

**John Abbott and Terry Ryan** say our education system needs not reform but creative restructuring, in line with the new scientific knowledge about how people learn.

# Education should go with the grain of the brain

**W**E will start with two simple assertions: humans are born to learn and learning is what we are better at than any other species. These old and essentially intuitive insights are now supported by new biological understandings yielded by brain imaging technologies developed since the late 1980s. The brain is revealed as a flexible, self adjusting, biological system which grows and reshapes itself in response to challenge, or withers through lack of use. It is now seen as a collection of specialised and complex systems, each engineered by natural selection to aid our species in decision making. Human beings are predisposed to learn from and adapt to their environment.

So why does today's environment seem to run counter to productive learning? Why do schools need more controls and incentives than ever to get children to learn those skills and values that civilised democratic society holds dear? The biology of learning is providing some powerful answers that, in turn, raise serious questions about whether our schools are able to prepare children for life in the 21<sup>st</sup> century.

Evidence has accumulated to show that, for education to go with the inherited basis of brain function, the learning needs of young people must be seen in terms of both the culture and the accumulated evolutionary experience previous generations found useful to their survival.

## The language of survival

Human nature matters enormously in learning. For the vast majority of time homo sapiens' experience of living as a wandering tribe in the ancestral environment shaped the broad structures of our predispositions, which encapsulate various successful evolutionary adaptations. These have since been recreated in the brain of every succeeding generation. Thus, what served the purposes of our ancestors is still with us. Without language or social skills the young child could not talk effectively or empathise with other children and would not have been able to survive when the group moved around. Language and social empathetic skills therefore need to be seen in a survival context. The critical lesson from the evolutionary sciences is that all human development is an intricate interplay: "nature and nurture don't compete; they cooperate".<sup>1</sup>

In the 1950s the linguist Noam Chomsky argued that language was simply too complex for each

individual to learn from scratch. Without a stumble, the average person can produce 150 words a minute, each word selected in milliseconds from as many as 50,000 possibilities and arranged in a meaningful sequence dictated by an elaborate mental style-book of grammar and syntax. Work on the nature of language development from Chomsky onwards contends that each brain has, from birth, the predisposition to learn language in a particular, natural way. Our brains owe their basic design to our genetic program. Virtually every child born today has the innate capability of recognising about 100 sounds – quite enough to combine in various forms to create all the alphabets in each of the earth's 5000 plus languages.<sup>2</sup> The neurological structures that make the acquisition of language possible are identical to all human beings, regardless of culture.

Newborn babies can tell the difference between the sounds 'pah' and 'bah'. By four and a half months of age, an infant 'understands' the significance of clauses; at 10 months, the ordering of noun and verb phrases in sentences. Before 18 months, babies learn the meaning of new words at a rate of about a third of a word a day; from then onwards it speeds up to about 10 words a day. By listening to the language spoken around them, children set the rules appropriate to their own language by 18 months of age, and in many instances earlier.<sup>3</sup> However, human newborns must acquire their language: they need to hear speech. Without linguistic information, their initial biological abilities remain unexploited.<sup>4</sup>

The language predisposition has largely disappeared by the age of 11 or 12, and children who have grown up without hearing speech never talk. For this reason, too, no matter how hard we may work at learning a foreign language as an adolescent or adult, we will always have an accent discernible to native speakers.

## Children are naturally social

Even though it may seem counterintuitive to those of us living in an era that glorifies individualism and cut-throat competition, it seems that we humans are predisposed to friendliness and cooperation. Human survival is almost totally dependent on relationships with other people. Faced with a hostile environment, our ancestors banded together to achieve as a group what they could not do alone.

Children reflect strongly the predisposition to be

social, collaborative and problem solving in groups through play. It was an intriguing early insight that created the word 'toy', for this, linguistically, is the diminutive of 'tool'. Evidence is accumulating to show that the predisposition towards such empathetic activity is at its strongest before the age of six. If collaborative skills are not valued by that stage, then the networks are likely to be replaced with other useful 'skills', such as solitary behaviour or a simple regression towards violence.

With all this evidence available, it seems curious that education systems still place children in classes of 25 or 30 at the age of five, and secondary school students into schools of 1500 pupils or more. Young people react to this impersonal scale by immediately forming into more cohesive units of friends with similar views and interests. Go to any secondary school and you will see packs of athletes, scholarly-types, beauty queens, and numerous other sub-groups and cliques. Children find out about themselves by measuring themselves against the standard of their group mates. They come to think well or poorly of themselves by judging how they compare with other members of their own group.

Ronald Kotulak, in his Pulitzer Prize-winning series of articles on violence and young people for *The Chicago Tribune*, powerfully makes the point, and illustrates the dangers: "By failing to provide young children with the supportive and nurturing environments in which they can develop their predispositions towards social, collaborative and team building skills, young children's brains react with astounding speed and efficiency to the violent world they experience around them by rewiring trillions of brain cells that literally create the chemical pathways for aggression".<sup>5</sup> If Kotulak is right, aggression rather than conciliation becomes the action of first response. "He dissed me in front of my friends, so I popped him" is the simple kind of explanation American police officers repeatedly hear for why a young person kills. Nurture (in this case a peer group that has a complete disregard for human life) has the power to modify nature in each succeeding generation.

Even if we don't study the extremes that Kotulak did, there is much evidence to worry us deeply. It is highly likely that there is a direct connection between the child who was not encouraged to use his or her innate desire to collaborate in the earliest years of life and the young graduate in a first job who, after 16 years of formal education, shows no initiative, can't work in a team and has to be told what to do. Developing such collaborative higher order skills at the age of 23 or 24 is infinitely harder, and more expensive, than developing them with the grain of the brain at age five or six.

There are other innate predispositions that are informative. We know, for instance, that there are critical periods for the development of numerical skills<sup>6</sup> and for different forms of musical apprec-

iation.<sup>7</sup> It is a fascinating fact that two of the countries that most stress the teaching of music for young children – Japan and Hungary – consistently score well in mathematics on the International Mathematics and Science Survey. New knowledge about the role of the structure in the brain called the amygdala also has a bearing on our understanding of how we learn. The amygdala regulates our aggression, emotions and sex drive by intentionally bypassing the brain's carefully constructed logical functions. The existence of an 'override' mechanism is an important clue to the nature of learning, for it indicates a primacy of emotion above logic in driving attention spans, shaping action and aiding memory retention.

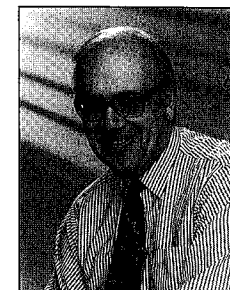
## The motivation behind learning

The link between emotions and intrinsic motivation should surprise no one. Consequently, the sterility of emotionally drained and aesthetically neutered learning environments has to be understood as contributing to low learning achievement. A successful childhood and adolescence is to a large degree defined by learning how to control and channel one's emotions to positive ends. A model of learning that focuses on the needs of all children will have multiple outlets for high performance that integrates intellect and emotion – whether on the playing field, the stage, in academic competitions or the music hall. Young people need more outlets for success, not fewer.

There are many definitions for creativity but in the literature from psychology and cognitive science there is one key concept that is mentioned repeatedly: intrinsic motivation. In their review of research on creativity, American psychologists Beth Hennessey and Teresa Amabile observed, "People will be most creative when they feel motivated primarily by the interest, enjoyment, satisfaction and the challenge of the work itself – not by external pressures".<sup>8</sup> No one has ever enjoyed science as much as Einstein.

Teachers are doing what they can to make learning happen in their classrooms, and central to creativity is a base of knowledge on which children can build new ideas and connections. Good schools and teachers help children acquire such knowledge. But for children to develop creativity and a passion for excellence there are other personal factors that must come into play. These are persistence, commitment and a sense of purpose. It is purpose (meaning) that drives all human activity. The most creative and successful people in any endeavour seem to get extremely involved in a problem. They become so immersed that they stick to the problem, and the problem sticks to them. Such dedication comes from an internal desire to succeed.

Yet on both sides of the Atlantic teachers make the point that there just isn't time for children to explore what they are good at because the curriculum must be covered.<sup>9</sup> In response, educators



**John Abbott** (above) is president of the 21<sup>st</sup> Century Learning Initiative, a transnational association of education researchers and practitioners. Following a long career as a teacher and headteacher in England, Abbott became director of Education 2000, spearheading nine community-wide education projects in the UK. In his current role he has lectured around the world on new understandings about learning. He lives with his family in Bath.



**Terry Ryan** is senior researcher for the 21<sup>st</sup> Century Learning Initiative. After receiving his Masters in political economy in 1994, he worked with educational reformers and students in Poland, and co-authored a book on Polish history with former Solidarity leader Wiktor Kulski. He lives in Virginia, USA, with his wife and daughter.

The ideas presented in this article are expanded in *The Unfinished Revolution* by John Abbott and Terry Ryan, (Network Educational Press Ltd. £14.95).

use extrinsic rewards to bribe children to learn and take control of their own mental faculties, and the fear of failing standardised tests as the stick to punish those who have turned off education.

### Learning by discovery

Within cognitive science, there is an approach known as constructivism. This is learning by discovery, aiming to enable children to structure their own knowledge of the world into a unique pattern, connecting each new fact, experience or understanding in a subjective way that binds each child into rational and meaningful relationships with the wider world. It is a dynamic interaction between the environment and the brain. This approach to learning has been strengthened by the recent findings that the brain is a plastic, flexible, self adjusting, ever-changing organism that grows and reshapes in response to challenge, with elements that wither through lack of use.

Constructivism is open ended, as is the neural structure of the brain. In contrast, the alternative is a structured and closed process that leads to high performance in encyclopaedic-type recall. It follows, therefore, that national curriculum targets, for all their achievements, do not support the genuinely creative or entrepreneurial. Students learn in school that the path to success is not the risky path of entrepreneurs but the apparently safer path of professionals. This may be true in rich countries, but it is the entrepreneurs who add real value to the economy over the long haul, and it is an entrepreneurial attitude that individuals will need if they are to play their full part in the new economy of the 21<sup>st</sup> century.

The present arrangements for conventional schooling are a reflection of the assumptions about human nature and learning that emerged to support the needs of the Industrial Revolution, whereas the key to success and social stability in the 21<sup>st</sup> century will be people working and living smarter than in any previous generation. They will need to be more productive to help provide for an ageing population, and thoughtful enough to deal with a world where problems are increasingly global in scale and solution. Einstein's statement that the problems of today will never be solved with the techniques of yesterday was never so true as now.

All this is not intended to suggest, however, that students can be left to discover everything for themselves, because real understanding means overcoming personally held naïve theories.<sup>10</sup> For true understanding to occur, process and knowledge must be integrated in an effective partnership, and this requires an initial source of valued information (this is where the curriculum and the school come in). Understanding is related to the ability to make valid connections between existing knowledge and experiences, and new inputs.

In 1989, Lauren Resnick of the University of Pittsburgh Learning Research and Development

Centre spoke for many cognitive scientists when she wrote: "First, we know that human memory for isolated facts is very limited. Knowledge is retained only when embedded in some organising structure. Thus students who learn many separate facts are unlikely to retain their knowledge beyond the current period of test-taking – a much noticed, worrisome feature of the current educational system. Second, we now recognise that skills and knowledge are not independent of the contexts – mental, physical and social – in which they are used. Instead, they are attuned to, even part of, the environments in which they are practised.

"A new challenge for instruction is to develop ways of organising learning that permits skills to be practised in the environments in which they will be used (ie outside the classroom). Such contextualised practice is needed both to tune skills and knowledge to their environments of use and to provide motivation for practising abilities that in isolation might seem purposeless or meaningless."<sup>11</sup> Resnick is pointing out that successful learning and its application is too complex and multifaceted to be constrained within the walls of a school.

### Experience is the best teacher

Learning that leads to understanding and ultimately expertise in a field has traditionally been associated not with the decontextualised setting of a classroom but with the more integrated process of learning called apprenticeship, which puts students into situations where they learn by doing. It builds functional skills through experimentation, explanation and story construction. Apprenticeship teaching provides instruction reactively, in response to the learner's action.

Cognitive apprenticeship applies that process to thinking, enabling the processes of the activity to become visible to the learner. It assumes that children are inquisitive and, if initially fascinated by some mighty works, do not find it difficult to practise whatever subtasks are first needed. The 'apprentices' learn by applying their knowledge in an activity that matters to them and to the group they feel a member of. As in traditional apprenticeship, an older person must model that subtask, so that the learner sees the significance of it to the final product. New skills are progressively built onto those already mastered, with the individual learners eventually assuming full responsibility for their own work. As the learners' confidence increases, the support gradually 'fades'. The more proficient the learners become, the more they become independent of the teacher.

It is widely accepted in business that the more experience a worker gains in a particular position, the better they do the job, and most professional development still takes the form of 'on-the-job' training. Nearly everyone would agree that experience is the best teacher. But, as Roger Schank and John Cleave of the Institute for Learning Sciences

at Northwestern University have pointed out, "What many fail to realise is that experience may well be the *only* teacher".<sup>12</sup>

Lauren Resnick has shown that in-school learning often fails to transfer to out-of-school performance because the two are treated as separate, disconnected activities unrelated to the learner's earlier understandings and mental models. She writes: "Even in arithmetic, a curriculum whose usefulness is seldom questioned, the packages of knowledge and skill that schools provide seem unlikely to map directly onto the cluster of knowledge people will use in their work or personal lives. This seems true even for highly technical professional training."<sup>13</sup> She cites one study that demonstrated that expert radiologists interpret X-rays using mental processes different from those taught in medical courses, textbooks or even hospital teaching rounds. Another study showed that extensive training in electronics and troubleshooting theories provided very little knowledge and even fewer skills directly applicable to the task of electronic troubleshooting. The mismatch between the structure of the knowledge used and the social conditions of its use may be more fundamental than previously thought.

Apprenticeship integrated learning, working and living, and was far more than just skill acquisition. At its heart was a process in which the young learned to take full responsibility for finding appropriate solutions to novel problems. Cognitive apprenticeship appreciates that, in nearly every instance, learning involves social skills as well as intellectual/practical skills. It is a process within which the learner becomes totally immersed. Apprenticeship recognises that once people have acquired certain skills, and real motivation, they need to be given full responsibility for their outcome.

During the past few years, scientists working with brain imaging technologies have been able to 'see' the ways in which ideas developed in different parts of the brain come together; this is close to providing a neurological base for appreciating why apprenticeship is such a successful model of learning. It is no coincidence that cultures worldwide evolved using apprenticeship; it simply goes with the neurological structure of the brain.

### The pyramid model of education

It is a fact, across the world, that educational spending favours older learners over younger ones.<sup>14</sup> There is more money spent on secondary school students than on primary school children, and considerably more expenditure per college and university student than there is on secondary level students. Yet there is little evidence from the brain sciences to justify spending three times more on the learning needs of a 20 year old than those of a four or five year old. The fertile predispositions for learning in younger children and what is now known about brain plasticity suggest that it is good public policy to develop a more balanced investment

between the learning needs of younger children and those of older students. We can also make the case that it is not just about investing more in younger children but investing in such a way as to enable children, as they enter adolescence, to take more personal responsibility for their own learning.

Teenagers who are functionally literate and understand how to become better learners actually need and want less direct formal classroom based instruction. Many students in elite secondary schools have already gone beyond their dependence on teachers by accessing learning information online and through community based resources such as museums, local universities and businesses. In the US and Canada, a group called Schools Without Walls has developed an entire secondary educational experience around just this model of community based learning resources. A model of learning which builds on the skills children acquire during the primary years and crosses an entire community will create greater flexibility for older students, and for education systems that increasingly face budgetary constraints and teacher shortages.

If the opportunity offered by our various predispositions for learning is not seized when children are very young, then the young will struggle to deal with the challenges of adolescence. In pre-industrial societies, the more skills a learner acquired, the more responsible the learner for using those skills. Successful apprenticeship followed a strict weaning process, which was a tough survival principle. In such societies there was no room for people who could not act to the benefit of themselves, their family and their community. There is an obvious lesson here for our times. If we maximise the potential of young children and help them take control of their own learning, then we should begin to see adolescence as an opportunity rather than as a problem to be controlled.

### Faulty assumptions

Alas, through the introduction of the national curriculum, national testing and an emphasis on greater accountability, the English education system has become more centralised and entrenched in faulty assumptions about learning than ever before. Opportunities to embrace more open systems of learning – which involve the community and complement the natural way children learn – have been missed.

The following incident does much to demonstrate how stuck and polarised education has become. In August 1999, researchers at the University of Durham, who were studying the effects of homework on school-based test scores of 20,000 primary age pupils, came up with a curious result: the highest

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test scores were achieved by students who had relatively little homework, whilst those who had most tended to get lower grades. Since this finding seemed so counterintuitive, the Department for Education immediately dismissed the research, saying, "Homework backs up what is happening in the classroom. It should be properly set and marked. Children do regular homework in secondary school, so it is sensible to prepare them for it at primary school."<sup>15</sup> This comment shows complete lack of awareness of the different developmental stages of children. Anyone who has children, or who works with children, understands that primary age pupils are not simply miniature versions of secondary pupils; they are essentially different.

Author, and former teacher, David Almond expanded on this topic in his speech when accepting the Carnegie Prize for Children's Literature in 1999. He accused the British government of being obsessed "with tests, grades and levels of homework which are killing joy and creativity in childhood. What children need is 10 per cent 'Eureka' time when they can be left alone to use their own imagination; a time when target setting consists of maps of possibilities; where record keeping can consist of speculation; a time perhaps when we can admit that we haven't really got a clue what's going on in children's minds. There is an arrogance at work, an arrogance that we know exactly what happens when someone learns something, that we can plan for it, that we can describe it, that we can record it and that, if we can't do all these things, then the learning does not exist."

David Blunkett, then Secretary of State for Education, accused Almond and the Durham University researchers of wanting to return to the "ill-disciplined anything-goes philosophy that did so much damage to the last generation."<sup>16</sup> Chris Woodhead, then chief inspector of schools, further commented that there was no conflict between an emphasis on tests and targets, and creativity: "If we want creativity, we must do everything possible to drive up standards of literacy and numeracy."<sup>17</sup> No one would ever deny that high levels of literacy and numeracy create better conditions for the human intellect to function. But these are processes. And processes need content on which to work. Creativity comes from the ability to indulge intelligently in divergent thinking.

### The unfinished revolution

A revolution in thinking about learning, human development and community regeneration has been simmering for well over a century. The aim is to develop learning arrangements that maximise human potential by 'going with the grain of the brain'. However, such new ideas challenge the theoretical assumptions and mindsets that have underpinned much of educational thought for more than a century, and the institutional framework built up to support them.

There have been times when this revolution seemed to be gathering momentum. For example, the followers of Froebel, Montessori, Pestalozzi and John Dewey thought they were beginning to make real progress in the 19<sup>th</sup> and early 20<sup>th</sup> centuries. So too did those working in the English experiential elementary schools in the later 1960s and early 1970s. A few innovators have made a lasting impression on educational practice but, like Montessori, they have maintained their convictions by keeping outside mainstream education.

Nevertheless, there are reasons to believe that we are living at a time of special opportunity. The nature of the world in which education exists has changed dramatically in the last generation. What young people need is qualitatively different from what was previously thought to be necessary.

### The schools of the future

Young learners need the opportunity to stand on their own feet. For an intellectual weaning that parallels normal human development, it follows that maximum teacher support is needed when the student is very young. We recommend, as a starting point for discussion of ideal class size, the principle of the age of the student times two. Thus five year olds would be in a class of 10, six year olds in a class of 12 and so on. Smaller class sizes give teachers the space to help children develop thinking skills and help children 'see' their own learning. The idea is to fully utilise the learning predispositions and windows of opportunity of the younger learners with the intention of ensuring that later, as adolescents, they are equipped with the basic skills and ability to become autonomous learners. (It is critical that teachers are given the opportunity for relevant professional development and understand the practices of non-academic learning.)

The role of the teacher should change as pupils mature, and thus would change the concept of class size for older students in a dramatic way. For example: if thirty four 17 year olds need to be taught for each of eight periods in a day and there is only one teacher available at any one time, then a class of 34 is the inevitable result. However, if thirty four 17 year olds are effectively working under their own direction for half the time (and for the previous 12 years have been prepared to do just that) then, certain timetable logistics permitting, they could be taught in classes of 17 for four lessons in a day, or classes of up to 12 for three lessons, directing their own work for the remainder of the day.

The potential significance for secondary education is immense. There is no reason why 14, 15 and 16 year olds who understand their own learning and have a rigorous base of knowledge on which to build would any longer need to take all their coursework in the confines of a teacher-directed classroom. Young people who have gone through the kind of education we are advocating would need, and want, a different form of education in the upper years of

secondary education. This is where the most profound changes have to occur.

In a model of learning that accepted the ability of adolescents to take responsibility for their own learning, it would be desirable if part of the experience of older adolescents also involved some commitment to working formally with younger pupils. A recent illustration of this comes from Estonia. With money for only three years of information technology education, the education system concentrates this on 14, 15 and 16 year olds. It then requires such young people to spend five hours or more a week in each of the subsequent four years as teacher assistants in elementary schools, working with children four to six years younger than themselves. This is another example of adolescents learning from their experience of being useful and allows them to give something back to the community that is paying for their education. Brought in as it was for pragmatic reasons, it nevertheless addresses a basic need: you never really know something until you have had to teach it. In a properly worked out scheme utilising this principle, such teaching would be the result of careful tutoring of the older students, and then the careful assessment of how well they assisted the younger students.

### Adolescent aimlessness

Conventional schooling methods clearly clash with the progression of normal human intellectual development. The clash reveals the desperately inappropriate provision for the youngest children and goes far to explain why, as they move into adolescence, many are so ill-equipped to handle the biological and social changes that then hit them. Over the years teachers have come to fear the aimlessness and apparent reckless irresponsibility of so many adolescents. So the call has constantly been for more resources to control youngsters, who are already feeling increasingly sullen and misunderstood.

Adolescents' criticism of teachers and the system, not always well articulated but certainly full of passion, is immediately thrown back on them for being uncooperative. At the stage in which they are impelled by their natural predispositions to take responsibility, they are inhibited by their lack of early skill development. They become frustrated, disillusioned and awkward. In ways that often seem incomprehensible to worried adults, their energies are expended in kicking the system.

At all levels of the education system it seems as if the system is simply reluctant to 'let go' of students. It is as if no learning is taking place unless students are being taught. Rather than weaning youngsters, the system seems bent on playing down their ability to do something for themselves. In a variety of subtle, and not so subtle, ways, Western society has trivialised all levels of young people in school. Is it any wonder teenagers say they feel bored, uninvolved and often in conflict with a world

that tells them what to do, rather than expecting them to work it out for themselves?

### Involving the community

With the knowledge and experiences currently available it is no exaggeration to say that societies now stand at an exciting time in human history – at an evolutionary crossroads, so to speak. Will we be able to capitalise on the many understandings about learning and brain development so as to harmonise our knowledge about learning with the rapidly changing economic and social needs of post-industrial societies? If we are to rise to the challenge, then the unit of change can no longer simply be schools but the larger community. Learning communities would have as their first priority the strengthening of families and providing for the learning needs of all their young people. All available resources, both formal and informal, would be used towards the goal of helping children become responsible adults who know how to function successfully within a community.

Learning would no longer simply be bound to the walls of a single institution. Rather, it would be seen as a total community responsibility, and individual schools would be seen as responsible to the whole community, not just part of it. From this perspective it is not merely teachers who can teach, it is not just pupils who need to learn, and it is certainly not just the classroom that is any longer the major access point to a range of knowledge, information and skills.

For example, within the community at large there is an ever increasing number of early-retired people who are fit and strong and have many professional skills. At the moment they are largely wasted in terms of helping the young develop a motivation for learning, and an understanding of how what they learn in the classroom can actually be applied in the workplace, voting booth or in life generally. Such people don't want to become full-time certified teachers, but many would be interested in sharing their expertise with young people informally. These are just the individuals that adolescents need to be able to relate to – almost as surrogate grandparents – to provide them with the immediate feedback they need to make connections between academic learning and events in the real world.

The brain does not turn itself on and off to fit a school's hours of operation. That is why we advocate turning systems of education not just upside down but inside out. ■

*To support the numerous people in different countries who are now seeking to develop agendas for change, plans are being formulated to establish an Institute for the Advanced Study of Human Learning and Community Development. This will be a transnational resource to stimulate radical transformation of formal and informal learning arrangements for young people. For further details, please contact John Abbott on 01225 333776.*

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