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Invited Paper: Evidence for Addressing the Unsolved through EdGe-ucating or Can Informing Science Promote Democratic Knowledge Production?

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Abstract

Nearly everyone can be successfully involved with intellectual frontiers – if they are efficiently educated to do so. This article offers evidence of the processes applied to bring ordinary citizens to the edges of the known, and beyond, which the article calls, "edGe-ucating." David Cavallo, for example, an MIT engineer, has guided Thai villagers to break through expert understandings to address a specific local problem that required "sophisticated mathematics, biology, engineering, physics, and computer science." The purpose of this article is to encourage researchers, educators, and problem solvers to engage with the professional adventures of democratizing intellectual breakthroughs through edGe-ucating. The source of this encouragement will be evidence that this is not only possible, but that there are a variety of experiences to draw on to be successful in edGe-ucating neophytes into our respective disciplines.

The conclusion from the research is that, if our international communities of inquirers (along with our institutions and agencies) worked together to edGe-ucate, more will be accomplished at the edges of our respective inquiry disciplines, a far greater number of breakthroughs will occur, and more world citizens will understand, through their own experience and the experiences of their friends and neighbors, the rich nature of scientific inquiry at the frontiers of knowledge. Most important, all societies will benefit from the creative intellectual work of their citizens in ways that have never been widely developed or promoted.

Keywords: democratic knowledge production, neophytes working on frontiers of knowledge, integrating intellectual breakthroughs into education, edGe-ucating

Introduction

This article suggests that it is possible to tap the potential intellectual energy of ordinary citizens to work at the frontiers of scientific breakthroughs. It offers evidence that this can be done by applying educational experiences of the present and the past (often not in schools or universities), but it also calls for the design of entirely new curricular strategies to educating citizenry for working at the intellectual frontiers of what is known.

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This set of new strategies will be called "edGe-ucating."

The intent of this article is to challenge researchers, educators, and problem solvers to consider how their work can greatly accelerate the creation of new thought and action by engaging ordinary citizens of all societies to work at our intellectual frontiers. Included in my aim is to interest *Informing Science* readers in edGe-ucating because I know, as an educator, that educators alone cannot do what is required to get ordinary citizens to the edges of professional understandings. Too few of us educators have enough experience at the edges of knowledge to do the necessary work, as can be seen by the lack of attention to edges in curriculum theory. Furthermore, few educators seem to be interested in breaking through their own intellectual frontiers, which may explain the cyclical movements in educational thought over the past century, regardless of the huge transformations of human understandings over the same time. Researchers and problem solvers from all fields of knowledge production are needed if citizens of the world are to be edGe-ucated.

It will also become clear in this article that much work, more investigation and experimentation, must be done before the processes of edGe-ucating are fully understood and capable of being practiced in a range of different settings, disciplines, and citizen populations throughout the world. In short, the primary challenge in this article rests upon readers carrying the next steps of edGe-ucating further than this author has.

What is EdGe-ucating?

"EdGe-ucating" is the intentional effort to guide a neophyte to work at the edges of the unknown and expand the frontiers of expert inquiry. (In The Oxford English Dictionary, *neophyte* is "a beginner, a novice, one who is new to a subject;" thus *neophyte* captures the sense of someone not yet aware of the knowledge and traditions of a field.) The processes of edGe-ucating are what we do to bring neophytes to the intellectual frontiers of expert knowledge and understanding, and to work at those frontiers, in order to extend expert knowledge. Readers may ask, why invent a new term for this process? Three reasons: first, to move away from traditional assumptions about teaching and learning; second, to remove edGe-ucating from current educational reforms; third, to appeal to those outside of education, especially researchers and problem solvers.

From the brief description above, there are two essential steps to edGe-ucating. The first step of edGe-ucating is to bring neophytes to a frontier of an unknown, including what may be required to extend beyond that unknown. The second step of edGe-ucating is to provide guidance and opportunities for the neophyte to extend, or assist in extending, beyond an edge of expert knowledge. The second step must be realized for edGe-ucating to occur successfully.

There are three primary features to edGe-ucating. First, is the intent to bring neophytes to a particular frontier of a field for the purpose of helping to extend that frontier. Second is the application of a specific strategy or set of strategies to reach that aim. Third is this process of becoming informed, and then engaging with the frontier is accomplished within a comparatively short time frame of a few months.

Evidence for success in edGe-ucating would include citizens of any age and background entering the frontiers of expert understandings in a field of inquiry and intentionally reaching beyond those understandings. Furthermore, we can acknowledge that success in edGe-ucating would include neophytes reaching and then working at expert frontiers within comparatively short periods – a few weeks or months. Thus, to be successful, edGe-ucating events would need to be considerably more efficient in bringing a neophyte to contribute to the frontiers of knowledge than what current educational theories, curriculum designs, instructional practices, specialized research fields, or research institutions have assumed, or have habitually enacted. Another way of understanding the difference between edGe-ucating and what is currently being done in most professional fields of inquiry, is to realize that edGe-ucating has a purpose different from graduate training. The purpose of graduate training is to provide the graduate student with the foundation required for a lifetime pursuit in a specialist area. The intent of edGe-ucating is to provide neophytes with what is needed to fully engage in a specific specialist inquiry at the edges of a field. Thus, successful edGe-ucation would require less professional energy than is currently applied to bring graduate students to the frontiers of our respective fields, and beyond.

The above criteria for successfully edGe-ucating are not yet understood to be possible by most educators, scientists, or problem solvers. And certainly not by their institutions. But I intend to demonstrate through the evidence I will be presenting why edGe-ucating is possible (and has happened in the past). Furthermore the evidence will suggest how the challenge for edGe-ucating is not only related to the themes of *Informing Science*, but that some of its practitioners and contributors are suggesting ways in which edGe-ucating can be more successfully practiced. First we will consider edGe-ucating as it relates to the aims of *Informing Science*. Then I will go into my research methods and to the evidence that edGe-ucating has occurred in a variety of circumstances, and can occur to a much greater extent if we work together to edGe-ucate with more common focus, intent, and creativity. I will conclude by discussing what edGe-ucating can do for our respective fields of inquiry as well as for the improvement of our societies through public engagement at the frontiers of expert knowledge.

What is NOT edGe-ucating?
Neophytes only performing mundane, routine tasks of data gathering is **not** edGe-ucating. Data gathering alone can be accomplished with little understanding of the theoretical underpinnings for gathering specific data. Furthermore, data gathering does not require the understandings necessary for analyzing the data or for creating ways to go beyond current theory if the data suggests. In the sciences, more than lab work is required to prepare the neophyte to work at the intellectual and conceptual challenges at the frontiers. What is essential to edGe-ucating is the intent to arrange opportunities for neophytes to participate in the intellectual challenges of working at the frontiers of an inquiry. Apprenticeships or internships, for example, are also not edGe-ucating without actions aimed directly at working successfully on a particular frontier. Features of mentoring may be effectively applied to edGe-ucating, but the purpose of edGe-ucating is not introduction to an expert profession; it is preparation for deeply engaging with and solving a particular unknown within an expert profession. EdGe-ucating is less than preparation for acceptance within a profession; it is focused on working on a specific frontier for the purpose of helping to break through that frontier.

Connecting EdGe-ucating to Informing Science

The professional and research aims of Informing Science are not only tightly connected to edGe-ucating, but the results of Informing Science research can inform future practices of edGe-ucating. In transferring knowledge, a primary feature of Informing Science has been the role of the client (Cohen, 2009, p. 9), which is also a primary feature when guiding neophytes to work at the edges of specialist understandings. Continuing with the role of the client, Informing Science researchers are interested in the communicative status of the client, particularly the insights the client can bring to the specialist. Birdsall (2009), for example, emphasizes what new clients can bring to specialist knowledge, an emphasis that can be especially significant when considering what the neophyte can bring to the expert when edGe-ucating.

In addition to Informing Science researchers' interest in the client is a deep curiosity about what the expert brings to addressing significant, complex problems. Gill's study (2012), for example, suggests that in "low complexity environments" expert guidance is especially valuable to the client. As the complexity of a problem grows, however, it is the client (what Gill calls "agent") who more effectively sets the goals (depending upon observations of others in the task), and subsequently outperforms the expert-guided client. The results of Gill's research are equally germane and thought provoking for edGe-ucators. The challenges of designing effective knowledge generating relationships with neophytes working together with experts on highly complex unresolved specialist problems fit within the model being proposed by Gill's research.

Another common interest between edGe-ucation and Informing Science is how to integrate multiple fields of inquiry more effectively and efficiently. Increasingly, human inquiry in the 21st century is encountering unsolved problems that must be addressed through diverse disciplinary perspectives. Murphy (2011) looks directly into these issues as they relate to the Informing Science Institute, for example, and provides analyses of how this work can be done, along with recommendations for greater success in collaborating between disciplines. The successes of edGe-ucating will likewise depend upon the capacity of the interdisciplinary community of researchers to "learn from each other" as Murphy says (2011, p. 91). One approach to bridging across separate disciplines, for example, is to edGe-ucate neophytes in one specialist field who are experts in another specialist field. Another approach is to edGe-ucate neophytes in all the relevant disciplines to be the connectors between the specialist fields.

Furthermore, the definition of an Informing System has much in common with the necessary components of edGe-ucating. As Murphy (2011) communicates Cohen's (2009) definition, the three components that must be present for an Informing System are:

1. an Informing Environment,
2. a Delivery System, and
3. a Task-Completion System.

In edGe-ucating, the task completion system is the edge of a specific field of inquiry that neophytes are expected to help break through; the delivery system is the set of procedures applied to engage neophytes within the processes of developing breakthroughs, including information technologies; and the informing environment is the setting in which neophytes in a particular field are being trained to engage in and assist in solving the problem being proposed by the expert inquirers.

Thus, I suggest that Informing Science practitioners, theorists, and researchers have much to gain from interactive communication and involvement with edGe-ucating. Underlying the purpose of this article is the assumption that the opposite is especially true: edGe-ucating has a lot to gain from Informing Science. The following will continue to suggest why both edGe-ucators and Informing Science practitioners would benefit from their collaboration, but let us first begin with a brief introduction to the methodology I have applied to research edGe-ucating.

Methodology

The method of inquiry applied for my studies on edGe-ucating has been eclectic, focusing on how breakthroughs have occurred in the sciences and other fields of inquiry, including documentations of neophyte contributions to expert fields of inquiry. These documentations have included historical accounts of neophytes working at the edges of knowledge, studies of intentionally bringing neophytes to the edges of expert understanding and beyond, and research on a variety of processes applied to the creation of intellectual breakthroughs. My studies have been in four stages, distinct in their respective focus, but also overlapping, and not always in the order I present them here.

One stage of the study has focused on philosophers and historians of science questioning what is happening at the frontiers of inquiry, such as Paul Feyerabend (1975) and Michel Serres (1995). These are theorists who lend support to neophytes engaging at the frontiers. Serres, for example, speaks directly to the spirit of edGe-ucating as he expresses his interest in intellectual movement across time and space, along with his skepticism of education. As Serres (1995, p. 92) puts it, "the goal of instruction is the end of instruction, that is to say invention."

This stage has also included the serious debate emerging from the Woods Hole Conference in 1959 between the nuclear physicist Jerrold Zacharias and the educational psychologist Jerome Bruner on the nature of knowledge production at the edges of inquiry (Dow, 1997). Zacharias and Bruner were co-directors of the 1959 Woods Hole Conference, formed to develop an educational response to the Sputnik challenge through analyses by scientists, psychologists, and educators. What is interesting about the encounter between Zacharias, an esteemed nuclear scientist who had worked on the Manhattan Project, and Bruner, a renowned educational psychologist, is Zacharias' outrage at how Bruner portrayed the practice of scientific inquiry. Bruner's account was expected to be the culminating report from their deliberations. In his account, published as *The Process of Education* (1960), Bruner suggested that "the scientific method" was composed of specific universal steps, and the book became a primary educational text for decades. Zacharias, however, argued vociferously that scientific inquiry at the frontiers "loses all forms of traditional rule and principle" (Dow, 1997).

Historians of science such as Strafford (1994) have emphasized how 17th century science began with a deep appreciation for the democratization of knowledge creation. Anyone could join and participate in the early intellectual communities of scientific investigation. That changed with worries about charlatans or fake inquirers. The solution was to replace graphic illustrations, readily accessible to all, with linguistic terminology designed to communicate only to select specialists. As Stafford points out, that solution has worked only too well over the past three centuries.

A second stage of my methodology has applied a case study mode of inquiry as I have surveyed a range of public and professional literature that captured the existence of intellectual breakthroughs by neophytes in many fields of inquiry (e.g. Fox, 1984, 2010b). The intent of this stage was not only to identify situations where neophytes had broken through expert understandings, but to identify the possible reasons for their successful breakthroughs. The primary aim of this stage has been to analyze to what extent the lessons being learned from neophyte engagement with the frontiers of knowledge could be applied to current educational and curricular practices, purposes, and theoretical outlooks (e.g. Fox, 2010a).

A third stage of my study has included references to the roles of information technology in bringing all citizens to the frontiers of knowledge (e.g., Gleick, 2011; Kelty, 2010). These sources have been especially powerful in identifying a variety of opportunities for edge-work with the wide population of information and social technology users. Sources have also focused on the potential of information technology within developing countries, in particular the ways that information technology can support local citizens resolving local, unsolved problems. This is where Cavallo (2000) has come in as he has involved neophytes in developing countries to apply themselves to resolving unsolved issues requiring specialist expertise. This stage has also included reviews of work that link the ubiquitous use of information technology to public learning in developed and developing countries, along with examples of neophytes engaging in a variety of expert fields through technology (e.g., Fox, 2010b).

A fourth stage of my study has been presenting my work to a range of professional audiences. These have included talks to scientists (e.g., Fox, 2010b), technologists and social reformers (e.g. Fox 2010a), as well as educators (e.g., Fox, 1995, Fox & Greenspan, 2011). The purpose of this stage has been to engage theorists and practitioners in a range of professional fields of inquiry with the possibilities for edGe-ucating and to learn from others – scientists, problems solvers, educators, social reformers – who have experiences that may be linked to edGe-ucating. This includes my attendance at the 2012 International Conference on Society and Information Technologies (ICSIT) conference, with the papers, sessions, and private discussions from that conference.

The following describes some of the primary areas that are addressed through the evidence I have collected and analyzed through these four stages of my inquiries. These include evidence for the successes of edGe-ucating, evidence for expected increase in the successes of edGe-ucating in the future, and evidence of the current challenges to supporting edGe-ucating. In these discussions, I will also be referring to potential examples of edGe-ucating that I met at the 2012 International Conference on Society and Information Technologies (ICSIT) conference.

Evidence for Successes in EdGe-ucating

We have a variety of examples of what can be done to edGe-ucate neophytes of all ages. *BioQuest* (BioQUEST notes, 1993; Jungck, 1996) has been a program for first year college students to study the unknowns in biology and has been operating successfully for over 20 years in many universities in the world, including the United States. David Cavallo (2000), an MIT engineer, has guided Thai villagers to break through expert understandings to address specific local problems that require "sophisticated mathematics, biology, engineering, physics, and computer science." Furthermore, the villagers have accomplished this in "extremely short time frames" of a few months. One difference between BioQuest and Cavallo is that BioQuest stops at the first step of edGe-ucating, bringing neophytes to the frontiers of the known. With Cavallo, the villagers start with the first step but continue to produce breakthroughs through opportunity, necessity, or the shared expectation that the neophytes extend beyond the frontiers of expert knowledge. More examples of each of these two steps follow.

Successes in Bringing Neophytes to the Edges of Expert Knowledge

Brockman (1995) is a scientist, researcher, writer, editor who has focused on the first step of edGe-ucating. He created the term "third culture" to describe a variety of expert researchers who communicate the frontiers of their fields to general readers. Brockman's term, "third culture," referred to the two cultures of C. P. Snow (1998, first published in 1959), the sciences and the humanities, by adding a third culture of scientists/researchers who communicate the frontiers and intellectual challenges of their respective fields to the general public.

The number of these "third culture" scientists has increased exponentially since Brockman created the term. More recently, Brockman has formed a web site, edge.org, to promote communication and interaction between researchers across the borders of their respective sciences. The web site is accessible to anyone. Other researchers who have developed successful ways for bringing neophytes to the edges of expert understanding include Brian Greene whose recent book, *Hidden Reality* (Greene, 2011) covers areas as erudite as string theory with its "loops," "snippets," and "branes," along with "the inflationary universe" and other ways to portray multiple universes. John Durant is one who is changing the nature of citizen participation in science, first through science and math museums and now through science festivals at a number of sites within the U.S (Weintraub, 2012). Brian Greene has been a participant in Durant's annual Cambridge festival and describes their attempt, "We've tried to inject the drama of science into these highly produced programs, so people leave the event saying, 'Wow, I didn't know that's what science is like'" (Weintraub, 2012)

Successes in Having Neophytes Participate in Developing Intellectual Breakthroughs

In addition to Cavallo (2000), other examples of successfully bringing neophytes beyond their expert trainers and contributing to the production of new knowledge include Paolo Friere (1970) and Miles Horton (1998). Both are social activists from the past century who brought in experts to train neophytes to do better within the trainees' local contexts than the experts could. Horton, for example, brought experienced activists and organizers from a variety of fields to his Highlander Folk School to engage with local union leaders, civil rights organizers, and other civic leaders, expecting the local citizens to improve upon expert understandings by creating new approaches and new actions to achieve social justice within their local contexts. Graduates of the Highlander Folk School have been applying new successful approaches to civic reform for social justice since the early 1930's.

A current example of untrained high school students working directly with scientists on scientific frontiers has been occurring with physicists at the Italian National Institute of Nuclear Fission at Frascati (Centioni, 2010). At the Italian Institute of Nuclear Fission, selected high school students work on the frontiers of nuclear fission for 6 weeks in the summer, living with the researchers over this time as well as working with them. In 1991, students from a New York high school (those who could pay an extra $2,000 for a summer experience) were paired with internationally acclaimed Russian microbiologists. This was just after the USSR fell, when many world-renown scientists had no salary for months, so the pay the microbiologists got to work with these U.S. high school students was attractive. These world award winning scientists reported that the high school students actually provided valuable help to their research (Specter, 1994).

In reference to working closely with scientists, Henrietta Swan Leavitt was a secretarial assistant to the astronomer, Sir Edwin Hubble at the turn of the 19th to the 20th century. Her job (called "computer" by Hubble) was to record the thousands of photographs of the heavens that Hubble and his team had gathered and to look thorough them for specific features of the luminous stars. Through insight gained from her observations of thousands of photographs, Henrietta Swan Leavitt began to realize that the size of the universe could be measured through the star brightness data she was documenting (Johnson, 2005). With her insight proven correct, astronomers' understanding of the approximate size and complexity of the universe increased dramatically.

The Sloan Digital Sky Survey, "Galaxy Zoo," is a more recent phenomenon in astronomy. Galaxy Zoo enlists the help of students and anyone who wishes to participate (http://www.galaxyzoo.org/). In one 60 minute session, amateurs can be tutored and then recruited to help classify images from the Hubble telescope circling the earth. The findings by neophytes working with "Galaxy Zoo" have been extensive, yet not surprising since astronomy has historically had too much data for expert astronomers to analyze on their own, and thus have often looked to amateurs and neophytes for help (Ouellette, 2010; Thompson, 2011). The question raised for edGe-ucating is how these amateurs can be trained beyond data collecting to address the theoretical understandings of our universe.

Continuing our look at technology, Hedy Lamarr, a Hollywood actress from the 40's and 50's, was an inventor who developed a remote controlled torpedo guidance system that avoided efforts to turn the torpedo off track (Rhodes, 2011) It was guided through a signal that hopped around the radio spectrum, a precursor, as Rhodes points out, to the current "spread-spectrum" technology of wireless phones, GPS, and Wi-Fi. A term used to describe what Hedy Lamarr did is "autodidactic learning," which refers to individuals learning to be experts in a field on their own. This has become much more prevalent in the age of information technology.

Recently, video games have supplied successes by neophytes working at the edges of specialist inquiries. As John Markoff (2011) reports, "Scientists at Carnegie Mellon University and Stanford University are attempting to harness the wisdom of crowds with the creation of an online video game that challenges players to design new ways to fold RNA molecules." The game acts as a training ground for citizen non-biologists to design complex new ribonucleic acid (RNA) molecules through creative folding techniques. The folding techniques created by the non-biology-educated players are then sent on to microbiologists who choose specific designs to be synthesized by trained biologists to see to what extent they can create new forms for nanoengineering. The game, called EteRNA, is a successor to an earlier game, called Foldit, where players would try to figure out how to fold about 10 proteins into specific 3 dimensional configurations. It was found that the players, non-trained, beat leading software in this game (Markoff, 2010, 2011). Clearly, gaming may be a very useful tool applied to the processes for edGe-ucating.

Continued evidence for the currently untrained to produce through ubiquitous technology include the following: more movies being created for and produced on the web than in Hollywood; child cartoonists publishing their work; clothes designers under ten years old having their designs manufactured, and best sellers being written by young and unschooled teenagers in countries from China to India to Italy (Fox, 2010a). As will be seen in the next section, many researchers of innovation and creativity are realizing that there is a tremendous amount of unrecognized talent out there – everywhere.

A recent event pulled in a range of scientists to discuss what they have learned from incorporating "amateur collaborators," or what they also referred to as "citizen scientists" (Columbia University Library, 2011). Participants included David Hogg, an astronomer and physicist who has applied amateur and hobbyist images within scientific astronomical investigations, Jane Hunter, who has used amateurs in her work on developing approaches and software for managing and analyzing scientific research data, and Rick Bonney, an ornithologist who is the founder and director of citizen.org to research projects where the public is actively engaged in scientific inquiries, such as environmental conservation. The significant question that remains in terms of edGe-ucating is the extent to which these citizens go beyond being data collectors and are included within the theoretical analyses and questions that may determine the next serious breakthrough in these specialist fields.

As we refer to evidence of "citizen scientists" working at the edges of expert knowledge, we need not refer only to adults or teenagers. The following is a quote from the abstract of a research article published in the respected peer reviewed journal, *Biology Letters.*

> *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 Primary School et al., 2010)

This peer reviewed article is about the way bees use color and space to navigate between flowers. The research was performed, and the paper was written, by 25 co-authors, all of whom are between the ages of 8 and 10. The 25 researchers/authors, 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 positive reviews by their apicultural colleagues. There is no doubt that, regardless of age or cultural circumstance, we can do better at guiding our citizens to the edges of our respective specialist expert understandings, and, even more important, beyond.

Did Eight Year Olds Really Publish Their Study in a Science Journal?
Yes, second grade students in Blackawton Primary School in Devon, England actually did design, conduct, and write every word of an experiment on the way bees use spatial relationships between colors to figure out what flowers to visit. And their study was published in the on-line, high powered science journal, *Biology Letters*. They were helped along the way by neuroscientist, Beau Lotto (whose son was in the class), and it was part of a science project, "i, scientist," designed to engage kids with on-hands science. The kids picked the question after trying on glasses that helped them imagine how bees perceive the world, and designed their own materials to conduct the experiment. The materials included a plexiglass cube filled with colored lights, each connected to a dispenser tube with either sugar water or salt water. They observed bees' behavior over several runs where the colored lights were switched on and off. They recorded in colored pencil the variety of behaviors and individuality of the bees' perceptive facilities.

Their paper was not considered "groundbreaking," but it was an addition to the research on bees' perception and behavior. Lotto first submitted the study to the publications, *Nature, Science,* and *Current Biology*, all "loved the idea" but passed on the work. It did not have statistical analysis nor references to past literature, but 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.)

The Potential for Increases in the Successes of EdGe-ucating

The variety of neophytes who have worked at the frontiers of knowledge demonstrates that the potential for edGe-ucating has barely been tapped. Past experiences with neophytes working at the frontiers of inquiry are suggesting how we can be efficient in training neophytes to reach and then extend the frontiers of knowledge. But evidence for how we can move more citizens to the edges of what is known goes further than past experience, as we continue to gain new understandings of innovation, creativity, and learning, as well as understand better the latent potential of all citizens. Furthermore, as we continue to understand better how technology can support new approaches to creativity and innovation, we become more aware of the significance of the connectivity provided through technology. Rich communication is possible regardless of the space between the neophyte and the expert, and the certified expertise and cultural background of the expert and the local expertise and cultural background of the neophyte. Gliek, for example, shows how the "annihilation of space and time" (Gliek, 2011, p. 413) of the present parallels the promise offered by the telegraph nearly 150 years ago, but has extended that promise exponentially. As we learn what the ubiquitous use of technology brings to the capacities of the human mind, we will continue to become much better prepared to engage neophytes at the frontiers of knowledge.

In the following, I will relate how a variety of research studies into the processes of innovation provides evidence for an expected increase in the successes of edGe-ucating. I will start with our increased understandings of the processes through which edGe-ucating has been successfully performed. I will then review some of the research reported at the 2012 ICSIT conference as an example of the kind of work currently being done that can inform edGe-ucating. After that, I will address the ways in which we are understanding innovation and creativity, and how technology is being applied to promote many of these increases in productivity. These are only a small sample of new insights from recent research that can inform us on how we can be more successful in guiding nearly all world citizens to engage at the edges of the known through efficiently minimum prior training.

Evidence of Three Successful Meta-Strategies for EdGe-ucating

An analysis of past and current approaches to bringing neophytes to the edges of knowledge and working to extend those edges suggest three primary meta-strategies. One meta-strategy is through pedagogical means alone. Another meta-strategy is approached through solving a specific local problem that requires specialized knowledge, but that no specialized expert may be able to resolve because of a lack of the required local knowledge. The third meta-strategy is through continued interaction with the researchers while being embedded within their working and living contexts.

The focus of the pedagogical meta-strategy is on developing a curriculum for neophytes that can prepare them for work at a particular frontier of what is known. Bioquest (1993) and Brockman (1995), for example, describe how a researcher's careful analysis of prerequisite knowledge can be applied for neophytes to quickly reach a frontier of a specialist field of inquiry. Their approaches include providing the language (linguistic and visual) necessary to communicate the required knowledge necessary to understand the unanswered questions at the edges of a specialist field. Their primary aim is to bring neophytes to the edges quickly, efficiently, effectively, and on a larger scale than current curricular approaches have imagined.

The second meta-strategy for engaging neophytes with problem solving at the edges of knowledge is to engage them with a local unsolved problem. The process includes starting with the neophytes' knowledge of the conditions of the local environment and cultural context (along with essential local skills), then bringing in specialist expert understandings that are considered necessary to be integrated with the local knowledge to solve the problem. Cavallo (2000) uses this approach effectively with the residents of a Thailand village, where they identify and solve local problems that cannot be solved by specialized experts because they do not have the local knowledge required. From his successful application of working with neophytes on a variety of edges of expert knowledge, Cavallo has the following advice:

1) apply a respectful and observant eye that can locate the expert knowledge of the novices with whom one is working,
2) identify the need for a solution to a local problem that may require knowledge and understandings that go beyond what is held by \experts, and
3) ensure that the local neophytes have a good grasp of the expert knowledge potentially relevant to the local problem that must be solved.

Once these three steps are taken, Cavallo demonstrates how local citizens can produce breakthroughs in solving local problems requiring specialized expertise that experts cannot solve, sometimes in less than three months. It may be useful to point out that progressive educators have a great deal of experience in performing the first two features of Cavallo's advice. It is the third requirement, ensuring that neophytes have – and can apply – the required expert knowledge, that is a new challenge to most educators, as well as many expert problem solvers. In following this third requirement that the best of expert knowledge can be applied by the novice/neophyte, we could learn from the examples of Horton (1998) and Freire (1970).

David Cavallo and the latent learning potential of citizens in developing countries.
David Cavallo is an engineer, technologist, and research scientist who has focused his work of the past 15 years on directing attention to the indigenous knowledge of those who have had little formal schooling. One of his first set of projects was aimed to enable "the discovery and utilization of latent, engineering expertise and creativity among people in rural Thailand" (Cavallo, 2000, p. 769). The setting began in Bangkok in 1997, then extended into rural Thailand, including Nong Baot, a village in rural northeastern Thailand in 1998. (This is the specific project that I have been referring to as "edGe-ucating.") One of the primary needs of this village was to retain the water from yearly deluges of rain in order that they could irrigate during the yearly droughts. It was a problem that had not been solved through expert attempts at damming.

Cavallo reported two features as being significant in the solution designed and put into effect by the villagers. One was the technical, innovative, and expert mind-set created by certain villagers around small motorcycle engines, developed through their adaptations of the motors to a variety of local needs. The second was the extent to which they understood their topographical context. Their entrepreneurial use of technology was tapped in training that encouraged their own development of computer applications, what Cavallo referred to as their "hacking spirit." The villagers' deep understanding of their terrain was essential as they were trained to be precise cartographers of the region, and as they designed the reservoir in the detail that was required for successful placement and implementation.

In reviewing his experience with this and related projects, Cavallo makes two primary points. One is that the engineering expertise of the villagers was never recognized by educators, including by school reformers. The second was the site specific nature of "what will resonate and what local concerns and knowledge exist" (Cavallo, 2000, p. 780). In these circumstances, Cavallo emphasizes the need for an Emergent Design approach, an approach aimed at being open to local talents, and an openness to the locals becoming experts in multiple specialist fields that are required for solving a particular, complex local problem.

Currently, David Cavallo is engaged with Project Lighthouse, a variety of pilot sites in Thailand for immersion into technological fluency, built upon the constructionism approach to learning. Another project, "The City that We Want," is a new project recently started in Brazil where students are designing computational models of how they want to improve their communities. There are other projects, called "Learning Hubs" that are being piloted by "learning activists" in sites as varied as Brazil, Costa Rica, Thailand, Ireland, and Senegal, as well as the United States.

The third meta-strategy is to embed the neophyte within the environment of the researchers. There are many ways to involve neophytes in the researchers' work-place, but primarily this involves the neophytes being fully engaged within the mundane and everyday actions of the researchers along with their work at the frontiers of their expert knowledge.

The Italian National Center for Nuclear Fission has a self-contained approach to embedding high school students within the community of researchers by having them live with the researchers for weeks at a time. This is especially effective when neophytes need to experience expert knowledge as being uncertain, unknown, and built through continuous interaction, failure, and revision (Centioni, 2010). The National Center of Nuclear Fission at Frascati recognizes that the assumptions about knowledge, expert language, and processes of inquiry at the frontiers of their field are culturally as well as professionally embedded. Thus, the neophytes experience the full culture of nuclear fission inquiry as they engage in the work at the edges of the field. I am convinced that Zacharias would have especially approved this strategy for training neophytes how to engage with the unknowns at the edges of fields of inquiry. This could also explain how the high school students who were engaged with the Russian microbiologists (Specter, 1994) were successfully edGe-ucated.

In a different context, Hall & Jurow (2006) suggest the term "hybridity" to describe how students can make sense of, and improve upon, various social practices outside of the classroom. For Hall and Jurow, "hybridity" refers to the combination of school experience with field experience. The goal of hybridity is for students to participate in their own learning, while also contributing to society by engaging in social issues while working in the field. For example, Kirschner and Geil (2006) analyzed how student youth activism groups use school board meetings, city council meetings, and other community forums as access points for assisting local democratic decision-making. Hall & Jurow (2006) studied hybridity in a middle school math class, where mathematicians were brought in to encourage students to apply mathematics in solving local real-world problems in a similar way as Cavallo (2000).

As can be seen, there is much yet to be learned about the processes we can apply to be more successful in edGe-ucating. This includes providing more experience in the pedagogical approaches for taking neophytes to the edges of understanding, and beyond, in working on local problems that require specialist expertise along with local expertise, and the ways in which neophytes can be embedded with researchers as they struggle with the unknowns in their respective fields. What the evidence tells us so far is that there are a variety of approaches that can effectively engage neophytes in helping to address and resolve unknowns in local problem solving as well as frontier work at the edges of specialist knowledge.

Evidence from the 2012 ICSIT Conference that Can Inform More Success in EdGe-ucating

The following are three whose work I was introduced to in the International Conference on Society and Information Technologies (ICSIT) conference held in March, 2012. I bring these up as examples of on-going work in Informing Science that could have direct implications to how edGe-ucating can be done more effectively in the future. They not only begin to show how edGe-ucating may benefit from the current work of Informing Science but also what could be shared between edGe-ucators and Informing Science practitioners to inform both fields.

Charles Pierre (Pierre, Chung, Abebe, & Kebede, 2012) introduced "emergent research" as a new approach to research method that included a range of different scientific disciplines. The word, "emergent," referred to chaos and complexity theory, that is, to a robust but essentially unpredictable, bottom up research process dependent upon feedback for the development of new understandings. The point was to begin with small research activities (the simile he used was the model for ants discovering food: many different paths leading to the most successful result). Pierre's emergent model for conducting research among faculty of different disciplines, along with their students, seems like a particularly valuable possibility for considering how edGe-ucating could occur efficiently, naturally, and successfully with small teams of interdisciplinary researchers.

Andrew Chen (2012) described how he approached teaching a course in gaming to undergraduates who he had anticipated knew more about gaming than he did. Basically, he taught the course as a game, starting with each student designing a game in the first week or two, and then each successive week, as the designs became more specific, the class voted for which designs were the best, and which should be voted out. Those who were voted out had to choose to work on one of the games that were still "in." This process continued throughout the course until there were 9 games at the end of the course, instead of the beginning 50. Chen's approach to gaming as a pedagogical process for teaching gaming seemed to be not only brilliant for his purpose, but equally innovative as a possibility for engaging neophytes with the frontiers of specific fields of inquiry. At the same conference, Scott Nicholson (2012) presented an important addendum when considering gaming to engage student learning, and that is the significance of debriefing after the experience of gaming. Nicholson offered a number of models and methods that can be applied to debrief experiential educational games.

Florian Barth and Matthias Luft (2012) reported how they found themselves with no highly qualified “hackers” to replace the international award winning security competition team that they had lost through graduation. After finding no experienced replacements, their only choice was to find a way to train new members efficiently for these security related competitions that required adaptive knowledge and skills in technological adaptability, insight to unknown technological problems, vulnerability oriented systems, team communication, and the ethics of hacking. Furthermore, they needed their training to be rapid and efficient, emphasizing both “offensive and defensive” measures. After lectures didn’t work, their solution was to train the hacking neophytes through ten highly interactive workshops, engaging the neophytes to work on problems together, but without any experts. It worked; through these workshops, primarily performed on their own, the hacking neophytes became very creative in finding vulnerabilities of technological systems. They won awards at international competitions, and Barth and Luft report that the collaborative self-training process has continued to work in training new neophytes. The interactive workshop technique that they applied appears to be another unique approach to engaging neophytes to work at the edges of knowledge in a variety of expert areas that require specialist knowledge, expert intuition, and unexpected challenges that require both insight and risk-taking when confronted with the unknown.

What these representative presentations from only one conference are suggesting is that another feature to “informing science,” can be “making science.” In other words, we can include within the intention of informing, the further intent for our clients to participate in and contribute to the breakthroughs of our science, assisting us in performing the inquiries we are undertaking, the questions we are asking, and the analyses we are creating to arrive at better understandings.

Evidence from New Work on Innovating, Creating, and Learning, as Supported by Information Technology

When it comes to understanding edGe-ucating from recent and on-going research into innovation, creativity, and learning, we cannot avoid the ubiquitous presence of the computer, and its technological companions in generating information access, transfer, delivery, and connectivity. Thus, I will not refer to technology or information technology as a separate topic in presenting the following evidence, but instead will focus on comparatively new understandings of how innovation and creativity can be promoted and supported, understandings that suggest an array of possibilities for the successful engagement of neophytes with the frontiers of expert thought. Many of these understandings will, quite naturally, be integrated with technology.

Crowd sourcing is an example of one new approach for tapping into the sources of knowledge and creativity held by many outside of a particular expert enterprise (e.g., Brabham, 2008; Mau, Leanord, & The Institute Without Boundaries, 2004; Surowieki, 2004). Brabham refers to the aim of crowd sourcing as “harvesting distributed intellect” (Brabham, 2008, p. 80), which is also the aim of edGe-ucating, where “harvesting” contains the purpose of breaking through a frontier. One recent example of crowd sourcing to break through a frontier, is a study of the biology of brain functioning by over 200 neurological scientists (Carey, 2012). This brain imaging study required a large data base to analyze genetic markers of specialized regions in the brain. The large numbers, about 21,000 people in this case, were required because of the variance in brain size and specialized brain regions between individuals. “I like this work a lot,” said a professor not involved in the project, “because these guys finally did what needed to be done to take a real stab at merging imaging and genomics.” Paul Thompson, a senior author of one of the papers, reviewed the process in the following way, “What’s really new here is this movement toward crowdsourcing brain research…it gives us a power we have not had" (Carey, 2012). Future approaches to harvesting distributed intellect could include neophytes across the world being brought to the edges of specialist fields and subsequently working on the unsolved problems of these fields alongside expert researchers.

Current critiques and analyses of crowd sourcing (e.g., Brabham, 2012) demonstrate that crowd sourcing has a range of problems and challenges that have not been resolved, such as intellectual propriety, but they also conclude that crowd sourcing is showing a potential for distributed, plural, and collaborative work that is worth the time to pursue and to perfect in specific circumstances. The suggestion here is that edGe-ucating is a ripe circumstance where crowd sourcing strategies can be adapted to engage a wide range of neophytes to work on the frontiers in a variety of fields.

Bell Labs and now Facebook, Google, and a wide range of office designers have a different approach to ensuring innovation in specialist areas. Instead of identifying and then sending out a specific problem with a request for wide-scale engagement with the problem, as crowd-sourcing does, the approach to innovation adapted from Bell Labs by Google, Facebook, and others has been to ensure that unplanned interactions occur between specialists of different fields. In Pixar, for example, this included not only placing meeting rooms and the coffee bar into the central atrium, but all the bathrooms of the entire building there as well. In this way, Steve Jobs thought, everybody from different departments and specialties would run into each other, by accident, which is how ideas percolate and innovation emerges from the spark of (often unexpected) human friction (Lehrer, 2012). A more recent example is the return of Yahoo home office employees to the central office building, with the expressed purpose of expanding creativity and innovation within the company through personal engagement, both planned and unexpected (Miller & Rampell, 2013).

Gertner (2012) describes in some detail how Bell Labs successfully developed this approach of continuous interaction across specialties from the 1920's to the 1980's, with innovations as widely spread as the transistor, laser, silicon solar cell, and Unix operating system. Lehrer (2012) goes on to capture many of the more recent adaptations of this approach to creativity, including the MIT Linguistic department in the 1950's (including Noam Chomsky), and the research of Isaac Kohane at the Harvard Medical School that showed the best research (determined by the number of subsequent citations) was performed "when scientists were working within ten meters of each other" (Lehrer, 2012, p 25). The Italian National Center for Nuclear Fission's approach to embedding high school students within the community of researchers may be an example of edGe-ucating that directly reflects how this approach of continuous engagement can be effectively applied to neophytes learning how a field works at its frontiers.

Diamandis and Kotler (2012) propose that we are entering a period of radical transformation with the potential to raise basic standards of living for all. Two sources for their optimism are the recent increase of advances of do-it-yourself innovators with comparatively few resources and the rising potential of the world's poor who, through technology, can implement solutions to their own local problems. Gertner (2012) suggests that what is most important is the evidence of what technology may be doing to increase the mass potential of the poorest. That is precisely the primary role of edGe-ucating: to make it more possible for all citizens of the world to address the problems that they are encountering in their lives, by applying the best in human thought and understanding by putting their own intellects, understandings, and insights into doing better than experts can.

When we refer to evidence that all citizens can contribute to invention at the intellectual frontiers of understanding and problem solving, we need to go directly to what all humans bring to intellectual work. Homer-Dixon (2000), for example, describes the role of our frontal lobe in human ingenuity, noting that many of the functions that all our brains do best, like pattern recognition, inference, strategic planning, and creativity, are performed better in our shared frontal lump of gray matter than in the hardware and software of computers. He then quotes from Romer on the significance of *ideas* in economic growth:

> Our knowledge of economic history, of what production looked like one hundred years ago, and of current events convinces us beyond any doubt that discovery, invention, and innovation are of overwhelming importance in economic growth and that the economic goods that come from these activities [i.e., ideas] are different in a fundamental way from ordinary objects. (Homer-Dixon, 2000, p. 225, from Romer, 1993)

Homer-Dixon goes on to review Romer's arguments about ideas versus what economists call "human capital." Romer's primary distinction is that ideas exhibit increasing returns, whereas labor or capital decline over time. The economic benefits derived from investment in the production of useful ideas continue to expand in usefulness over time; investment in labor and capital retract over time.

This distinction between labor, capital, and ideas is a basic argument for the promotion of edGe-ucating. Ideas, especially new ideas, make a significant difference to human development. Richard Lester and Michael Piore (2004) explore the economics of idea generation from their research applying case studies of industrial innovations, from cell phones to jeans to brain imaging medical devices. Their primary conclusion from their research is that rational problem solving dominated the management and engineering practices of these new product developments, but that an equal and absolutely crucial feature for innovation, a feature that has not been supported or even acknowledged, is what they call, "interpretation." Interpretation occurs when conversation is open-ended, on-going in time, often with no fixed goal of where it will be going or end. They point out that the stark contrast between interpretation, analysis, and problem solving is that interpretation "plays in the space of ambiguity" (Lester & Priore, 2004, p. 53). They address the lack of support for this essential feature for innovating and conclude that interpretation can occur more readily by creating "public spaces" and by adjusting the private proprietary rights to knowledge. In their conclusion, they state:

> A sensible policy for innovation must balance the much-emphasized need to protect private rights to control access to knowledge with the under-appreciated but critical need to protect the public spaces from which economically significant new knowledge so often emerges. (Lester & Priore, 2004, p.192)

What we can add to their conclusion is that "public spaces," including attention to public access to knowledge, are absolutely essential for edGe-ucating to thrive. The inclusion of the general public, neophytes in developing new ideas has the same needs for a policy of proprietary rights to knowledge creation. That brings us to some of the challenges to edGe-ucating that the evidence has raised.

Current Challenges to EdGe-ucating as Raised from the Evidence

There are, of course, many challenges to anyone promoting or experimenting with edGe-ucating. Although challenges will differ for specific contexts within professional backgrounds, I will raise representative challenges, first as they refer to scientists, researchers, and problem solvers within their fields of inquiry, and second to educators at all levels of their practice. As I have throughout this article, I am including social activists as problem solvers as well as the many professions that are aimed to identify, prioritize, and resolve specific problems in their respective areas of expertise. These professions include engineering, business, community organization, and social reform, for example.

Challenges to Scientists and Problem Solvers in Specialist Fields

Some challenges that edGe-ucating brings to researchers and problem solvers are currently being experienced. Greater teamwork, for example, has been identified by many as a challenge to producing new breakthroughs, primarily because many 21st century problems are now interdisciplinary in scope, due to their complexity and to the expanded increase in relevant data that cuts across disciplines. Teamwork is also being promoted because current insights, connections, and ways to play off what has recently been constructed in other fields are considered significant to future breakthroughs gained from scientific inquiry (e.g., Brockman, 2008). EdGe-ucating folds into the current challenge of working in scientific teams by adding non-traditional members to those teams, along with the challenge of training these newcomers in new ways. This may include adding educators to the team: professionals who can add insight into how neophytes may be trained most efficiently and effectively in contributing to specific inquiries.

A second challenge that edGe-ucating can bring to researchers and problems solvers is the distribution of work on an inquiry with an added level of participants. A research team would not only contain experts in specific fields, along with educated and highly trained apprentices, but a third category of trained neophyte would be added, persons for whom working on this one event may be a singular experience. This challenge can be worth the required effort from adding a mix of neophytes working to solve a problem with expert understandings as has been shown in many of the previous examples.

A third area that has been noted as a 21st century challenge to researchers and problem solvers is how to acknowledge the contributions from a variety of participants in the research. This area is being resolved in ways that reflect the democratic and open nature of professional research in all areas of inquiry. EdGe-ucating supplies new considerations for future solutions.

The fourth challenge for researchers in specialist fields of inquiry, and for problem solvers, is the challenge of identifying intellectual property rights. Lester and Priore (2004) raise the importance of this challenge to change current laws and policies to increase the support of innovative ideas. Having participants who are temporarily engaged in an inquiry may further complicate the solutions that are being offered to this challenge.

In summary, it would appear from these examples of challenges that edGe-ucating brings to researchers and problem solvers do not create entirely new categories of challenges currently facing successful practices in the 21st century. Although edGe-ucating would add a new classification of team member, the challenges brought on by edGe-ucating appear to be resolvable by applying a similar kind of flexibility and creative engagement as has already been acknowledged and applied in science and problems solving. More important is how the practices of science could be improved and the support, involvement, and understandings of science could be dramatically increased for comparatively little investment. Societies throughout the world would benefit from the ingenuity and productivity of open engagement that citizens can bring to inquiry and to local and societal problem solving.

Challenges to Educators

Educators who want to engage with edGe-ucating are faced with a large set of challenges, challenges perhaps more complex than those raised for researchers and problem solvers. The first challenge to educators engaging with edGe-ucating is that they would be required to have an interest in the frontiers of human understandings. Educators would need to go beyond their professional training and experience, beyond anything most professional educators have done in the past, if they are going to apply their professional insight, expertise, and educational ambition to guide neophytes to the edges of the known and beyond. EdGe-ucating would require new understandings for teaching and learning, for designing curriculum, for organizing information and practices for learning. It would require new interest in what education can mean at the frontiers of intellectual work, on what is not known rather than on what is known. It would mean drawing up a new purpose for education, a purpose beyond any proposed in the past two millennia.

Educators involved with edGe-ucating would have to recognize that the significant part of science, of knowledge, is the creative work performed at the boundaries, not only on what has been, or is being produced. The 1956 debate between the physicist Jerrold Zacharias and the educator Jerome Bruner (Dow, 1997) would have to be played over again, only this time Zacharias would win.

As new educational strategies are developed for bringing neophytes to the edges of scientific work, imaginative new curriculum designs would be required. Perhaps "curricular moments," for example, could parallel "teachable moments." Integrating education with the intellectual borders of limitless fields of inquiry, and with the workers engaging with those borders, may dramatically transform the field of education. Educators would need to be intellectually and professionally engaged with the significance of uncertainty, ambiguity, and the resulting public debates around knowing and not knowing. New ambitions, goals, and purposes for education would be required, along with new areas and strategies for instruction, for curriculum, for educational research, and for cognition, learning, and creativity. Certainties like "the basics" would have to be traded with uncertainties like the arts. Consequently, the burgeoning field of educational assessment would need to be fundamentally redesigned as well.

Would these transformations be experienced in the schools and institutions currently oriented to educating students? Greenspan's study (2008) suggests perhaps not, based upon teachers' (and students') perceived periphery of working at the edges of knowledge within an award winning suburban American high school. Although edge-work was being performed in the school by teachers and by students, it was not being valued (or often acknowledged) by either teachers or students. Greenspan's study and continued analysis (Fox & Greenspan, 2011) suggests that schools are ill prepared and currently incapable of addressing the frontiers of knowledge with the uncertainties involved. Extensive interviews of six teachers from different disciplines showed that they did not consider working at the frontiers as part of their job, or of their students' work.

Of course, schools are not the only educational institutions that are ill prepared to confront the demands of edGe-ucating. Universities and other public and private research institutions and agencies are likewise ill-prepared. This is a common challenge to all involved in inquiry and the creation of new knowledge, along with teaching.

In summary, educators, we have deep professional problems if we want to support and engage with edGe-ucating. Yet it could be worth our effort in terms of the excitement, renewed curiosity, and increased professional energy stimulated by engaging with the intellectual unknowns of our own profession, along with those of all other inquiry based professions.

Conclusions

This article has suggested how a learning society can be defined as a culture in which citizens with little previous training can be supported and guided to work on intellectual unknowns. We can create strategies for engaging citizen's imaginations that will restructure, replace, or at least alter the templates which educators, researchers, and most problem solvers have been applying since ancient times. More important, as can be seen from the evidence supplied in this article, we have experiences that we can draw on to bring neophytes to the specialist edges of what is known, and subsequently participate in breaking through these frontiers of specialist understandings.

The evidence makes clear that our visions for "informing" can go beyond bringing what is known and valued to others who have not been trained in our respective fields of expertise. Our professional ambition can include bringing neophytes into our specialized research. The evidence also suggests that such a process could become the most powerful, efficient, and successful approach to informing, as well as to the primary purpose we have for informing citizens, which is to have them engaged in improving their own lives.

What is also clear is that edGe-ucating proposes to go beyond historical assumptions about learning being focused on what is known and valued. EdGe-ucating is a process aimed to democratize intellectual breakthroughs, replacing more recent assumptions about specialized experts being the only ones who can create new knowledge. But edGe-ucating is also accompanied with real challenges for each of us if we are to re-imagine what research, problem solving, and learning can mean for societies and cultures throughout the world if all citizens were prepared to enter into our investigations.

The economist Paul Romer has important advice for us as we consider the potential of edGe-ucating.

> Every generation has underestimated the potential for finding new ideas. We consistently fail to grasp how many ideas remain to be discovered… Possibilities do not merely add up; they multiply. (Brynjolfsson & McAffee, 2011, p. 74.)

Within all the uncertainties raised in this paper, one thing is certain. The intellectual energies of citizens working at the edges of knowledge would benefit all societies, including developing countries as well as minority cultures within developed countries. Cavallo and others (e.g., Mayur and Daviss, 1998) have demonstrated that these intellectual energies can be tapped in villagers in Thailand and elsewhere in the developing world. Cavallo's concluding statement from his work is the following:

> 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. (Cavallo, 2000, p. 782)

EdGe-ucating is a serious attempt to acknowledge and then apply the latent learning potential of the world's population. It is a call to scientists, problem solvers, and educators to work together in designing new directions for engaging citizens of the world in the work at the edges of our understandings, including resolving problems within the local and global environments in which they, and we, are living.

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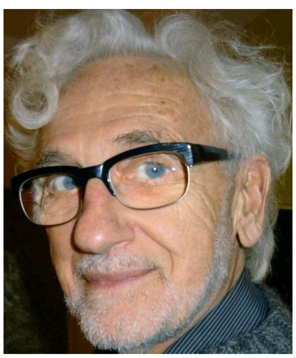
Biography



G. Thomas Fox is a professor and Faculty Co-chair of the National College of Education, National Louis University. Since the mid 1970's he has been a researcher of higher education, applying qualitative and quantitative research methods, and has also been active in teaching action research with teachers in the U.S., England, and Iceland. His research has emphasized the power of engagement in research for re-forming educational policy and practice. Considering this emphasis, he has applied alternative communicative forms for engaging with re-search such as graphics, photography, poetry, music, and story-telling. His current research focuses on the possibilities and practices for neo-phytes to participate at the frontiers of expert fields of inquiry, for the purposes of increasing the power of research, addressing local problems that have resisted expert attempts, and for improving the nature and effectiveness of democratic societies through a new aim for education. He calls the processes of engaging neophytes in research and problem solving, "edGe-ucating." In the past 5 years, he has presented edGe-ucating at eight peer-reviewed inter-national conferences in order to introduce the possibilities for democratizing intellectual break-throughs to a variety of researchers, educators, technologists, and social problem solvers.