

Chapter 2

Formerly ISE: Preparation for Continual Science Learning

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In order to prepare informal science educators for the future, we need to consider who they are, where they are, and what skills they need. I found myself rethinking the term *informal science education* (ISE, abbreviated throughout this chapter to save space, but to be read as the whole phrase) as a prelude to considering how we could prepare future educators. A memory came back to me. Years ago, when I had a bubbly three year old daughter dancing around in my kitchen, I became keenly aware and grateful for one instance of what I would call *informal science education*. She was hungry and had asked for a piece of cheese, as she had many times before. She took a bite and then, spurred on by her sister and brother, began to giggle at their antics. In seconds, the giggling changed to a gagging sound. I stopped my mixing and chopping to give her a tap on the back. The gagging did not stop. I turned her upside down and repeated the tap. No release. Her face began to change color. And then, from somewhere in my brain, there surfaced the directions and images I had seen on restaurant posters for the Heimlich maneuver. I quickly sat on a nearby step, positioned my daughter's back to me, clenched my fists and pushed up on her diaphragm. A wad of cheese spit out several feet across the room. She breathed easily and continued her play. I, on the other hand, began to shake, realizing how close we had come to a tragedy. The repeated pervasiveness of these posters—this *informal science education*—out-of-school information of the human body and emergency procedures—had probably saved my daughter's life.

This incident, real-life drama with a happy ending, is a short anecdote that compresses much of the nature and importance of continuing to learn science and to benefit from knowing how the world works. In the background were researchers studying human physiology and choking statistics, educators designing instructions, illustrators presenting clear visuals, health advocates insisting on the presence of these instructions, and my using the learning when called for. The anecdote tells

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a story of my benefitting from biology, physics, presentation skills, receptivity, policy (to make the information available) and collaboration (to display it in most eateries)—all packaged for the public. As a program developer and researcher, this event also provided me with a lived experience into the deep relevancy of continued science learning beyond schooling and an appreciation for my colleagues. Do we communicate this relevancy and offer the needed skills in this broad range of what continual science learning can mean?

The above anecdote describes a serious instance, a compelling case for *ISE*, but not the kind of example I usually read about in the literature. Much of *ISE* research has been generated from the institutions, programs/activities, and media that have been defined and been funded from the National Science Foundation (NSF). There is long standing recognition among education researchers and professionals about how important and pervasive science and public understanding are to us as participants through the course of our lives (e.g. Dewey, 1916; Kneller, 1978; National Commission on Excellence in Education, 1983; NRC, 2014; Rutherford & Ahlgren, 1990). Has this message reached the general public? That science is a human endeavor is a theme in teaching the nature of science, one that is clear in the *Next Generation Science Standards* (NGSS) and now propagated at every level of science teaching (Lederman et al., 2014; National Academies Press, 2013). Within schooling then, there are stated goals to teach students explicitly that science is indeed something we do as a natural part of who we are. Some people (professional scientists) choose to make a living doing science. The rest of us certainly need to be aware of what the scientists bring to light, and also to be aware of how we use our science skills in small ways every day no matter how we make a living (National Research Council (NRC), 2014; Tal & Dierking, 2014). What then of the messages beyond school, whose years are four to five times that of compulsory education? Enacting this encompassing perspective has enormous implications for changes in preparation, equity, policy and funding. For, instead of bemoaning the lack of science literacy, we could research and credit the science knowledge sought by everyone because we are all naturally motivated to learn what works in this world for us now and in the future. John Dewey wrote earlier in the 20th century, “The problem of an educational use of science is then to create an intelligence pregnant with the belief in the direction of human affairs by itself” (Dewey, 1916/1944, p. 225). The nature of science tells us that we must change the way we understand the natural and material world as evidence provides us with new insights. Is it not a basic goal of science education that learning how to continue to learn about the world is a key human necessity throughout our lives? And so, while I learned about the respiratory system in classes, I learned from pervasive posters that forcing air from my daughter’s lungs up into the trachea could push an obstruction out of this breathing passage, a combination of physics and physiology. The work of out-of-school science education colleagues made this possible.

I am adding my voice to a call for the perspective of continual science learning as a policy change. This will require educational adjustments in preparing both those of us who see ourselves as professionals and those of us who teach by questioning, modeling, mimicry and exploring beyond either schools or

ISE-designed experiences. This perspective—the basic human need that science fills—implies to me that continual science learning makes implicit the relationship of humans to the world, how we fit, how we adapt, and how we impact and sustain the life systems of which we are a part. The more I considered the preparation of *informal science educators*, the more I acknowledged that we are all participants, moving up and down in the consciousness of our participation throughout our lives. Therefore, future preparation for continual science learning may mean revising our vocabulary to expand and include in our vision those who do not now recognize the imperative, the opportunity, and their role in lifelong science education. In the recent NRC report, *STEM Learning is Everywhere* (NRC, 2014), Elizabeth Stage, Director of the Lawrence Hall of Science, says, “it’s the vision of science learning that needs to change...If we could change that vision, we could leverage all the public investment and private and independent investment....to be a game changer” (p. 44). This chapter then, is my contribution to this discussion of “game changing” in light of what it means to prepare for teaching within a new vision.

The Challenge of Words

A new vision of continual science learning requires a starting point that communicates beyond the professional research and education community to the non-professionals who are engaged, perhaps unwittingly. I have found that the term *informal science education* has not done this. Over the years, I have asked a wide variety of people if they knew what *informal science education* was, often in connection with talking about my work. It is rare that anyone provides an explanation that I do not have to modify. I believe that part of the confusion comes from the colloquial use of “informal.” Microsoft Word provides these synonyms for *informal*: relaxed, casual, familiar, easy, unceremonious, comfortable, easygoing and natural. Except for the last in the list, these words imply “unimportant” to me. And while I am making a case for *ISE* as essential and natural, grouped with the words above it on the synonym list, “natural” here suggests to me a meaning of “not requiring work or learning.” It does not surprise me therefore that *ISE* has not been well recognized by those with whom I talk in the professional *ISE* design and research field. This seems true even when I am in an *ISE* context during our conversation. In the Yorktown, Virginia U.S. Revolutionary War re-creation, I stopped at the army’s medical tent to listen to the costumed explainer speak about the medical services available in the 1770s and 1780s. He spoke about instruments, pain, medicinal herbs, bone settings, and amputations. He had studied his part to answer most questions. Did he know what *ISE* was? No, he did not. I listened eagerly to a young paleontologist talk about recent finds near a new parking lot at the La Brea Tar Pits in California. She talked about extraction methods, dating, and bone identification. She answered questions knowledgeably. After the group had dispersed, I said “hello,” and asked if she knew what *ISE* was. She had never heard the term. After a dinner with friends, we chatted about our lives. A man who has

worked in security at the U.S. Federal Emergency Management Agency (FEMA) had just retired from employment helping to control the outcomes of fires and floods across the country. He spoke about the hard work of communicating to people who had lost their homes about damage, disease, and safety. He knew both theory and practice. Did he know what ISE was? No. A young graphic designer who has moved into landscape design spoke with me about her need to learn more horticultural science to address the questions that came to her. She said to me, “I teach all day long. I teach about what plants work where because of light, elevation, and water conditions. I teach about insect and animal interactions. I teach all the time.” Had she heard the term *ISE*? No.

There are those of us who advocate for an alternate term, like “free choice” (e.g. Falk ed., 2001). There are others of us who accept that *ISE* is institutionalized, but do not feel that the term encompasses the whole of what we do or all who participate. Leonie Rennie has compiled the state of informal science education in her recent section for *The Handbook of Science Education Research, Vol. II* (2014) and notes that there is not a consensus for *ISE* among those of us who design, implement, and research out-of-school contexts. Irene Rahm plainly stated, “Informal science education is a broad field of research marked by fuzzy boundaries, tensions, and muddles among many disciplines, making for an unclear future trajectory (or trajectories) for the field of study” (p. 1). If we who work and study in the field do not have a clear sense of what it is, how can we support the public’s essential continued science learning?

A Little History

The work of informal science educators, separated from formal (school) science teaching has been recognized by the National Science Foundation (NSF) since the mid-1950s. There was a recognized need for funding designated to reach around and beyond the school years. Science education outside of school curricular science has also been referenced as *public understanding of science*, *free-choice science*, *out-of-school science*, or *nonformal science education*. We have developed, produced, and researched our work enough to know that it has provided many in the public with opportunities to continue to learn science beyond schooling (Rennie, 2014; Tressel, 1994; Ucko, 2010). Yet, we have struggled with how to capture and communicate the immersion we profess (Tal & Dierking, 2014).

The NSF is a major driver of the direction of science education in the U.S. The term *informal science education* was added to program definitions at the NSF in 1982. George Tressel, then Division Director of what became Materials Development, Research, and Informal Science (MDRI) briefly described the history and naming of *ISE* in an email:

Originally, the Public Understanding of Science Program [PUOS] was administered as part of NSF’s PR office....PUOS was moved into the Education Directorate where it could be

“monitored” for vulnerable grants and activities...I kept developing a philosophy that would fit... Most people, most of the time, learn most of what they know about science outside of school, from reading, broadcasting, hobbies, museums, etc. And the principal role of formal education is to prepare for this: to establish the foundation and curiosity that makes learning possible and rewarding. I tried a number of different words: “informal,” “experiential,” “activity,” “accidental,” etc. And “informal” worked best, so I started using it consistently and it stuck. In one of our endless reorganizations, we formalized it in the Informal Science Education Program. (December 5, 2013)

I have included this quote because it tells not only the history of the ISE term, but also something of the politics and one leader’s philosophy and impact. This quote describes the process of how things happen by serendipity and design at a major funding agency. In full disclosure, I tell all readers that I received my first NSF grant under George Tressel’s direction and have admired and respected his vision through many lengthy discussions over the years. Certainly, he has influenced my thinking. Nonetheless, many of us who work in this field have lived, somewhat uncomfortably, with this identification ever since. It is a *not something* rather than a *something*. In introducing the *ISE* themed issue of the Journal of Research in Science Teaching (JRST), Tal and Dierking say that the field definition difficulty presented itself in thinking about the articles in the issue. The diversity of articles, they say, points “to the difficulty in defining what informal science education is, or even what science learning in everyday contexts is (perhaps even science learning in general)” (2014, p. 4).

What has always been an exploration of the world became science when the Greeks, Chinese and Arabs passed on their knowledge to the privileged in academies and made efforts to insist on evidence, separating this way of knowing from mythology and religion (Bronowski, 1978). Science has been taught in U.S. schools since the 19th century, when education broadened quickly from classical preparation for the elite to include the study of nature for a rapidly expanding participatory democracy (De Boer, 1991). With the growth of public schools, this subject was included in the curriculum along with reading and writing. As professional scientists have increased the quantity and complexity of information, science has come to be approached by many non-professionals as daunting and hard. Our participation in everyday science is less acknowledged. *ISE*, as it developed institutionally beyond school, provided science for recreation in science centers, museums, national parks, trade books, and programs. As international scores showed the U.S. to be stagnating or falling behind other countries in schooling, educators have begun to pay attention to the kind of optional science learning that some people have sought out. What was its draw? Could the answers be applied to school science? How could the resources be used? There are instances where the boundary between in and out-of-school science education has begun to blur. What of the family and its conversations and choices? *ISE* has welcomed this recognition and attention. Yes, we support schooling and do not see ourselves as leisure time entertainers. Perhaps to encourage funding, *ISE* is described in support of schooling, when it is included in documents about the state of U.S education. In 1983, the report *Educating American for the 21st Century*, stated, “The child who has

regularly visited zoos, planetaria and science museums, hiked along nature trails, and built model airplanes and telescopes is infinitely better prepared for, and more receptive to, the mathematics and science of the classroom” (The National Science Board Commission, 1983, p. xii). In 1996, the same year that the U.S. National Science Education Standards (NRC, 1996) were published, the Association of Science-Technology Centers, Inc. (ASTC) released a report entitled *An Invisible Infrastructure, Institutions of Informal Science Education* (Inverness Associates for ASTC, 1996) arguing through survey research that science rich institutions support schools through providing services for both teachers and students. Within the National Association of Research in Science Teaching (NARST), the ad hoc committee on *ISE* prepared a report, later an article in *JRST*, summing up the committee’s discussion about informal science learning.

...learning in general, and science learning in particular, is cumulative, emerging over time through myriad human experiences, including, but not limited to, experiences in museums, schools, while watching television, reading newspapers and books, conversing with friends and family, and increasingly frequently, through interactions with the Internet. The experiences children and adults have in these various situations dynamically interact to influence the ways individuals construct scientific knowledge, attitudes, behaviors and understanding..... This broad view of learning recognizes that much of what people come to know about the world, including the world of science content and process, derives from real world experiences within a diversity of appropriate physical and social contexts, motivated by an intrinsic desire to learn. (Dierking et al., 2003, p. 109)

The Ad Hoc Committee on Informal Science Education at NARST spent time thinking about a name change in 2001, but the NSF, the NRC, and the National Science Teachers Association (NSTA), among others, have continued to use *ISE* to distinguish lifelong science learning beyond schooling from what happens in required schooling (Bell, Lewenstein, Shouse & Feder, 2009). While my work in the science education research field and anecdotal evidence among the public led me to believe that few people knew the term and what *ISE* encompassed, I designed a questionnaire to be able to research my impression in a more systematic way. This exploratory study then, was prepared with the research question, “How does the term *informal science education* communicate the field of *informal science education*, including its essential quality?”

I constructed an electronic survey and also collected some data in person using the same instrument with a dozen people. I kept the survey short to maximize responses. There were nine questions. The first was the open-ended response to the meaning of the *informal science education* phrase and the other questions asked for demographic information by U.S. Census categories or *ISE* participation by the NSF categories of institutions, media and programs.

After constructing the survey and examining it with another educator, I piloted it with six people whose professional backgrounds were diverse. I made adjustments to the survey from their feedback. I distributed the link by emailing it to a wide range of colleagues and personal contacts with an introduction and a request for them to distribute it with encouragement, as well as the promise of anonymity. When I scanned the data as it accumulated, I found fewer African American and

Hispanic respondents than I had hoped. I then made paper copies of the survey and went to a large regional playground. I approached African American and Hispanic/Latino adults at the playground, explained the educational nature of my work, and asked for their help in completing the survey. All consented.

These are the descriptive statistics. There were 153 respondents to the survey. They were 78% female and 22% male. The disparity between male and female respondents would require further investigation. Is it that more women are interested in educational issues and are willing to take their time for a survey? Is it that there was an inherent bias in my contacts? The age groups representation were: 8 in the 18–24 age range (5%); 69 were 25–44 (45%); 46 were 45–64 (30%) and 29 were 65 and over (19%). In terms of education levels, 2 respondents had not completed high school, 4 had finished high school, 41 had some college or a B.A.; no one selected “technical school” and 105 had graduate and/or professional school attendance. Using U.S. Census Data categories, I asked the respondents how they identified, explaining that this would tell me if I were reaching a broad audience. Although the predominant respondents were White (105), there was representation from other groups: 26 Black/African American, 7 Spanish/Hispanic/Latino, 7 Asian, 7 identified with two or more groups. There were no American Indian or Alaskan natives and no native Hawaiian or Pacific Islanders. This is a limitation of this study. However, at this point, the data do not suggest responses vary by identity.

I asked three questions about *ISE* participation. The first was about activities or programs, the second was about institutions, and the third was about media, reflecting the NSF strands within the *ISE* (now *Advancing Informal Science Learning—AISL*) program. The responses are shown in Table 2.1 by percentages of respondents. Multiple selections were allowed and therefore the numbers do not sum to 100%.

Interestingly, the category “family and friends activities/discussions” had about twice the participation of other activities. Almost all respondents had visited *ISE* institutions and more than half used science-related media.

I reviewed descriptions of *informal science education* from the last 30 years (e.g. Crane et al., 1994; Dierking et al., 2003; Falk (Ed.), 2001; National Science Board, 1983; Bell et al., 2009; Rennie, 2014; Tressel, 1994) and found four repeated themes describing the *informal science* field:

1. Historically, *ISE* is designed for places, programs and media in out-of-school contexts (although schools sometimes use them). It continually happens out of school without design in the course of living and communicating among families and other affinity groups.
2. Since it is not compulsory, there is some element of attraction, often called “fun” or “pleasure” in the design of these experiences.
3. Adults select environments and experiences for themselves or children and decide on the strength and length of their commitments; therefore the satisfaction or evaluation is self-determined.

Table 2.1 Participation in ISE programs/activities

Programs/activities		Institutions		Media	
Type	%	Type	%	Type	%
Non-school science classes or programs while you were a student	39	Zoo	97.8	Science reference websites? (for example, medical information, weather, science history, homework help)	85.3
Summer science-related programs while you were a student	34	Museum	96.3	Science documentary movies (such as Imax films)	70
Adult science exploration programs (including citizen science)	29	Public aquarium	95.6	Factual science information books	60
Online science programs (self-guided, webinars, videos)	34	National park	94.9	Science reference or research magazines or newsletters	53
Science activities, experiments and discussion (not a program) with your family and friends	68	Public botanical garden	91.1	Science internet videos or web-based games	44
None of these	17	Science Center	89.7	None of these	4.5
		Planetarium	90		
		None of the above	0		

4. The underlying motivation for the field is that continued science learning is essential or compelling both on a personal level for understanding “the world in movement,” (Bronowski, 1978, p. 5) and one’s own position in it (Bronowski, 1978) as well as on a national level for security and economic growth (Rutherford & Ahlgren, 1990; Bell et al., 2009).

I used these four themes and as well as “no answer,” and “I don’t know,” to analyze the responses to this question, conferring with a colleague for consensus of coding. Below are examples of how I coded the open-ended *ISE* responses. The numbers that follow the code category are the participant survey identification numbers. Sample data and analysis:

1. **Out-of-school setting recognized as informal**, #16: “Science education that happens outside the structure of a K-12 school but could be in a school being brought in by a partner group.”
2. **Out-of-school and pleasure or fun**, #76: “Fun AND educational TV program, articles, etc.”

Table 2.2 Summary data for recognition of ISE themes

No answer	No clue	Out-of-school setting	Pleasure element or fun	Self satisfaction or evaluation	Compelling need to continue to learn
15	20	89	17	21	26

- 3. **Out-of-school and compelling**, #109: “Building understanding of the scientific process and problem solving outside of the science classroom. Building curiosity and inquiry beyond the science classroom.”
- 4. **Out-of-school, fun, self-satisfied/evaluated, and compelling**. #116: “Learning about the material world (not necessarily called “science”) in a setting outside an institutional classroom. Done for its own sake, usually fun, no exam or formal credit.”

When asked to define informal science education, 17% of my sample, as shown in Table 2.2, admitted to not knowing at all with almost as many leaving the fill-in blank. Since the purpose of the survey was to answer that question, no answer might be added to the “no clue” group, but since I cannot say that with assurance, I have separated those non responses out. Of those who answered, more than half noted an out-of-school setting. Few respondents mentioned pleasure or fun. Perhaps this is assumed. Few mentioned self-satisfaction or self-evaluation (no tests). Perhaps this is assumed. And few mentioned the inherent need to know as part of their definition. Although those of us in the field think and write about these reasons for participation, are we communicating? If anything, my survey is biased in favor of those in my mostly educated extended communities who would be more exposed to science education. Surely a larger, random sample of the general population is needed to make a statement with more certainty, but this exploratory sample suggests that *informal science education* would be less well known, not more.

ISE: Language, Teaching and Learning

What might this fuzziness about the term *informal science education* mean to science teaching and learning? Our extensive human ability to use language to communicate ideas and knowledge among each other and from generation to generation has allowed science learning to be cumulative and complex. We become excited as children learn to speak and respond to our language(s). Adults know that this is the beginning of extensive learning through the exchange of ideas. There is evidence that children begin early to recognize patterns and to categorize the things that they experience (Gopnik et al., 1999). There is evidence that the extent of early vocabulary can determine future learning and consequently success in life (Risley & Hart, 1995). As adults, our words and phrases reinforce or question our common understandings. Using the word “*informal*” with science education is confusing. It

does not communicate the seriousness of our work to the public or other educators. It does not communicate the seriousness of the way learners are encouraged (or discouraged) from communicating the sense that they are making of their experiences as they interact within family and other cultural groups. Language is intimately entwined with learning science. The more I have thought about it, the more I have come to believe that the term *ISE* is counterproductive and does not help me consider how to prepare those who are engaged in it. ISE I believe is an historic term—one that helped distinguish out-of-school learning when its development needed that boundary to fund advancement and contribution to the whole science education enterprise. The phrase is now holding us back and reinforcing old boundaries that need not exist. The term is not helpful in creating a vision and plans for how we learn and teach science.

Continual Science Learning (CSL), Adaptive Core

I have argued for a language change to reflect where science teaching occurs and to reconsider how we can better prepare those who teach science. Now I want to return briefly to the adaptive quality of our learning to preface my suggestions for changes in teacher preparation. One categorization of animals that biologists make is between those that are precocial and those that are altricial. Precocial organisms operate more along the lines of innate patterns, with short adolescences and learning periods before they reproduce the next generation. We are altricial—that is, we are born with the potential to learn as we go, unlike precocial animals who are programmed by their biology to survive through inborn behavioral patterns. Physiologically, we are born with a skull structure that allows for an expanding brain. Ducks can walk and swim at birth. Monarch butterflies make a three generational migration of thousands of miles in their reproductive cycle. We cannot walk or swim at birth, even though we may need these skills for survival. Nor do we have a migratory pattern for finding our mates, even though there are cultural patterns which can determine our limits (if we accept them). Humans are the most widespread creatures. We live in all parts of the planet. We have learned to adapt to hot and cold, wet, and dry climates. We have learned to build in mud, clay, wood, stone, steel, and glass. We control our climates within these spaces. We do all sorts of things and erect all sorts of structures in which to do them. We are social creatures, living and depending upon communities (Wenger, 1998; Wilson, 1975). And, most importantly, we can pass on continuing knowledge and the learning of how to learn what we cannot foresee. This evidenced-based knowledge of how the world works and ways in which we seek new reliable knowledge is what we call science. We hope to create useful individual and collective memories as social creatures with rich cultural variations that influence how we express our learning. Science learning then, is the learning of patterns that can help us live, predict, and adapt successfully is an innate need. What we find, test and record is part of our altricial nature. We must keep learning to keep adapting, to keep living, to be the humans we are (Moss et al. 2013). My theoretical perspective, then, is that of

a biologist, understanding that organisms have needs, that humans are social organisms and that we must interact with the environment in such a way as to further our survival, meeting our needs, using our well-developed human ability to discern patterns so that we may predict and prepare for what comes. Continual science learning is not an option. It is our survival strategy. Our brain capacity and structure tell us this as we learn more about learning (Krishnan & Carey, 2013). We are always taking in data and processing it. To look at learning neurologically is to call science the conscious systematic handling of all of these data. As people, our schooling is meant to give us tools to make sense of these data and to be efficient about the learning process by passing on some of what we already know in terms of facts, processes, and theories that will help us make the best choices for our own survival and success. Most references to “adaptive” learning in education have been used to describe the needs of disabled students. Bransford et al. (2005) write about “adaptive expertise” for teachers. They speak of the ability to teach while balancing efficiency and innovation. The goal in teacher education then is to develop teachers who can continue to learn to teach flexibly in educational environments—adaptively. But they do not emphasize the modeling of this attribute for students. It seems that the concept of adaptation as a driver is implied in many documents that speak to “preparing students for the 21st century,” but while the notion of relevancy to student learning is a motivation concern, the development of an intentional ability to study science to change with a changing environment has not been apparent to me.

Science learning is a very old human enterprise, born of our awareness of a future for which we might prepare, and spurred by innate curiosity to ask “what if?” Therefore, continual science learning goes beyond the annals of history, although it is deduced from the results—our very existence and success as a species, living in the broadest array of environments. What we do then, is learn how to succeed through science. Science is an adaptive outcome of being human. And as such, what we have called *ISE* is not optional, not a choice, but an essential and continuing human need. Along with evolutionary biology to explain that we have survived by interacting and adapting to our environment as all living things do (or perish), there is ample evidence to suggest that play (that is, low risk experimentation and practice) is also an essential part of what we do to learn science from our earliest years (Pramling-Samuelsson & Fleer, 2009). We often engage in play as adults to flex our minds to experiment with alternatives for the pleasure using our minds brings us—and for the practice. Our continual science learning institutions offer dedicated venues for this kind of pleasure. Conversely, since these places are not required, they employ elements of play to attract us, to engage our natural curiosity. It must be fun, pleasant, engaging, or entertaining for us to take advantage of their teaching capacity.

Play is low-risk experimentation whether with our muscles or minds. We try things out, see how it goes, make mental notes that tell us things like falling can result in broken limbs, and a lack of strategical understanding of our opponent’s move can lose us our queens and the game of chess. In either case, we usually survive to continue our lives, the wiser. We often associate the notion of play with children, but play occupies adults in the popularity of sports, both participatory and spectator, and more so now, video games. Jarret (1998) found a high correlation

between teacher professional development ratings of fun, interest and learning potential and the intention to implement in their own classrooms. Ackerman (1999) has written about deep play, or the pleasure element that continues through life in mental and physical self-determined activity. Play is an important part of continual science learning. Our brains need to relax from high stakes work. The lower stress of play fulfills a physical survival need. The critical “what if” question can be a playful one. Play is not optional. It is interesting to note that learning outside of schooling is often called “enrichment” and its support is most often by supplementary fees. In this way, we perpetuate inequalities in learning, not only through “good” public schools that have the largest tax bases, but in the venues that enhance learning and charge for it because they cannot do their work without money. What does this say about our education policies?

A New Vision Has Been Growing

In 1983, Bonnie Van Dorn, then Executive Director of the Association of Science and Technology Associations (initially funded by the National Science Foundation in 1980), participated in the discussions which resulted in the report, *A Nation At Risk*, foreshadowing the slide which we have seen in our international standing in science education. She was especially pleased that the report recommended that out-of-school science education had a key role to play in the U.S. (National Commission for Excellence in Education, 1983). In 1985, I was a contributor to the National Science Teachers Association’s (NSTA) first book on the variety of out-of-school science that was available: *Science for the Fun of It*. Marvin Druger, then President of the Association, encouraged a group of us to write about our projects and places beyond the classroom. Other authors included Don Herbert—better known as “Mr. Wizard,” and Ray Bradbury, the well-known science fiction author. In 1994 Valerie Crane et al. published the first volume devoted to research in *informal science education*. The science education journals dedicated almost no space to out-of-school research. Science for All Americans, a landmark publication put into print the statement that “Even today, it is evident that family, religion, peers, books, news and entertainment media, and general life experiences are the chief influences in shaping people’s views of knowledge, learning and other aspects of life.” (Rutherford & Ahlgren, 1990, p. 171). The momentum was building. The report *An Invisible Infrastructure*, written by Inverness Associates (1994), provided evidence that out-of-school institutions support school learning far more than was evident. In the years that followed, researchers sought detailed insights into the links between schools and ISE institutions, mostly, but not always, in school-museum collaborations. In my research in Project Nexus at the University of Maryland where pre-service teachers chose an afterschool science enrichment internship and in research at other universities, students in teacher preparation or in-service programs were shown to benefit from experience in ISE settings (e.g. Jung & Tonso, 2006; Katz, 2011, Kisiel, 2013; Stocklmayer, Rennie & Gilbert, 2010). The linkage created

space in school-centered journals. Slowly research expanded to include afterschool programs, summer camps, media (including internet), and homes/families. The Harvard Family Project collected and distributed research about learning and family, with a section on out-of-school opportunities (<http://www.hfrp.org/>).

Words and Actions

By redefining and communicating more clearly about what we have called *informal science education* and transforming the term to reflect the concept of *continual science learning* that is essential, pervasive, creative, and lifelong (CSL then, in our acronym prone style), I can shape a vision of science teacher preparation. Contrary to what the term *ISE* suggests, CSL is compulsory—not by law, but by our nature. We may sometimes have a choice as to where we learn, but not when. We are always learning and our minds are organized to seek learning for adaptive success. Does it not follow that support for continual science learning is a priority for us and for the nation we have created to enhance our survival—a democracy of freedom and choice for allowing a wide variety of strategies from which we can choose to survive. John Dewey told us this in the early 20th century. Democracy and education are bound together (Dewey 1916/1944). There is a need for a citizenry that is science literate enough to make democratic [and adaptive] decisions, as well as a cadre of scientists who choose to spend their lives exploring deeply (Osborne & Dillon, 2008). As social creatures, we have multiple identities within different communities in our lives, taking different roles and responsibilities within each. But we must do at least everyday science to make choices. In a very real sense, CSL educators are all of us. As with scientists, some of us will make a living at it and some of us will not. We are *continuing science learning* educators when we are parents, grandparents, aunts, and uncles, modeling interest and enthusiasm, talking to our children, choosing toys, raising questions, and involving them in skill building as we go about daily tasks. We are CSL educators in site-based and research careers that present and consider opportunities to explore the world. The current ISE institutions of science centers, space centers, zoos, botanical gardens, aquaria, national parks, and museums are very much a part of this. But we are also CSL educators when we write and illustrate books and other media about how the world works. Some of us design playgrounds, as I saw in Capistrano Beach in California, with a sturdy sign illustrating what muscles are used in climbing a rock wall. We are CSL educators when we move health information out to the public in practical ways. Yes, like the Heimlich maneuver posters in restaurants. We are CSL educators as intentional science activity participants or when we explain to consumers how their plumbing and electricity works and how to create a compost bin. A CSL educator then, is one who is aware of and uses the adaptive interests of the learners to teach science as a starting point and maintains a reciprocal understanding of her own learning and teaching in any relationship. Figure 2.1 displays the model that evolved in my rethinking continual science learning as adaptive learning/teaching.

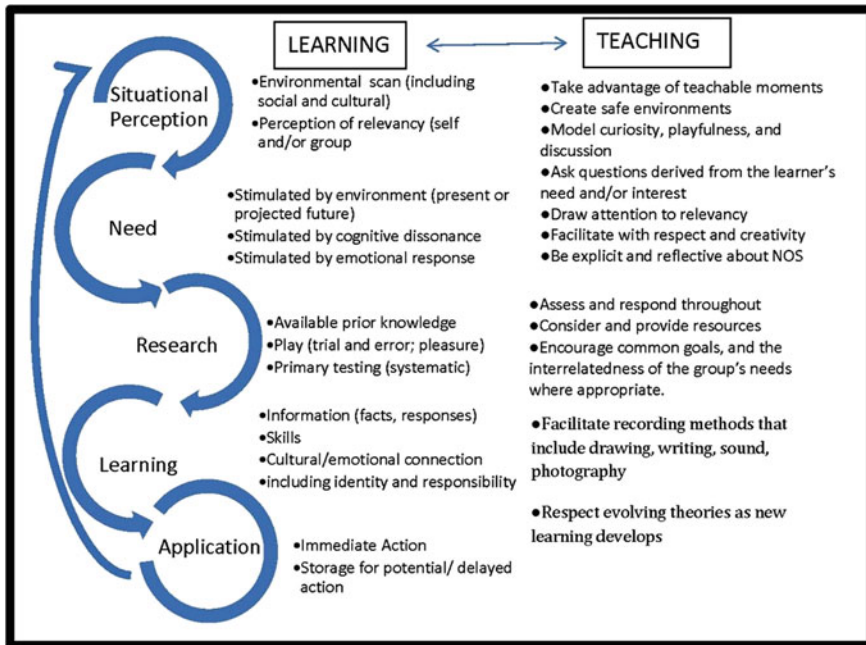


Fig. 2.1 Adaptive model of Continual Science Learning (CSL) learning and teaching

The implications of this model (all of which require research for confirmation or modification), are that:

- Learning and teaching are reciprocal ongoing activities
- Learning occurs when the learner perceives a need that is personally relevant. Can groups with which the learner identifies help create need and perception of relevancy?
- The learner is personally motivated to consider the environment and has a stake in the outcome.
- Cultural, identity, emotional and social components influence relevancy.
- The learner wants to investigate options for decision making.
- The learner seeks and assimilates the information and/or skills to protect or further him/herself at some level.
- The learner incorporates the new information by taking relevant action or banking the learning for perceived future need. In sociobiology theory, there is "proximate" or immediate need and "ultimate" (survival) needs that are filled.
- The time of this process can be short or long.
- The decision process derives from the learner. While the learning process is not optional, the participation is the learner's choice. Learners who are not "on task," in terms of a given activity, may be distracted by a competing need, or do not see the relevancy in their involvement.

- Experience is cumulative and proceeds at different rates for different learners based on their own life histories.
- Teachers provide experience, appropriate resources, safe environments, and would therefore be prepared by having their own experience in science, knowledge of research methods, community resources (as well as those available virtually), developmental psychology, and safety.

My model was certainly influenced by the work of science educators around me, many of whom struggle with the immense diversity of schooling situations in our country (e.g. Clark, 1996; Delpit, 1995; Goldberg, 1976). I believe that the *formal education* and *out-of-school education* boundaries no longer support the education of many students. It is not enough to have a scientist visit a class. It is not enough to travel to a museum as a field trip. These occasions reinforce the concept that learning beyond the school is an unusual or special event. What we have learned about learning from science can guide us. Our brains have a need for stability (homeostasis)—repeated pattern recognition on which our lives depend (Damasio, 2010.) We also have a need for creativity, given the plasticity of our brains. Creativity facilitates our adaptive need to be ready to solve new challenges as they arise in our lives (Csikszentmihalyi, 1996; Piaget, 1973). Pattern recognition and creativity are continual activities within our culture.

Science education is about how the world works interdependently. From sociobiology theory we consider that the more relatedness that is felt within a group, the more empathy or altruism is acted upon (Goldsmith, 1991). It goes beyond people. Accredited zoos no longer see themselves as exhibiting collections of animals, but as active partners in conservation, countering the spread of humans, who have dramatically and quickly changed long standing ecosystems. Biologists tell us that even small changes in the flora and fauna of the world can impact on how we humans must also adapt. Relatedness is not only about how we feel about people, but how we relate to the country we have created or the planet that sustains us.

Science education depends on and creates emotional reactions. Feelings or emotions are primal. They drive us to react for our own safety and they fill us with affordances and inhibitions in terms of safety and further learning (Damasio, 2010). Learning appears to be a mixture of memory and emotion. (Boyd, 2012). As we learn and teach we couple the emotions of trust (or distrust), kindness (or harshness), pleasure (or pain), satisfaction (or anxiety) into the memory of the experience and its outcome (adaptive or not). And then memories may be retrievable by and for our use, further molded by new experiences and emotions as we live. As continual science learning educators, our challenge is to provide memorable experiences with positive emotions that will afford the use when needed. How might this look in an out-of-school conversation?

Walking along a street after a major hurricane, a 6 year old boy turns to his grandmother and asks, “Why are some of the trees in this line of trees down and the

others still standing? How did the wind choose?” He notices a curious difference—a discrepant event—in his environment. He is aware of the hurricane wind damage. He anthropomorphizes the wind with volition. He wants to know more. A continual science educator asks, “What do you think could have happened?” She is conveying to him that she is interested in his answer and respects his thinking. “Well”, he says, “the wind didn’t hit the trees the same, so maybe it changed direction suddenly—or maybe the roots are different.” “That sounds possible,” she replies, holding his hand. “Let’s look around and see what has happened to other trees and then we can look it up when we get back to the house.” Alternate responses might have changed the child’s attitude toward inquiry. Might the grandmother have said she was cold and they should just keep walking? Might she have said that the wind just wants what it wants? Might she have told him about variations in wind direction and the strength of different kinds of tree roots, until he wandered away? We need to be prepared to give context and age appropriate responses.

Preparing Continual Science Learners: Implications for Teaching

Change in science education is often resistant, slow, and underfunded. I am therefore breaking my suggestions into two categories: “transitional,” and “transformative.” The first is my vision of how we could work within existing structures (whether schools, other institutions or programs) to plant seeds of a continual and adaptive science learning approach among them. The second is my own playfulness. If I could design from scratch, here is how I would do it!

(1) Where do we begin? I am going to go through levels of preparation chronologically through life, beginning with pre-parenthood and leading to the universities and beyond. Some of my ideas come from proposals or projects I witnessed or read about over the years. Where I am able to credit the source, I am happy to do so. And where I can no longer remember, I ask for the reader’s understanding. Preparing educators for this vision of continual science learning (CSL) would begin with parent preparation in high school, since this is the highest level of our country’s compulsory education system. As students get ready to enter the workforce and/or advanced education and take an adult role, what skills do they need to be self-sufficient people, to participate in decision-making communities, to raise the next generation, if they choose?

Transitional: Science teachers become explicit and reflective about the role of parenting in science learning. Students could journal (perhaps multi-media) about what encouraged (or discouraged) them in their own families and discuss what they would repeat or change. Science teachers focus on modeling and conversation for science learning: the asking of thoughtful questions, the active display of curiosity, the potential in the playful, “What if?” Perhaps all science teachers would modify

their curricula to give credit for students who tutor and reflect on teaching techniques. Physics teachers could assign projects such as the evaluation of manipulative toys, and ask students to describe how they work, their learning and play values and any safety concerns. Assignments could include interacting with young children and reporting on the findings, giving students practice in research and reporting. Chemistry teachers could explore the chemistry of cooking and other chemistry examples within the community, perhaps using the American Chemistry Society's *Chemistry in the Community* textbook as a guide.

Transformational: Science, mathematics, history, language, art, and physical education teachers meet with parents, community planners, engineers and other stakeholders to consider what the community needs. A project is designed which benefits all and teachers design a year's curriculum that is cross-age and meets Common Core goals and more, depending on the circumstances. At The Learning Center at Linlee, a Fayette County public secondary school in Kentucky, Scott Diamond wrote about a program for at-risk high schoolers that has done something very much like this (Diamond, 2014). Working with and teaching younger children are a part of the plan. Science teachers become explicit and reflective about the role of parenting in science learning, as above. Assessment proceeds by the setting of mutual goals. All participants are credited on the new community resource.

(2) When the next generation starts to sprout, I would hope that the high school experiences in talking with younger children as mentors and reflecting on the responses would carry over into the early years of parenting. Various parent support programs around the country, among them Head Start, report success with parent education components. Many preschool settings have done a very good job of providing environments where children can explore and experience new materials and processes.

Transitional: Like Head Start, all preschools need to require parent participation so that the young children and the parents learn science together and parents become metacognitive about their roles as continual science learners and teachers. Explicit and reflective experiences considering the nature of science, safety, messiness of some science explorations, and the wide world of resources in toys, on the internet, in books and in places can be made available.

Transformational: Our society creates policies that allow parents of young children to support themselves with fewer hours of work (or gives work credit for time with children), so that parents and professional teachers can form a closer partnership to do continual science learning as a team, infusing it with cultural richness appropriate to the community. Our society recognizes that starting this early will prepare a work force that is conscious of learning how to learn about the world from early on and that this is a good investment.

(3) Elementary schools are where children have been guided to develop writing, reading, and arithmetic skills and the beginning of science, history, art, and health education. We have labelled these subjects and skills "basic." I found it (unhappily)

fascinating, that science was not as crucial as reading and mathematics in the fading No Child Left Behind Program. A generation of elementary school students had minimal science as their schools and teachers strove to do well on the high stakes tests. How did we let that happen?

Transitional: Design class projects based on student interest and connect to science education themes and skills as described in reform documents. Map activities to Next Generation Science Standards (NGSS) and discuss NOS explicitly and reflectively with children. All of us are citizen-scientists and could collect data and follow studies from a young age.

Transformational: A school talks with children, teachers, parents, and other stakeholders and decides on a school-wide theme for a year. Many years ago, I visited an elementary school in Oak Park, Illinois, that was studying the theme of *time* for the year. There were examples of timepiece technology, and the concept of time in history, as I recall. I do not remember how the school was organized, but I would envision cross-age projects and groups setting goals, planning, gathering materials, and creating presentations and displays that involve good communication skills.

(4) In undergraduate education, science courses provide content and skills to students. Those skills emphasize laboratory techniques and data analysis. In graduate programs, the research narrows and writing publishable papers is an important skill.

Transitional: Add a section to all research papers on the meaning of the research to the public.

Transformational: Make communicating science to the public an essential part of university work, either as an individual expectation or by some form of institutional assistance. Reorganize university science departments to encourage regular, cross-disciplinary gatherings to share research on not only science, but poetry, history, and other disciplines. Consider a theme and speak to the connectedness and contribution of these different areas of study. Consider how continual science learning is a part of all of this.

(5) Science teacher preparation is essential to this vision. Now, most universities offer programs for primary and secondary teacher candidates. They are prepared by strengthening their content knowledge and having them intern within their chosen levels. Although research has shown that experience in *ISE* settings enhances their abilities, the costs and complications of transportation limit program continuity. There are very few certificate programs for people who want to teach outside of schools. Those people usually apprentice at institutions or programs and learn how to communicate to the public through practice.

Transitional: Professors could seek out continual science learning partners and establish relationships that will benefit both parties in terms of the research-based benefits. This means that our education would include: local knowledge of educational resources and potential project resources; communication skills, team building skills, networking skills, e-skills, etc.

Transformational: I have gone so far as to design an outline for a science teacher preparation program that does not distinguish between in and out-of-school

preparedness, assuming that schools become project-based and a much more integrated part of the community.

Continual Science Learning (CSL) Teacher Preparation for Career Teaching/Learning

1. Program Admissions Process

- a. Writing sample to include rationale for teaching career
- b. Interview
- c. Provisional admission pending performance

2. Year 1

a. Learning Theory

- i. Comparative Educational Philosophy among different cultures (to include developmental theories)
- ii. History of Education in the United States
- iii. Neuroanatomy and its contribution to learning (including plasticity and adaptability)
- iv. Evolution Ecology-change over time and impact of changes/projects

b. Research Methods

- i. Print sources
- ii. Web sources
- iii. Interviews, surveys, drawings, photographs.
- iv. Cultural sensitivity
- v. Communication skills (speaking, writing, drawing, web design, clothing)

c. Field Work

- i. Observations in which theoretical constructs are sought in the field schools, continual learning sites (museums, playgrounds, work training sites—many/any).
- ii. Group discussions (real time and/or virtual) of match or mismatch between theory and practice
- iii. Collaborative and contributive work project with one observation site

d. Creative

- i. Year 1 project presentation evaluated on inclusion of components of a, b, c above
- ii. One alternative suggestion for teaching gleaned from Year 1 experience, presented in choice of media

3. Year 2

a. Foundations of Science

- i. Along with an advisor, select a learning site in the community and research the science necessary for it to function at the highest level
 1. Select and succeed in two science courses related to above (assessed)
 2. Map the relevancy of the science to the learning site and/or project (assessed)
 3. Consider the adaptive quality for individual learners

b. Science in teaching

- i. Provide an example of how relevant science could be taught to students at different ages/experience (pre-school through senior citizens)-discuss and compare among program participants
- ii. Discuss resources and relevant learning settings in the community. Begin developing a resource catalog.
- iii. Design ideal plan for implementation of one possible learning scenario—compare and assess among program participants' group.

c. Field Work

- i. Internship at the site selected for basis of science courses
- ii. Visit alternative community sites related to science theme and compare with internship site using research methods and considering impact factors (cost, resources and so on).

d. Creative

- i. Write media release on link between science and community
- ii. Collaborate with a teaching setting on refining or developing a science learning opportunity

4. Year 3- Repeat Year 2 with alternative setting

5. Year 4-Repeat Year 2 with alternative setting

6. Year 5

- a. Apprenticeship with science learning setting of choice (mutual assessment)
- b. Prepare a self-reflective teacher-as-researcher report in any media approved by teacher development institution—preferably a report that will contribute to setting as well as self.
- c. Certification

7. Continuing CSL certification (Frequency to be determined)

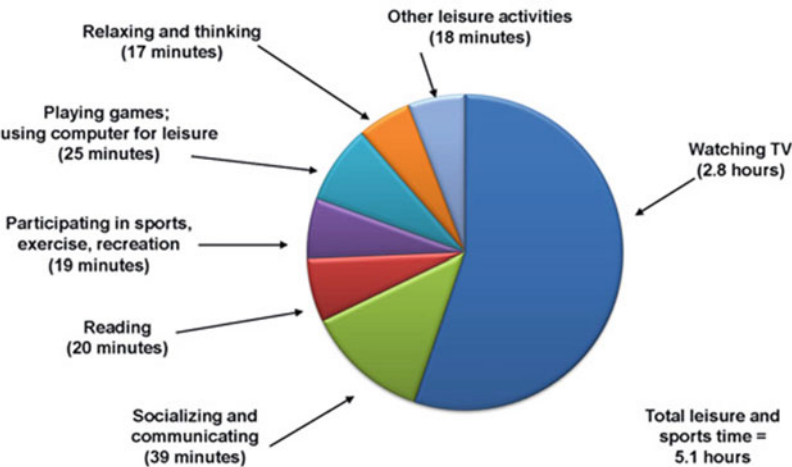
- a. Attend Science Teaching and Learning conference for networking and updates on work of others

- b. Present evidence of one’s own work and contribution
- c. Apply for recertification among peers based on a and b.

(6) We continual science learner/educators can take the lead. Our work has given us a great deal of experience in designing engaging exhibits, meeting the public, in collaborating and communicating. We need first of all, to communicate our professional existence and importance to the public! We work in parks, playgrounds, as authors of fiction or non-fiction for children or adults. We work on films, TV shows, and videos. We work in museums, science centers, botanical gardens, aquaria, zoos, and aviaries. We are parts of projects on ocean vessels and space ships. We are writers, photographers, illustrators, explainers, actors. We are partners in school education. We are partners among our venues and projects. Our lives speak to invisible career options for the next generation, but I have suggested that in part, because of our field name and certainly by examining funding proportions over the last 30 years, we are considered optional and even discriminatory towards those who cannot afford what is seen as enrichment.

The U.S. Government surveys and publishes an American Time Use Survey (ATUS) survey each year. Figure 2.2 represents a leisure time analysis. As a start,

Leisure time on an average day



NOTE: Data include all persons age 15 and over. Data include all days of the week and are annual averages for 2012.

SOURCE: Bureau of Labor Statistics, American Time Use Survey

Fig. 2.2 Average day leisure time for U.S. public

we can use this research to reach people where they are spending their leisure time to present the message creatively with options for continual science learning. Such tools can be made visible in teacher preparation. It appears that preparing opportunities for TV would be a good start.

Implications for Policy

In terms of broad policies, it would be protective and productive in our population if:

- All school systems and schools had incentives to become community-based science education projects that were self-determined, used stakeholder resources, parents and partners who could feel the advantages to all.
- All continual science learning places, programs, and media had incentives to connect with schools to participate in needs-based projects with their resources.
- Professional science researchers had incentives to communicate the value of their research to the public.

Implications for Funding

Increase the National Science Foundation (NSF) educational funding. It will take resources to transform our country's science education to a higher level providing an adaptive advantage to individuals and the country. The NSF is charged with funding non-medical, non-defense science research and science education. It is not the only science education funder, but it most often takes the lead and is the most clearly visible. I researched the budget for the Education and Human Resources (EHR) total budget and the portion of that allocated to *ISE*. I was unable to obtain the figures for the last four years, even though this should be on public record. The numbers in Fig. 2.3 of the chart represent the number of years from the beginning of the NSF. We spend 80% of our lives outside of schools. And yet the proportion for *ISE* is small.

If we view science education outside of school as an option and we structure its use as mostly unsupported by the public and if we make these environments charge fees for participation we insert discrimination by ability to pay. Many venues create ways to offer free days or make arrangements with schools for bulk pricing (covered by the public in the end) or work-study or other alternative means to encourage participation without regard to ability to pay. Let us think about this. Work and materials cost money. If we believe that science research leads the way, keeps us healthier, provides routes to the future, why are the only ways that people learn science beyond school poorly funded by our government, inherently (and unintentionally) discriminatory and viewed as optional? A society that values the

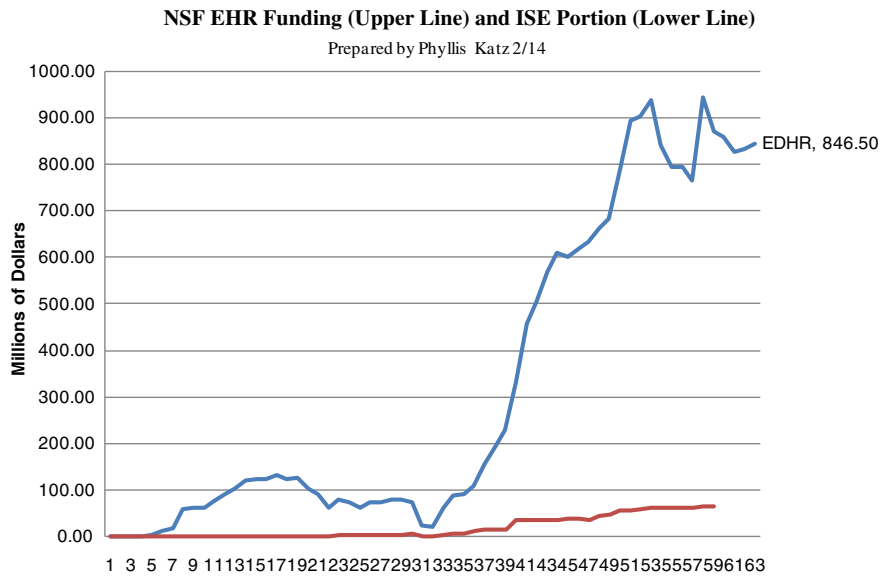


Fig. 2.3 NSF Education and Human Resources (EHR) total and ISE portion

survival of all individuals will invest in the availability of naturally occurring and designed learning opportunities. It will make these available to the population at affordable costs because its benefits to the population are critical.

- All science education projects should provide evidence of *funded* efforts to go beyond the “broader impacts” statements and entail how the projects or curricula yield better adaptiveness through in and out of school work that can continue, according to the cultural and individual interests of the participants.
- All higher education and research scientists should be funded to employ continual science learning teachers to communicate the adaptive qualities of their work to the public who may need to use their research. Researchers should be funded to learn to teach the next generation of researchers in a continual science learning approach. Too often, today’s researchers do not value teaching skills when their students need them in the job market.

Conclusion and Discussion

Living and learning are complex and cumulative. As professional scientists or continual science learners, we have no option but to engage. Most of us no longer live on farms where we participate in food production in the rhythm of the seasons; most of us do not shear, pick, weave, or piece our clothing. We do not construct our homes or even fix what breaks, now controlled by micro-chips where the

engineering is less visible. And in the places where people routinely still do these things, the time consumed in doing them makes a comprehensive education of the interrelationships less likely. With the advent of electronic communication, the rate of change in our environments is rapid. Learning how to be efficient through task mastery is not sufficient. We need to be able to adapt our thinking within new contexts (Bransford et al., 2005). We need to work as individuals to enact our learning within organizations toward social change in the way that humans have always used our minds to affect our environments (Jarvis, 2006).

The message of continual science learning is critical just because of these interrelationships. Science is piecing together this puzzle of current facts and connectedness that are creating an image of a world in which bees and frogs tell us their part in the dependency of one organism on another, where wind and water movements near Africa affect hurricanes in North America, where viruses and bacteria hitch rides on airplanes with travelers from one part of the world to another in a matter of hours. We cannot stop (nor do we want to) the world from spinning, nor time to be held constant. So, we study what has been, what is, and the process of change within which we must adapt.

Continual science learning is not an option. Understanding how we come to trust information that is essential to our lives through evidence and argument is not an option. And utilizing the information is not an option. We live by making decisions based on information—making decisions that allow us to adapt to our environment (s), personal/social and material. Nor is the process of learning without cost. We need resources to purchase programs, visit special venues, and acquire equipment with which to do our own investigations. Our challenge as continual science educators is to communicate the persistent, essential, and urgent nature of continual science learning in the context of living and in a mode of communication that is targeted at the learner's zone of proximal development (Vygotsky, 1978). This is what we need to be prepared to do.

We need to be prepared to succeed in a project that would be judged not by how many academics read papers in journals, but by an impact measurement yet to be developed and tempered by the type of research, for its contribution to adaptability, and the success of its reach. "Different kinds of metrics will be needed for policy makers to be convinced of the value of cross-sector collaboration in producing such outcomes as persistence and having a STEM identity," the STEM Learning is Everywhere, report reads (NRC, 2014, p. 5).

Supporting this approach is communication. Continual science education researchers have been moving toward this approach. It is time to shift our vision, as Elizabeth Stage said. This discussion is about learning and only coincidentally about where. It is more about when, as our key interests and attention shift as we move through life from childhood to young adulthood to careers and perhaps parenting. We all grow older. We all must deal with changing bodies, and changing technology, and other changes. Perhaps there has to be a continual science educator on every project to seek understanding and opportunity to communicate to the public. This person's specialty would be collaborations and communication. This person would seek ways in which projects that prove fruitful would be offered as

models and sustained, because they were maximizing adaptability. We need to be prepared to do these things.

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