Engaging All Citizens in Research and Problem Solving Through EdGe-ucating

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ABSTRACT

Current information access by citizens of all societies, along with the globalization of expert inquiry, suggest that nearly everyone can be successfully involved with intellectual frontiers – if they are efficiently educated to do so. This paper suggests calling the efficient processes of bringing neophytes to work at the edges of the known, "edGe-ucating." We have many experiences of what can be done to edGe-ucate neophytes of all ages. David Cavallo, an MIT engineer, for example, has guided Thai villagers, among other populations, to break through expert understandings to address specific local problems that require "sophisticated mathematics, biology, engineering, physics, and computer science." One implication from recent research and experience in bringing neophytes to the frontiers, and beyond, is that there is a new strategy for integrating research, education, and problem solving. This new strategy includes new approaches to curriculum, and new relationships being drawn between educators, researchers, and expert problem solvers. The purpose of this paper is to challenge researchers, educators, and problems solvers (along with our institutions and agencies) to engage together with the professional adventures of democratizing intellectual breakthroughs through edGe-ucating. Included are suggestions for next steps to be taken for edGe-ucating to become a common reality.

Keywords: integrating research and education, preparing neophytes for research, educating for the frontiers, edGe-ucating

1. INTRODUCTION

This is an interesting time to be a scientist, educator, or problem solver. Scientists are being doubted for their morality, while also being promoted as the primary movers for expanded (or even continued) economic growth. Educators are considered essential for societal development within the global economy, while also being told that anyone can do the job since research can identify how successful learning occurs. Problem solving is being hailed as the primary cognitive trait for economic success, while political action and social process demonstrates how seldom realities are being applied in social, economic, political, or individual decision-making. Any profession that is undergoing such public contradiction must be alive and enriched. And we are. We can all anticipate, for example, that our respective professions will become more integrated through democratic participation and engagement, regardless of background, training, or educational background. Information technology and social media make full participation inevitable. This paper suggests how to harness the energy of citizen participation in learning to work at the frontiers of scientific breakthroughs. It suggests that this can be done by applying educational experiences of the present and the past (often not in schools or universities), and it calls for a new curricular strategy to educating citizenry for work at the frontiers of what is known. This new strategy will be called "edGe-ucating."

The purpose of this paper is to challenge researchers, educators, and problem solvers aimed at developing societies through new thought and action. Two opposing facts are made clear. One is that edGe-ucating is possible. Neophytes can be brought to work at the edges of expert knowledge with considerably less energy and time than currently applied. The other is that neophytes will not be regularly contributing to the edges of knowledge without a great deal of effort and change in habit by those in expert fields of inquiry and problem solving as well as by educators. The paper begins by describing the methods of inquiry applied in this study. It then defines "edGe-ucating," and captures the nature and processes of edGe-ucating through a selected variety of examples. Strategies for edGe-ucating are gleaned from these past experiences, along with challenges that can be anticipated by researchers, educators, and problem solvers taking on the transforming possibilities in edGe-ucating. Suggestions are offered for possible next steps in preparing everyone within our global learning environments to contribute to the development of new understandings. The paper concludes that there are alternatives to the templates that have been applied to learning, inquiry, and problem solving over human history. It proposes that edGe-ucating is a serious strategy to acknowledge and address the latent learning potential in all humans, along with previously unimagined opportunities for access to the frontiers of human thought.[1]

[1] This organization leaves one major feature out of the discussion of this paper, a statement of the societal and professional benefits of edGe-ucating. Many of these benefits are included within the contexts and purposes stated for the Symposium (see [7], [14] and [15]), and they are also referred to in a previous paper by this author [12].

2. METHOD OF INQUIRY

The method of inquiry applied for this study is eclectic, reflecting on past breakthroughs in the sciences and other fields of inquiry, including recent accounts that document contributions to expert fields of inquiry by neophytes in the field, and from personal experiences in classrooms of elementary through graduate schools. The study began with philosophers of science questioning what is happening on the frontiers of inquiry, such as Feyerabend [10] and Serres [26], and includes the serious debate between the physicist, Jerrold Zacharius, and the educational psychologist, Jerome Bruner on the relationship of education to the nature of inquiry at the edges of science [9]. The initial stages of the research also applied an historical and case study mode of inquiry to capture the existence of intellectual breakthroughs by neophytes in fields of inquiry (e.g. Fox [11]). The intent of this stage of the study is not only to identify situations where neophytes have broken through expert understandings, but to identify possible reasons for these successful breakthroughs, and to analyze to what extent the lessons being learned through neophyte engagement with the frontiers of knowledge can be applied to current educational and curricular practices, purposes, and theoretical outlooks (e.g. Fox [12]). Finally, the study has included references to the roles of recent information technology in bringing the frontiers of knowledge to all citizens of this earth (e.g. Gleick [16], Kelty [22]).

3. WHAT IS EDGE-UCATING

Any student of any age can enter the frontiers of expert understandings in any field of inquiry, and reach beyond them. We can call the effort to guide a neophyte to work at the edges of the unknown through intent, design, and practice, "edGe-ucating." EdGe-ucating, then, is taking a neophyte to the frontiers of what is known for the purpose of extending that knowledge. Furthermore, we can acknowledge that edGe-ucating can occur within very short educational periods – a few weeks or less in some cases. Thus, edGe-ucating is considerably more efficient in the time required for a neophyte to contribute to the frontiers of knowledge than what current educational theories, curriculum designs, instructional practices, specialized research fields, or knowledge institutions assume or habitually enact. EdGe-ucating also takes less energy in terms of professional support and engagement than it currently takes to get neophytes to the edges of knowledge, and beyond.

4. EXAMPLES OF EDGE-UCATING

We have many experiences of what can be done to edGe-ucate neophytes of all ages. *BioQuest* [2; 21] 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 [5], 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." And they accomplished this in "extremely short time frames" of a few months. As one difference between BioQuest and Cavallo indicates, there are two steps to edGe-ucating. The first step of edGe-ucating is to bring neophytes to the frontiers of the known; BioQuest is one of a variety of approaches have done that successfully. The second step of edGe-ucating is to provide guidance and opportunities for the neophyte to extend beyond an edge of expert knowledge; Cavallo is one who has done that purposefully, and successfully.

Brockman [4] created the term, "third culture" (adding to the two cultures of C. P. Snow [27], first published in 1958) to describe a variety of expert researchers who communicate the frontiers of their fields to general readers. The number of these "third culture" researchers has increased considerably since the term was created. More recently, Brockman has begun a web site, edge.org, to promote greater communication and interaction between researchers across the frontiers of their respective sciences.

An educational step beyond researchers extending new frontiers through their dialogue across disciplines is neophytes going beyond their expert trainers and contributing to the production of new knowledge. Cavallo [5] provides an example, but there are many examples of neophyte production of new knowledge that can be considered, including those described by Paolo Friere [13] and Miles Horton [19]. Horton, for example, brought experts from a variety of fields to his Highlander Folkschool to engage with union leaders, civil rights organizers, and other local leaders, expecting the local organizers to improve upon expert understandings while putting those understandings into action. Other examples come from more recent times as more movies are created for and produced on the web than in Hollywood, child cartoonists are publishing their work, clothes designers under ten years old are having their designs manufactured, and best sellers are being produced by young and unschooled teenagers in countries from China to India to Italy. These examples reinforce historical accounts of neophytes going beyond experts, such as the "computer" Henrietta Swan Leavitt discovering how to measure the size of the universe in the late 19th century [20].

In addition to the above examples that occur outside of formal schooling, Greenspan's research [17] on the presence of edGe-ucating in a suburban U.S. high school provides recent data on how the presence and the absence of frontier work occurs within a high school. Greenspan, a high school science teacher, describes two

projects to engage students in making some intellectual breakthroughs of their own. One was a project to involve students with piloting a multi-user virtual environment curriculum alongside educational researchers at Harvard University [8]. What made this experience interesting is that the high school students were more engaged in advising the expert designers of the piloted curriculum on how to redesign their curriculum than they were in performing the instructional features expected of them. Greenspan's other example was students making inventions of their own, from conception to design to actual product.

These examples bring up the possibilities of neophytes working closely with experts in a specific field of inquiry. Occasionally this has happened, for example, when 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 occurred in 1991, just after the USSR fell, when many world-renown scientists had no salary for months. That meant the pay they got to work with these U.S. high school students was welcome. These world renowned scientists reported that the previously barely trained students did help in their research [28].

A current example of students working with scientists on their frontiers is occurring with physicists at the Italian National Institute of Nuclear Fission at Frascati [6]. 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.

The Sloan Digital Sky Survey, "Galaxy Zoo" is probably better known. Galaxy Zoo enlists the help of students and anyone who wishes to participate (http://www.galaxyzoo.org/). In one 60 minute time session, amateurs can be tutored and then recruited to help classify Hubble images. The fields of astronomy, historically with too much data to analyze on their own, often look to amateurs and neophytes for help (see [30; 25]).

5. STRATEGIES FOR EDGE-UCATING

An analysis of many examples of past and current forms of edGe-ucating suggest two primary meta-strategies through which neophytes can be intentionally guided to assist in producing new knowledge. One is through primarily pedagogical means, where the focus is on developing a curriculum for neophytes learning what is required to work at the frontiers, and preparing for the necessary qualities required to help in making breakthroughs within an expert field of inquiry. The second is by embedding 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 as they work at the frontiers of knowledge. These two strategies are listed below; each with two examples of different approaches to demonstrate how these strategies can be applied. It should also be apparent that these are not two entirely distinct and separate strategies, but can be applied in tandem.

Pedagogical: Bringing neophytes to the edges of the known

Bioquest [2] and Brockman [4] are two examples of scientists bringing students and neophytes to the edges of a field of inquiry. They each describe how a researcher's careful analysis of prerequisite knowledge can be applied for neophytes to get to the frontiers of their respective fields of inquiry. There approaches include providing the language (linguistic and visual) necessary to communicate the knowledge and the unanswered questions at the edges of their respective fields. From a curricular perspective, these approaches to getting neophytes to the edges of the known are quicker, more efficient, at least as effective, and generally on a larger scale than current curricular approaches and their theoretical underpinnings have allowed.

Pedagogical: Dealing with local unsolved problems that require expert knowledge along with uniquely held local knowledge

A related approach to engaging neophytes with problem solving is to engage those within a culture with a local unsolved problem, but bringing to them the specialist expert understandings required to solve the problem along with the required local knowledge that they already have. Cavallo [5] has the following advice on working with untrained local community members with the aim of their solving local problems that a) require expert knowledge in more than one field, and b) cannot be solved by these same experts because they do not have the local knowledge required. Requirements for this kind of edge-work to be successful are:

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

Once these three criteria are reached, Cavallo demonstrates how local persons can produce breakthroughs in solving local problems that experts could not solve, sometimes in less than three months. Perhaps we should 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 piece that is a new challenge to many educators, who could follow the examples of Horton [19] and Freire [13].

Environmental: Embedding neophytes in inquiry cultures

The Italian National Center for Nuclear Fission's approach to embedding student scientists within the community of researchers is significant, especially when neophytes need to experience the realities of expert knowledge being uncertain, unknown, and being built through continuous inquiry and interaction [6]. At the National Center of Nuclear Fission at Frascati, it is being assumed that the assumptions about knowledge, the language, and the approaches being applied at the frontiers of their field are culturally as well as professionally embedded. Thus, neophytes must experience the culture of the scientist to be able to engage in the work at the edges of the field, which is why the high school students live with the researchers for weeks at a time.

Environmental: Creating "hybrid interactional practices"

Hall & Jurow [18] suggest the term "hybridity" to describe how students can make sense of, and participate in, various social practices outside of the classroom. The goal of hybridity is for students to participate in their own learning, while also contributing to society by engaging with those who are working in the field. For example, Kirschner and Geil [23] analyze 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 [18] studied hybridity in a middle school math class, where mathematicians were brought into contact with the students in an effort to involve them in experiences that encourage their participation in the field of mathematics by applying mathematics to solving real-world problems. Viewing the classroom as a venue for hybridity could be considered to be a way for neophytes to deal with local unsolved problems that may require the application of frontier knowledge.

6. THE CHALLENGING TRANSFORMATIONS OF EDGE-UCATING FOR RESEARCHERS, EDUCATORS, AND PROBLEM SOLVERS

The challenging transformations of researchers through edGe-ucating

What happens if researchers were engaged with neophytes working at the frontiers of their fields? Efficient communication with neophytes would require clear language, and deciding what would be necessary to bring a neophyte into a contributing role within the investigation. An initial transformation for researchers would be their increased attention to the language, concepts, and analyses required for someone not trained in the field to work side by side on the inquiry with the researcher(s). This is not an entirely new challenge, but it does go beyond the goal described by Brockman [4]. Instead of communicating only the nature of inquiry at the edges of the field, one is informing neophytes in order that they can be expected to aid in the inquiry process. New skills would be required if researchers were to do this well.

Nearly every 21st century researcher knows that teamwork is required to produce new breakthroughs. EdGe-ucating, of course, would be even more challenging in terms of organizing and integrating a number of neophytes to work at the frontiers of specialist research. Likewise, however, an expansion of breakthroughs could be anticipated with the work force at the edges of science would be dramatically increased. With greater participation from a variety of untapped experiences, understandings, and connections, a huge range of participation, and greater focus on leadership, experience from group work suggests an immense potential for new breakthroughs in every area of science and investigation, and the resulting generation of new knowledge.

We can also expect alternative ways of investigating if the new challenges of working with neophytes were pursued. With expanded roles for team players, it can be expected that the processes of inquiry will be enhanced, and the attempts to inquire, explain, and question may be expanded, and enriched. We will have opened up our uses of language within our respective fields of research, through our attention to accurate terminology and precision of capturing actions and relationships that can communicate fully to outsiders working with us on our research.

We are considering here the effects of democratizing research at the edges of our respective fields, a back to the future move as Strafford [29] suggests in her study of the beginnings of 17th century science. As Strafford and others describe the early intellectual communities of scientific investigation, anyone could join. No certification required. There were no rules for who should be engaged in deep conversations around their discoveries, questions, and surprises. Science was a community of inquirers, open to all. That changed as many began to worry about charlatans, fake inquirers. The solution was to replace graphic illustrations, readily accessible to all, with specific linguistic terminologies designed to communicate fully only to select specialists. That solution has worked only too well in the past three centuries [29]. EdGe-ucating could make research a democratizing activity once again. The primary rule of research has always emphasized that the results of science be independent of the reputation of the scientist.

The challenging transformations of educators through edGe-ucating

Educators would have to begin to have an interest in the frontiers of what is known. They 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 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 for the purposes of learning. It would require new interest in the engagements at the borders of scientific investigation, but also of what education can mean at those frontiers. If not, educators would be pushed aside by others involved in educating neophytes at the frontiers of knowledge and inquiry.

Educators would have to recognize that the significant part of science, of knowledge, is the creative work at the boundaries, not only on what has been produced. The debate between the physicist Jerrold Zacharias and the educator Jerome Bruner would have to be played over again, only this time Zacharias would win. As Dow [9] captures their debate, it started as both were co-directors of the Woods Hole Conference of 1959, and the debate continued through the publication of Bruner's *Process of Education*. Zacharias argued vociferously that working at the edges of science was an entirely different enterprise than working with the knowns of science. Zacharias wanted this fact acknowledged by science educators, but, as we know, he lost that argument [9]. And so did education for the rest of the century.

As new educational strategies are developed for bringing neophytes to the edges of scientific work, imaginative approaches to organizing curriculum will be required. "Teachable moments," for example, could be replaced by "curricular moments." Integrating education with intellectual borders of limitless fields of inquiry, and with the workers engaging with those borders, would dramatically transform the field of education. Educators would need to be engaged with the roles of ignorance, uncertainties, ambiguities, and the resulting public debates around knowing, in ways that few educators have entertained. New ambitions, goals, and purposes for education would be required, along with new areas and strategies for instruction, for curriculum, for educational research, for cognition, learning, and creativity. Certainties would have to be traded with uncertainties. Consequently, the burgeoning field of educational assessment would need to be fundamentally redesigned as well.

Would these transformations be experienced in schools and institutions currently oriented to educating? Greenspan's study [17] suggests perhaps not, based upon teachers' (and students') perceived periphery of working at the edges of knowledge in 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. Extensive interviews of six teachers from different disciplines showed that they did not consider working at the frontiers part of their job, or of their students' work. Educators, we have a problem here.

The challenging transformations of problem solvers through edGe-ucating

21st century problem solving is already transforming as many problems and their solutions become more accessible to the general public. Information access, particularly information from the frontiers of science and inquiry, has been increasing exponentially along with the recognition that knowledge itself is not the key to economic growth -- creativity and innovation is. The primary question is not what science and education can do to assist leading this transformation, but what could happen to the ubiquitous nature of problem solving if nearly all citizens were working at the edges of expert understandings? If all were being edGe-ucated, nearly every citizen would become a potential problem solver. Not because she or he knew all the answers, but because they would begin to know the kind of hard work, attention to detail, interaction, teamwork, and trial and error that is required to accomplish success in productivity through public analysis. An example of this is Berger's work with elementary and middle school students, where, among other tasks, the young students designed, and then built their own house [1].

When nearly every citizen experiences the nature of genuine inquiry, and gains a better understanding of the nature of human knowledge, along with how the challenges of intellectual creativity are applied on specific problems, an entire society can feel the effects. Information would be better understood and criticized, decisions could be better made as well as better informed, the actions of a democratic society could be conducted in ways that it never has. Failures would be understood as necessary. This would occur not because we would have a society of scientists, but because citizens of all walks of life, all sorts of beliefs, working contexts, cultural backgrounds, religious backgrounds, political leanings, and ideologies would also have experiences of working at the edges of the known. More than that, they would have a deeper understanding of the generation of human knowledge because they had been engaged in these actions from their own contexts and understandings. A whole society would have a rich understanding of the possibilities and the potential of human intelligence gained from their own collective experiences, experiences that included the hard work involved in trying to make intellectual and scientific breakthroughs. Problem solving would be a natural

activity for all citizens to be called upon to address and resolve, regardless of where they live and work.

We can anticipate that a society which supports edGe-ucating would experience a significant increase in innovation and breakthroughs in a variety of problem areas. We could also expect that the general population itself would demonstrate much greater understandings of what problem solving entails, along with what "knowledge" means, and especially the demands of the work of imagination, trial, and error in resolving difficult problems. The society's general population would not only understand, but they would have experienced the importance of dialogue and questioning certainties as actions are taken. There would be a dramatic increase in the number of citizens who appreciated the meaning of action in the identification of and resolution of problems.

7. NEXT STEPS

The following is a proposal for next steps that could begin a serious movement towards making working at the frontiers of knowledge a reality for the world's citizens, and getting them there part of our work. The suggested steps are offered for discussion and debate from our varied perspectives. One thing that we can all agree on, however, is that our specific areas of expertise and experience would need to be expanded and perhaps transformed if breakthroughs were able to be contributed to by the general populations in our respective societies. In this regard, the following four basic steps are offered as a beginning set of steps to make edGe-ucating a greater focus of our work.

Record past, recent and current edge-like activities

We need to develop greater documentation and analysis of past, recent, and current edge-like activities in engaging neophytes at the frontiers in all fields of inquiry, and in problem solving. This paper and study is only a beginning, but even this paper represents little of my own library on past and current edge-like activities, to say nothing of others who have found successes and possibilities in neophytes contributing to scientific breakthroughs and solving primary problems. These documentations and analyses would include the range of actions that are occurring because of developments in information technology and social networking that promote interactions and investigations across the world. As the work of this study suggests, a library of breakthroughs in a variety of expert areas, inside science, education, and problem solving, and outside, would be astounding in its variety to observers. Even more important, that collection would also be fundamentally significant to future designs for edGe-ucating, and especially for understanding the human capacities for engaging in intellectual breakthroughs. And it could be the basis for piloting more successful, larger scale approaches to edGe-ucating.

Form teams to analyze and plan different strategies for edGe-ucating

We need a range of creative analyses of what can be done to edGe-ucate. The suggestion here is to form many teams composed of a few researchers, educators, and problem solvers on each team. These teams of scientists, educators, and problem solvers would continue the imagination and analysis of possibilities for edGe-ucating, including how to gain more participation, and doing away with the resistances that may occur in the various areas of our professional work. There are two features that can make this step significant. One is that a number of teams would involve a variety of different inquiry traditions, experiences, and working environments. That would not only provide for greater dialogue with conflicting views in developing new strategies, it would provide more experience in integrating the varied environments of our work: national, international, and cultural. The second feature of this step that could make for successful advances in edGe-ucating is how the teams may differ from each other, and thus form competing strategies, extending the range of possible plans for making neophyte involvement in frontier work possible throughout a much wider range of societies and cultural contexts. These teams may become blogs, websites, or other forms of promoting discourse across geographical and national boundaries.

Develop proposals for implementing edGe-ucating

The next step would be developing specific proposals for edGe-ucating to occur in specific settings, even over the resistances that can be anticipated from our respective professions and their environments. The development of these proposals would include involvement of a range of interested parties, including private and public organizations supporting inquiry, government and private agencies funding inquiry, public policy makers, and private decision makers whose understanding of the environments for inquiry and the ways to transform the environments of inquiry would be helpful. To make edGe-ucating viable throughout the international contexts in which they are being proposed, the proposals would include the following actions:

a) specify specific aims, purposes, and goals for edGe-ucating within a context,
b) pilot and research focused strategies and approaches to edGe-ucating,
c) develop new curriculum and pedagogy for edGe-ucating,
d) create a forum for communicating the procedures applied and their results,
e) decide whether this would be a matter of integrating current research and education and problem solving enterprises, or whether this would be a new field with its own specialists from these (and other) areas of expertise,
f) decide on the nature of the environment(s) in

which this work would be accomplished,
g) create a schedule of actions to implement edGe-ucating,
h) provide a process to document and communicate the approaches used, and the resulting experiences gained and lessons learned for others to apply or adapt.

Use these proposals to get funding for the specific actions listed above

These proposals can be made to public and/or private funding agencies (national, local, and international), to current organizations that are promoting inquiry and informing public understandings, as well as to organizations and agencies aimed at live-long learning and intellectual development.

Admittedly, these steps are truncated and briefly stated, but it is hoped that they can begin to provide a basis for immediate work among us as we consider the possibilities for increasing neophyte participation in and contribution to the work at the frontiers of human knowledge, and to solving the challenges of our 21st century and beyond.

8. CONCLUSION

This paper has suggested how a learning society can be defined as a culture in which every citizen is supported and guided to work on intellectual unknowns. We can create strategies for engaging citizen's imaginations that will alter the templates which educators, researchers, and problem solvers have been applying since ancient times. Our visions for educating can go beyond bringing what is known and valued to others. These visions can include alternatives to specialized research being conducted only by its certified members. EdGe-ucating proposes to leave behind historical assumptions about learning what is known and more recent assumptions about experts being the only ones who can create new knowledge. EdGe-ucating is aimed as a process to democratize intellectual breakthroughs, but it is accompanied with real challenges for each of us to re-imagine what research, problem solving, and learning can mean for societies and cultures throughout the world, including how better to integrate these professional enterprises.

Within all the uncertainties raised in this paper, one thing is certain. The intellectual energies of all citizens working at the edges of knowledge would benefit all societies, including developing countries as well as minority cultures within developed countries. Cavallo [5] and others (e.g. Mayur and Daviss, [24]) have demonstrated that these intellectual energies can be applied by villagers in Thailand, and elsewhere. Cavallo's [5. p. 782] concluding statement from his work in Thailand 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.

EdGe-ucating is a serious attempt to acknowledge the latent learning potential of the world's population, and a call to scientists, problem solvers, and educators to work together in designing alternatives within our global learning environments.

I will conclude with one more example of edGe-ucating. The following is a quote from the abstract of a research article [3] 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." [3]

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 we can all do better at guiding all our citizens to the edges of our respective expert understandings, and beyond.

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