described in two *New York Times* articles by John Markoff: "In a video game, tackling the complexities of protein folding" (2010, August 10) and "RNA game lets players help find a biological prize" (2011, January 10).

198 Andrew Chen, "Student voted multiple-round elimination team projects." Presentation at the 3rd International Conference on Society and Information Technologies Conference (ICSIT 2012). Orlando, Florida. March, 2012.

199 Barth, F. & Luft, M. (2012). "Towards a practical approach for teaching

IT-security." Presentation at the 3rd International Conference on Society and Information Technologies Conference (ICSIT 2012). Orlando, Florida. March, 2012.

199 Greene, B. (2011). *The hidden reality: Parallel universes and the deep laws of the cosmos*. New York: Alfred A. Knopf.

199 John Durant is described by Karen Weintraub in an April 9, 2012, *New York Times* article, "A celebration of science with a popular touch." The quote from Brian Green is in that article.

200 The meeting at Columbia University where "amateur collaborators" (or "citizen scientists") participated with scientists David Hogg, Jane Hunter, Rick Bonney, and others, is described in Columbia University Library (2011), "Working with Citizen Scientists" event probes collaborations between professional researchers and the public. (Retrieved November 11, 2011 from http://library.columbia.edu/news/libraries/2011/20110127_cdrs_citizenscientists.html)

What is NOT edGe-ucating?

202 Gerard O'Neall wrote the article, "The Spark Chamber," in the Princeton Alumni Weekly, December 7, 1962, pages 13 to 18, including photos and charts of the paths recorded. It first appeared in *Scientific American* earlier that year.

unexpected enthusiasm

204 I gave two talks on edGe-ucating at the International Conference on Integrating Research, Education, and Problem Solving (IREPS), Orlando, Florida, March, 2012. The plenary address was titled: "Addressing the Unsolved Through EdGe-ucating," and the other was, "Engaging All Citizens in Research and Problem Solving through EdGe-ucating."

Actually, it turned out to be two international conferences, integrated. One was on integrating research, education and problem solving (IREPS), the other was on society and information technologies (ICSIT). The two topics blended effortlessly.

204 Pierre, C., Chung, G., Abede, F. & Kebede, T. "An emergent model: a vehicle for research methods and research activities." Presentation at the 3rd International Conference on Society and Information Technologies Conference (ICSIT 2012). Orlando, Florida, March 2012.

205 T. Grandon Gill is a professor in information systems and decision sci-

ences at the University of South Florida. He also is academic director of the Doctor of Business Administration Program, which teaches working executives how to apply research methods to their business problems. His primary research is in the transdisciplinary field of informing science, and, as an educator, he identifies himself as a "constructionist." His homepage is: http://www.usf.edu/business/contacts/gill-grandon.aspx

205 Fox, G. T. (2013) "Evidence for Addressing the Unsolved through EdGe-ucating, or Can Informing Science promote democratic knowledge production?" *Informing Science: the International Journal of an Emerging Transdiscipline*, 16, 165-185.

edGe-ucating is too elite

206 A more formal description of the ACE Doctoral Program at National Louis University can be found at: http://www.asktostudy.com/pd/national-louis-university/doctor-s-degree-adult-education/ph-d/164639.html A list of the group of 14 Doctoral students and their respective titles for their dissertations (called Critical Engagement Projects) can be found at the NLU Library.

Eleven on becoming edGe-ucated

uncertainty

214 An example of having an educational certainty of mine being questioned was when Barry MacDonald described to me an observation that he made during a study of two adjoining classrooms of a school in England. In one classroom was a teacher who was the best progressive teacher he had ever seen, comfortable with all students, informal, a listener who could take what the teenagers were saying and link their comments to significant expert thought and analysis in the students' language and experience. In the other classroom was a teacher so disinterested and uninvolved that he couldn't remember which text pages he had given the class the day before, and usually was reading the morning paper as they worked alone on their textbook at their desks. What surprised Barry was that the students loved the second teacher, and not the first. When he asked them why, they told him because the first teacher was obviously brilliant and able, knowledgeable and comfortable, and just so different from them. They could never be like him. The second, however, was just like them, so overwhelmed by

it all that they had to help him every day. Should I have been surprised?

215 In Technical Report #2, "Interpretations of CMTI" of the *Study of the Teacher Corps Member Training Institute* (1976, page 27), four succeeding hypotheses were proposed by the professors over the year of the study. The first hypothesis, created before the event, was that there would be no difference between the trainees' views of what teachers do and what trainees should learn to do. The second, created from the data after the first month of training (CMTI), was that the trainees' differentiation between what teachers do and what trainees should learn to do would become even more pronounced as they began to work with teachers. The third, created after two months of conversations with the trainees at their work sites, was that the trainees' views of "teaching as technique" and "teaching as personal development" were crucial factors in their development of perspectives towards teaching. The fourth hypothesis, developed after eight months of the study, was that there was no identifiable professional perspective being developed by trainees during their first year of training. Their conclusion formed at the end of the year-long study was that the first month of training had "an immediate impact" on trainees' perspectives towards teaching, powerful in its own right, but "almost meaningless" in the year's activities following that event. As can be seen, the four faculty learned something special about the role of uncertainty in students becoming teachers.

218 "Understanding our own relationship with uncertainty has never been more important, for we live in unusually challenging times," state Mark Miller, Katheryn Nave, George Dean, and Andy Clark in "The Value of Uncertainty," *Aeon*, 25 September, 2020. They go on, "By better understanding both the varieties and the value of uncertainty, and recognising the immense added value of turning our own uncertainties and expectations into concrete objects apt for test and challenge, we become better able to leverage the power of our own predictive brains." I propose that edGe-ucating may be useful to help all to build this essential understanding.

218 John Dewey, *The Quest for Certainty: a study of the relation of knowledge and action.* Minton Balch And Company. New York. 1929.

218–219 An article by Marc Lewis in *The Guardian*, titled "Why we're hardwired to hate uncertainty" (4 April, 2016), refers to research that has shown how and why the human brain has regarded uncertainty as dangerous. He re-

fers to a variety of experiments on anticipated uncertainty, including one that described both how and why an anticipated uncertainty in receiving an electrical shock is more stressful than receiving the electrical shock. (One article Lewis referred to was, de Berker, A., Rutledge, R., Mathys, C. et al. Computations of uncertainty mediate acute stress responses in humans. *Nature Communications* 7, 10996 (2016). https://doi.org/10.1038/ncomms10996.)

219 William Hogeland in The New Republic, January 25, 2021, titled, "Against the Consensus Approach to History," exposes how an honored American historian, Edmund Morgan, used his historical skills to hide specific records that Morgan had found through his research. Morgan's scholarly purpose was to hide the evidence that denied his certainty that all American colonists had resisted English taxation. That certainty then became a view other historians took to be reality for decades. (The U.S. public generally still does.) As Hogeland concludes, "To avoid being forever bluffed, forever tricked—forever Morganed—our descendants will have to be warier than we were, and maybe more playful, too."

219 Recent research on social media's effect on "overknowing" includes Filippo Menczer and Thomas Hills, "Information Overload Helps Make Fake News Spread," Scientific American, December 1, 2020.

219 The conclusion from Daeyol Lee, Yale professor of neuroscience on the role of uncertainty to learning was reported in the Yale News, July 18, 2018, Lee refers to how activity in the frontal cortex becomes dramatically reduced when there is little uncertainty about an event occurring or not occurring. He goes on to add that that is also why breaks can be so important when learning.

219 Among recent studies that address the serious challenges of uncertainty to medical practice is a review of many of these studies, including how uncertainties can be successfully addressed by medical practitioners by Kangmoon Kim and Young-Mee Lee, "Understanding uncertainty in medicine: concepts and implications in medical education," published in Korean Journal of Medical Education, 2018, Sept. 30 (3) 191-188, and online in 2018, August 27, DOI 10.3946/kjme.2018.92.

219 One article concluding from the study of how to address uncertainty in medicine is from the UK and continues with the following. "Further, we argue that to manage uncertainty, medical students must cross from a scientific training based on positivist understandings of evidence and

knowledge, to one which foregrounds multiplicity, nuance, interpretive critical thinking, and which understands knowledge as contingent and contextually produced." "Capable of being in uncertainties: applied medical humanities in undergraduate medical education." *BMJ Journals*, http://dx.doi. org/10.1136/medhum-2020-012127

219–220 The story of the German CEO's is told in an article from the *Boston Globe*, written by Maggie Jackson, January 17, 2021. The title of the article is "The gift of being unsure of what we do."

220 Richard P. Feynman, *The Quotable Feynman*, 2015, p.291, Princeton University Press, edited by Michelle Feynman.

combining educating with edGe-ucating

223 Ron Berger's book is titled *An ethic of excellence: Building a culture of craftsmanship with students*, Heinemann Publishers, 2003. Sonia Thompson, headteacher of Saint Mathew Primary School (UK), recently described Berger's work as focusing on "real quality, where quality means rethinking, reworking and polishing… the book emphasizes the need to give students a reason to care, that they know their work is important. She republished the book in their "Action Series" collection in 2022.

223 "Ready, fire, aim" has been a phrase often stated by entrepreneurs to describe how one can be productively creative through trying something new before one is absolutely sure, then analyzing what happens and trying again. An example is *Ready, Fire, Aim*, a book by Michael Masterson, published in 2008.

placing edGe-ucating into science and inquiry

226 Frank Wilczek, Nobel Prize winner in Physics in 2004, wrote *Fundamentals: Ten Keys to Reality*, published in 2021 by Penguin Books. In the preface, he refers to scientists taking up the same questions as religious fundamentalism, but through "consulting physical reality." Later, he goes on, "in studying how the world works, we are studying how God works, and thereby learning what God is. In that spirit, we can interpret the search for knowledge as a form of worship, and our discoveries as revelations." (Italics his) The primary message from the fundamentals of physical reality, he says, is that "our understanding of the physical world is still growing and changing. It is a living thing."

226 Another way of looking at the role of emotion to the conduct of science

at the edges can be found in the article, "The Necessity of Awe," by Helen De Cruz, professor of philosophy and Danforth Chair in the humanities at Saint Louis University in Missouri. In reviewing a number of scientists such as Copernicus, Galileo, Newton, Lavoisier, Darwin, and Einstein who have broken into new ways of thinking about their work, new paradigms of creative thought, she concludes, "Awe increases our tolerance for uncertainty and opens our receptivity to new and unusual ideas, which are crucial to paradigm change." (*Aeon*, July 10, 2020)

228 In "Scientists for the People," Deborah R. Coen, professor of history of science and medicine, describes Erwin Schrödinger's three reasons why a two-way interaction with the public is valuable to research at the frontiers of science and inquiry. In addition to Schrödinger's statements, professor Coen also refers to other researchers of the 1930's, such as social scientist Otto Neurath, philosopher Edgar Zilsel, bacteriologist Ludwik Fleck and literary scholar Walter Benjamin who argued not only for the necessity of informing the public, but for the inclusion of the public in reflecting and analyzing throughout the processes of producing new knowledge. Science, they argued, needed what a two-way communication with the public could provide. She also pointed out how their interpretation conflicted with Abraham Flexner, the founder of The Institute for Advanced Study, housed at Princeton University in the 1930's. Referring to the U.S. elections of 2020, professor Coen concludes by suggesting that an approach to the public inclusion in science could have been useful in influencing public views towards science. The article can be found in *Aeon*, February, 2021.

229 Daren Brabham, 2008, refers to the aim of crowd sourcing to be "harvesting" data that can be required to break through a frontier ("Crowdsourcing as a model for problem solving: An introduction and cases," in *Convergence: The International Journal into New Media Technologies*, 14, 75-90). In a later 2012 publication, Brabham describes how future crowd sourcing could include neophytes along with experts from specialist inquiry fields ("The myth of amateur crowds: A critical discourse analysis of crowdsourcing coverage," *Information, Communication & Society*, 15(3), 394-410).

229 In the *New York Times*, April 16, 2012, Benedict Carey describes the brain imaging research conducted by over 200 neurological scientists with over 21,000 individuals around the world. Paul Thompson is quoted in Carey's

article, titled, "Crowd-sourcing expands power of brain research."

229 The Bell Labs approach to developing continuous interaction across specialties is described in detail by Jon Gertner, in the *New York Times,* on April 1, 2012, in an article titled, "Plenty to go around."

230 In "Groupthink: the brainstorming myth," *The New Yorker*, 2012, January 30, 22-27, Jonah Lehrer reports on the MIT linguistic department approach in the 1950's, the Pixar approach, and the Harvard Medical School study of its highest quality research based on subsequent citations.

proposing a study of the mind

232 In "How the brain deals with uncertainty," *MIT News*, October 14, 2021, Jennifer Michalowski, describes research on the role of the thalamus as the brain handles issues of high uncertainty. "A lot of cognition is really about handling different types of uncertainty," she quotes MIT associate professor of brain and cognitive sciences Michael Halassa explaining how we use ambiguous information to make inferences about what is happening in the world. Researchers in this study found that the prefrontal cortex got involved every time the message was certain, but that the mediodorsal thalamus was needed when the mice in the research were given signals that left them uncertain how to behave. There is a simple division of labor within our animal brain, Halassa says. "One area cares about the content of the message — that's the prefrontal cortex — and the thalamus seems to care about how certain the input is." Perhaps, ironically, expert brains tend to respect the perceived certainties? The research she refers to is titled, "Thalamic circuits for independent control of prefrontal signal and noise," is published in the October 6, 2021, issue of *Nature* with authors Arghya Mukherjee, Norman H. Lam, Ralf D. Wimmer & Michael M. Halassa.

232 David Cavallo. Ibid (see p. 165 and 245).

232 A Tel Aviv University (TAU) study identified the areas of the human brain as it reacted to conditions of uncertainty and stressful conflict. Focusing on brain activity in a gaming situation of winning or losing money, the study found a close relationship between memory processes and decision making when risk (stress) was present and when loss occurred. On the other hand, winning did not encode in the hippocampus (memory) and did not influence the choice of future behavior in conditions of uncertainty. Only when loss occurred was it encoded in the hippocampus

leading the participant to prefer to be cautious in future situations. Importantly, this phenomenon also was found only when the subject was influencing the result of the game. The study, titled "The role of mPFC and MTL neurons in human choice under goal-conflict" was by Tomer Gazit, Tal Gonen, Guy Gurevitch, Noa Cohen, Ido Strauss, Yoav Zeevi, Hagar Yamin, Firas Fahoum, Talma Hendler & Itzhak Fried. It was published in July, 2020, in *Nature Communications*.

234 "We only learn when there is uncertainty, and that is a good thing," said Daeyeol Lee, Yale's Dorys McConnell Duberg Professor of Neuroscience and professor of psychology and psychiatry, reporting from a study of monkey brain activity with a result similar to the Tel Aviv study. The report was reviewed in the *Yale News* July, 19, 2018, from an article in *Neuron*, volume 3, issue 3, published on the same date. In the research, rewards for a task were varied, and as the outcome approached near certainty of a reward, brain activity in the frontal cortex where learning takes place was severely reduced. Stability in the environment was accompanied by no learning. "We were able to detect how the brain decides to learn," he continued, referring to that being a good thing since learning takes considerable energy and "we don't want to be learning all the time."

235 A detailed description by Catherine Zandonella, Princeton Office of the Dean for Research, described some of the work being done between Intel and Princeton University in developing technological breakthroughs allowing for more decoding of digital brain data using fMRI. The description, titled, "Princeton-Intel collaboration breaks new ground in studies of the brain," February 23, 2017, www.princeton.edu., details some of the work that was done in making "realtime decoding of thoughts" possible. Instead of months required previously to analyze brain activity, it could now be done while an experiment was going on. A research article where this work is described in more precise detail is, "Computational approaches to fMRI analysis," by Jonathan Cohen, Nathaniel Daw, Barbara Engelhardt, Uri Hasson, Kai Li, Yael Niv, Kenneth Norman, Jonathan Pillow, Peter Ramadge, Nicholas Turk-Browne and Theodore Willke, and appeared in the March 2017 issue of the journal *Nature Neuroscience*.

235–236 Details from a study using both new developments in fMRI research can be found in a post from the Princeton Office of Communications, dated Jan 9, 2020, titled, "Baby and adult brains 'sync up' during play, finds Princeton Baby Lab." The author, Liz Fuller-Wright, describes the study

with quotes from some of its primary researchers. The published study is "Infant and adult brains are coupled to the dynamics of natural communication," by Elise A. Piazza, Liat Hasenfratz, Uri Hasson and Casey Lew-Williams, in *Psychological Science*, Dec. 17, 2019. The description and quotes describing the study here are taken from Liz Fuller-Wright's article.

238–239 A detailed interview with Princeton neuroscientist, Uri Hasson, is reported in another article from the Princeton Office of Communications, Dec. 5, 2011, authored by Ushma Patel and titled, "Hasson brings real life into the lab to examine cognitive processing." Uri Hasson, now a professor, was an assistant professor in the Department of Psychology and the Princeton Neuroscience Institute at that time. Quotes from Uri Hasson about his work come from this Princeton sponsored article, including his references to the potential significance of how listener and speaker connect to understand each other.

a new becoming

241–243 The article in the Princeton Alumni Weekly that quotes Addie Minerva, and describes her and other students' work is titled, "Student Science Writers Aim to Make Research More Accessible" by Richard Huang, March 2021. That article refers to how Ms. Minerva, beginning in 2020, questioned whether she and other students, graduate and undergraduate, could write about their research at the edges of expert knowledge for the untrained. It then describes how the idea grew in that first year, including the development of the website, Princeton Insights, at insights.princeton.edu, and the blog, "Highlights." Twenty months after that article, there are students from 13 departments involved, and the student run organization, Princeton Insights, has an executive board (Addie Minerva is Director, all board members are grad students), and includes a listing of current research described, the researchers involved, graduate and undergraduate, along with transcribed interviews of some. (When one goes to retrieve the writings on the website, by the way, a quote comes up, "always the final appeal is to cases," one I previously mentioned from the philosopher John Wisdom.) Thus, the number of Princeton students and departments involved in describing research to the untrained is growing, although this does not yet include education which is not a department in Princeton at this time, but a separate program for certification. In ad-

dition, some of those listed have been involved in helping newcomers on the list to write about their edge research to neophytes. Thus, the edGe-ucating that is going on is at more than one level. I clearly would have more work to do if I were to report about these students' activities, intentions, and lessons being learned as they continue edGe-ucating themselves before they leave Princeton. And after.

Acknowledgements

In a memoir, one's acknowledgments can be extensive, personal, and emotionally stated for good reason. But this book is not exactly a memoir, so I will stick closely to the development of the book, not to me. That decision saddens me since it takes away direct reference to most of the significant persons in my life in the only book I will probably write. But so be it. I hope they all understand, including my step-daughters, siblings, families, former students, teachers, research colleagues, and colleagues from multiple university and public agency settings.

I must start, then, with Jón Torfi Jónasson, who has read and responded to my efforts in writing this book from its beginning. His written comments have always been sharp and to the point, something he is known for by both friends and, especially, educational colleagues. But I have been lucky over the few years of this process because we have been able to talk and share comments in coffee shops and on the golf course, among other places. Throughout this time, Jón Torfi has been supportive with questions and comments that have shown his interest from the beginning with his critical voice in educational reform, and his unabashed interest in making sure I stay on my stated aim throughout the book. As an educator educated in the hard sciences, Jón Torfi has had a primary role in knowing what I have meant by edGe-ucating. He has also been one of twowho have helped shepherd this book through the University of Iceland Press procedures.

The other person who has been a primary helper through getting the University of Iceland, Educational Research Institute approval and subsequent procedures is Ólafur Proppé. Ólafur is another educator, and the former rector of the Icelandic University College of Education who marshalled the College of Education into the University of Iceland – creating a new leadership role then filled by Jón Torfi. (Such is the nature of close relationships in an island country of a third of a million people.) The sincere interest that Ólafur has shown came at a critical time for me as self-doubts and uncertainties rained inside of me the closer I came to completing the book. I am sure every writer has such a person as Ólafur, if they are as lucky as I to have had someone as well travelled in my field of education supporting what I have done while helping this book get through the necessary steps to be printed and published. Both Ólafur and

Jón Torfi have encouraged me not only about the primary intent to reach a wide audience of educators, but also a wider audience of those outside of education, both professional inquirers as well as the general reading public.

The book, as published, also has much to thank for in Dr. Teresa Ritterhoff, my editor and copy writer who has given me the full sentence by sentence professional attention my ambitions for this book required. I kept most of her suggestions, which also means whatever formal mistakes and lack of clarity you find are mine, not hers. Given her own sense of intellectual honesty and passion, along with her academic prowess and reading background, her support and understanding have also been primary to me through these last stages of making this book as accessible to educator, academic, professional inquirer, and public as I had hoped. No small task, made more difficult by my own limitations.

I have also had other readers along the way who have helped me with their directed comments, support, and suggestions on how this book could reach my aims.

One is my brother Tim, also known as Mathew Fox, a prolific writer who over many decades has always aimed his work both at a professional audience of inquirers as well as to a general public. And has been so successful in doing so, that years ago he was kicked out of the Dominican Order by Pope Benedict XVI (before he was Pope, but when he was the director of the modern version of the inquisition). Tim/Mathew has been an early supporter of what I am trying to do, and his comments were always directed at the book becoming more accessible and clearer to all.

Two others were colleagues of mine in the Department of Interdisciplinary Studies in Curriculum and Instruction at National Louis University. Nikola-Lisa is both a successful writer of children's books as well as a former teacher of teachers, who always responded when I sent him pieces of this work. His talents include a mix of a creative and imaginative mind along with attention to the rules of clear writing. He thought the later was what he had most to share with me, but the former was also why I respected his views so deeply.

Sue Hansen has a full background as an Australian who continued most of her work in higher education as a passionate educator in the United States. Her strong interest in teachers, the challenges of education that teachers face, and the potential of action research in helping teachers, es-

pecially urban teachers, respecting themselves as intellectuals along with their students, are unique to the profession. That is why her insightful comments to my work have meant so much to me through the completion process.

Finally, comes the first, Anna Jóelsdóttir, my wife of over 30 years, who has not only weathered my doubts, certainties and uncertainties battling each other, but has done so with insights of her own into what I have been trying to do, as well as showing me how to be both passionate in my work while always doubting it along the way – as she experiences every day in her work as a visual artist. There is no way that this work of mine would have been completed without her constant support, interest, and insight into what it takes to have the kind of ambition for this book as I have had. It is an ambition we share like a roller coaster ride through our lives. That we have held on together has made it all more fun than you can imagine.

And thanks to all I have not mentioned, but are in here, somewhere, as they may know.

G. Thomas Fox
Reykjavik, Iceland
June, 2023

About the Author

G. Thomas Fox is a professor emeritus from National Louis University, Chicago, Illinois. In his 55 years as an educator, Fox taught 6th graders for over eight years; for three decades, he researched educational policy and practice at national and local levels, including at primary school through university doctoral settings; and for nearly three decades he has guided teachers and adult educators in researching their own professional settings. Throughout, he has proudly called himself an educator, one who has been fortunate to have been hired to do this work in three countries: the U.S., Iceland, and England. Dr. Fox has delivered a variety of papers in international conferences, and has published chapters and articles in research publications within these national settings. Over the past three decades he has focused his inquiry on what it can mean to education that untrained members of societies throughout the world have engaged successfully with frontiers in the sciences and other expert fields of inquiry. He calls the processes of guiding the untrained to understand and engage with expert unknowns, "edGe-ucating."

In this book, Fox tells stories from the range of his educational experience to show where educating and researching occasionally met edGe-ucating – or why it did not. Following that, he describes how others, primarily non-educators, have achieved edGe-ucating in a range of its possible manifestations. The aim of his book is to bring edGe-ucating into the discussions, practices, policies, and imaginations of educators, scientists and other expert inquirers, problem solvers, and general publics who may be interested in the possibilities of working together to make inquiry at the edges of knowledge an intellectual challenge for all humans on this earth to take on. He considers why we all may not only enjoy engaging with expert inquiry, but that it may be helpful for the future well-being of our societies, while continuing the development of expert understandings, along with our own.