CHAPTER 10

Future Possibilities for Education and Learning by the Year 2030

Introduction

2030 is 23 years from now (The study was conducted in 2007).

Looking back over the past 23 years can give a sense of the rapidity and magnitude of the changes we experience today and that are likely to accelerate in the future. Twenty-three years ago it was 1984. In 1984 how many would have believed that the Republic of Korea by 2007 would successfully compete with the United States in some areas of the transportation, information, and communications industries? Or that its economy would be larger than Russia's? Or that many of the world's brightest youth would be playing computer games created in Korea? The rate of change over the past 23 years seems very fast to many people today, yet the factors that made those changes are accelerating. As a result the changes over the next 23 years will be even greater.

In 1984 there was no European Union, World Trade Organization, International Criminal Court, Space Shuttles serving Russian and American astronauts in the International Space Station, millions of people searching billions of references in less than a second, or cloned sheep. 23 years ago what Ministry of Education had the objective of connecting their school children to the Internet? What Ministry of Education had the objective of preparing students to participate in the global knowledge economy?

Imagine two countries back in 1984. Both were about the same in all things except that one declared a national objective of cooperating with international computer networks[1] to connect their educational systems into an international knowledge system in order to improve education for all in their country. Now, 23 years later – today – which country would be in a better position for the emerging global knowledge economy? And which country would have produced more students ready for today's complexities and opportunities?

Today educational policymakers face the same kind of choices: to look far ahead seeking emerging educational opportunities or just make moderate innovations that appear creative. Fortunately, the Ministry of Education and Human Resources Development of the Republic of Korea has requested this international assessment of future possibilities for education and learning by the year 2030 to help inform them of their choices for setting better long-range educational policies.

What might surprise us today about 2030?

If we don't know that something is possible, then we will not try to make it happen.
What are some of the educational and learning possibilities by the year 2030? What might we do today to take advantage of these emerging possibilities? Since the implementation of new ideas

---

[1] In 1984 there were several such efforts: EARN (European Academic Research Network), BITNET (A network of universities in the USA), ARPANet (US Department of Defense with relays through Stanford University, UCLA, and MIT), CARNET by PfP International, CompuServe, Econet, TCN, and FIDO net. There were also satellite computer connections for educational applications by ATS-1 and ATS-3 of NASA.

can turn out differently than expected, it is also wise to ask what could make them turn negatively as well as positively.

To answer these questions, the Millennium Project reviewed futurist thought to design a Real Time Delphi which collected the judgments of 213 experts around the world, selected by the Nodes of the Millennium Project.[2]

This study assessed 19 possibilities:

1. National programs for improving collective intelligence

2. Just-in-time knowledge and learning

3. Individualized education

4. Use of simulations

5. Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.

6. Improved individual nutrition

7. Genetically increased intelligence

8. Use of global on-line simulations as a primary social science research tool

9. Use of public communications to reinforce pursuit of knowledge

10. Portable artificial intelligence devices

11. Complete mapping of human synapses to discover how learning occurs and thereby develop strategies for improvement of learning

12. Means for keeping adult brains healthier for longer periods

13. Chemistry for brain enhancement

14. Web 17.0

15. Integrated life-long learning systems

16. Programs aimed at eliminating prejudice and hate

17. E-Teaching

18. Smarter than human computers

19. Artificial microbes enhancing intelligence

These possibilities present a broad array of policy choices and options which can inform the policy-making process. Each possibility was rated by an international panel in terms of its likelihood. These average ratings by the international panel gave 14 of the possibilities better than 50% chance that they will occur. Figure 1 presents the possibilities in rank order by average likelihood.

---

[2] See Section III Analysis and Appendix for a full report on the process of the Real Time Delphi for Education and Leaning Possibilities by the Year 2030, and the list of participants.

Figure 1: Likelihood of Education Possibilities—year 2030
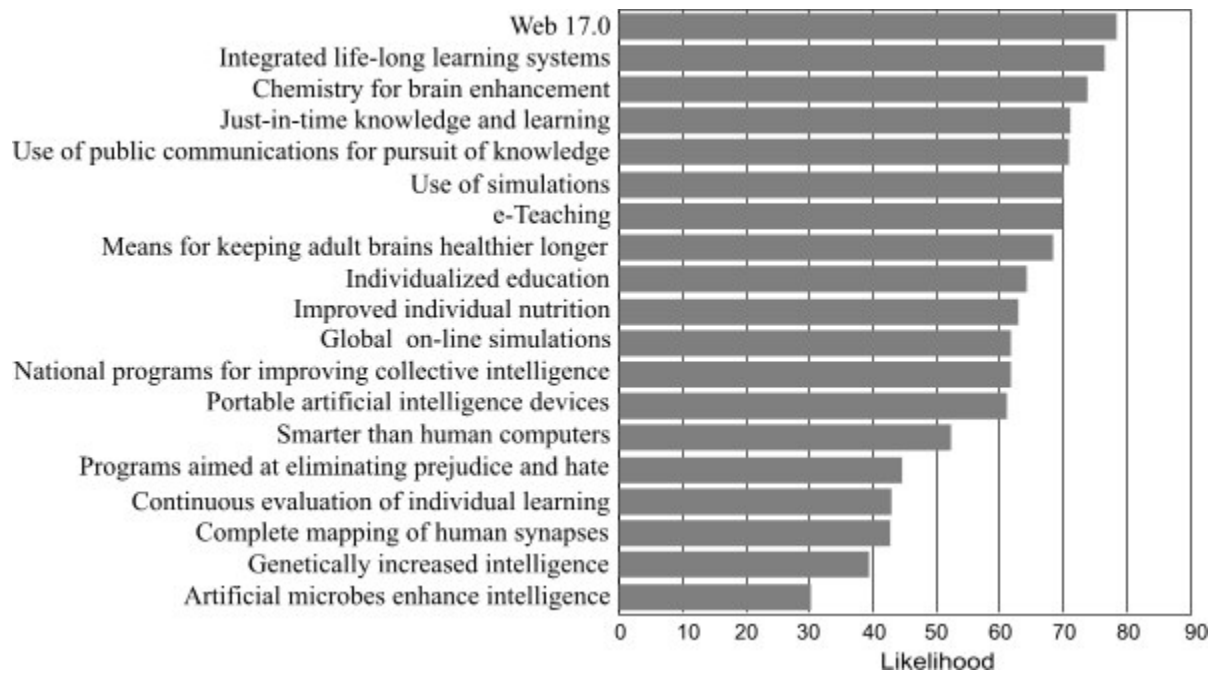
If educational policymakers believe these results, then what steps should policymakers consider today?

To answer this, the respondents were encouraged to provide judgments about factors that could help or hinder the possibilities, and assuming they occurred, to conjecture about consequences that might follow.

As Moore's Law continues to be valid over the new 23 years, portable intelligent devices could have the processing power of the human brain. Individuals would access the world's knowledge that has been integrated by Web 17.0 for "just-in-time knowledge and learning", using simulations with virtual reality interfaces adapted to individuals' unique needs throughout their lives. Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill, along with programs aimed at eliminating prejudice and hate could bring about a more beautiful, loving world.

In parallel, brain function should also be dramatically increased by improved personal nutrition and brain enhancement pharmaceuticals. Insights from partial mapping of the human brain and other methods could dramatically increase personal intelligence and longevity by 2030. More remotely in the future, brains may be genetically enhanced and designer bacteria could make the brain cells work more efficiently. With the use of public communications to reinforce the pursuit of knowledge and the use of these learning innovations and educational concepts, individual and collective intelligence of societies could be improved.

Advances throughout history have created gaps between early adapters who can afford the initially higher costs and those who are less able to afford the advances. Many participants in this study warned that serious efforts will have to be made to prevent dangerous

knowledge/intelligence gaps leading to unstable conditions. Policymakers should develop ways to encourage broad democratic usage of these new powers without letting their abuse by the few to disadvantage the many. Over the last several years, the digital gap has begun to narrow, giving hope that greater decentralization, access, transparency, and proliferation of feedback mechanisms can address these concerns. Although many comments from the international panel could be grouped into advances for individual learning or group learning, the overall picture of the future is so extraordinarily rich and complex that both approaches can be accommodated.

The following paragraphs list the possibilities in the order that they were presented in the questionnaire (together with the references provided to the participants in the questionnaire), the average of the panel's estimates of likelihood by 2030, and a distillation of the pattern of both positive and negative features of these possibilities. The full text of the responses is presented in the Appendix.

1. <u>Distilled Insights per Possibility</u>

1. National programs for improving collective intelligence

2. Just-in-time knowledge and learning

3. Individualized education

4. Use of simulations

5. Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.

6. Improved individual nutrition

7. Genetically increased intelligence

8. Use of global on-line simulations as a primary social science research tool

9. Use of public communications to reinforce pursuit of knowledge

10. Portable artificial intelligence devices

11. Complete mapping of human synapses to discover how learning occurs and thereby develop strategies for improvement of learning

12. Means for keeping adult brains healthier for longer periods

13. Chemistry for brain enhancement

14. Web 17.0

15. Integrated life-long learning systems

16. Programs aimed at eliminating prejudice and hate

17. E-Teaching

18. Smarter than human computers

19. Artificial microbes enhancing intelligence

1. National programs for improving collective intelligence[3]

Some richer as well as lower income countries have (by this year of 2030) made improving collective intelligence a national goal; this includes improving individual capabilities as well as intelligence for their nations as a whole. The average of 189 respondents' estimates of likelihood of this by 2030 was 62%.

1.1 What might make this happen?

The widespread realization that collective intelligence (CI) provides a political and economic advantage in an increasingly knowledge- and creativity-oriented globalized economy will lead to the adoption of this national objective. In addition it should also improve the general functioning of society and social well-being and reduce the fear of falling behind. Some respondents saw this as inevitable due to the continuing advances of ICT, the continuation of Moore's Law, and Internet's increasingly easy use by the general public. CI will become a new buzzword with major academic institutions using it as a strategic research focus and demonstrating that it is the next logical step in social-technological evolution. Downloadable open source prototypes for collective intelligence by MIT or similar institutions, and promoting successful experiences such as Wikipedia and Google will also help.

Countries with leadership that respects and encourages free thought and the rights of the individual might announce this goal first, especially Asian countries that want increased respect and economic power, but it might also take complex and urgent national and international problems and disasters to get CI accepted as a national goal. Increasing and intense international competition among countries might also tend to develop the concept of competitive human capital within national education programs. Another way to foster CI is the pursuit of nationally important projects like landing on the moon, especially if the process is equitable in mobilizing many people to ensure collective solidarity. Finally, the increasing volume and complexity of knowledge will continue to drive the world toward collective intelligence approaches.

1.2 What are some positive consequences?

More people will work together to solve problems. It should make large-scale intelligence-improving programs possible, which will improve national economies and reduce the rich-poor gap. It should stimulate more meaningful participation of civil society in national intelligence and reduce repetition, overlap, and confusion with information pollution and overload. Virtual learning and decision making communities could gradually supplant nation-states in effective decision making, increasing social stability. Human life would be more civilized and earth's resources might be more treasured, with better protection of the environment.

---

[3] References given for this possibility in the RT Delphi were: 1) Collective intelligence examples: http://www.socialtext.net/mit-cci-hci/index.cgi?examples_of_collective_intelligence ; and 2) Are dramatic increases in collective human-machine intelligence plausible within 25 years? Yes – 70%, The Millennium Project Delphi, 2003 linhttp://www.acunu.org/Delphi/SciTechScenariosRnd2.html#humachk

A smarter society will reduce some of the costs of low-cognition individuals (in terms of crime, wasted education effort, failed social projects), increase the number of people able to handle more complex work, and might have the benefit of attracting more creative people. It might vigorously promote the reformation of the educational system and the development of education. Research is continuing to show that learning is fundamentally a social process. Open-source, knowledge creation communities, and mass collaborations have resulted in very widely used information, social sharing and learning resources such as Wikipedia, YouTube, MySpace, FaceBook, and SecondLife. Learning will be primarily accomplished on the Web, as continua of new structured knowledge are developed on the Web by Wikipedia-like collectives which will enable anyone to do a self assessment of prior knowledge, and then be placed into the particular knowledge continuum just where they need to be in order to progress in a guided learning experience at their own pace of learning.

1.3 What prevents this from happening?

Ideologies that make any intervention into cognition are politically controversial. These include issues involving group cognitive differences, gender differences, the heritability of cognitive abilities, the use of biomedicine for enhancement and the relationship between individual and state. The lack of a single decision point for a curriculum tends to increase the number of people involved in the decision who could defeat the idea, such as politicians fighting globalization, religious groups with conservative views, and others who do not want a change in the status quo.

Some other perceptions that might prevent this possibility are: escalating costs with benefits too far in the future to be seen as 'real'; romantic anti-science backlash focusing on feelings; the inability to make major changes in beliefs about how learning and value creation really happens; the lack of interest in long-term projects; and "Conspiracy theories" about methods of increasing intelligence. War, famine, pandemics, economic depression, social convulsion, disease, poverty, ignorance, religious prejudices, and other disruptions could hamper efforts to improve collective intelligence, potentially resulting in a vicious cycle, and self-destruction.

1.4 What are some negative consequences?

Those countries that do not pursue increasing intelligence as a national goal are likely to have less economic growth, leading to "intelligence divides," increasing gaps between the rich and poor, and massive inferiority complexes and depression about "falling behind." If techniques were manipulated, it could lead to vicious competition, ignoring basic education, controlling choices, invading privacy, and regimenting thoughts. Psychological effects of diminishing individuality and authorship could cause a student revolt against being part of a "collective." If improved cognition reduced acceptance of traditional values it might be politically disruptive, while other forms of cognition enhancement might be supplied with subtle or not-so-subtle attempts at manipulation towards ideological ends.

2. Just-in-time knowledge and learning[4]

Rote learning has diminished in importance by 2030. With ubiquitous computing and education for life-long learning, 'just-in-time knowledge' has become the norm. The average of 181 respondents' estimates of the likelihood of this by 2030 was 71%.

2.1 What might make this happen?

Possibilities are failure of rote learning to achieve educational objectives; desire for personalized learning; continued advances in artificial intelligence; and the realization that this it the only way to keep up with rapidly changing knowledge in all fields. Life is too complex to know what one needs to know and when one needs to know it, so this will occur by necessity. Infrastructures will be built for teachers and students to use 24 hours a day and 7 days a week worldwide.

The confluence of advances in nanotechnology, neuroscience, artificial intelligence, and avatar-based synthetic online worlds will make education more experiential and engaging by 2030. Rote learning will continue because it "trains" the brain, but "Just-in-time knowledge" works, because it gets us what we want. The need to be constantly updated on new knowledge and developments will require transferring the teaching from specific subjects to those needed for specific purposes with fast, practical learning procedures and new methods of teaching. We will need to learn more about how to learn and how to use information and spend less time on learning specific information or subjects.

2.2 What are some positive consequences?

Anyone anywhere will have access to the education they want where this is implemented. People will become more self-confident, more empowered, businesses will be more efficient, countries will improve their economic development, and societies will be more practical, efficient, and harmonious. Education and training costs will lower. It will be easier to change jobs, taking greater advantage of human resources. Rote learning will continue to diminish leaving room for reflective thinking, which is indeed the cornerstone of significant learning.

Just-in-time knowledge and learning might greatly improve human competence and intelligence; enhance democracy by creating a more educated public; increase the number of more responsible global citizens; accelerate the creation of advanced knowledge and learning networks; reduce the 'power' of academic arrogance; and initiate another Renaissance. Much of traditional education will be replaced by Web-based, managed learning provided by open source collaboratives or vendors who compete in delivering measurable knowledge acquisition and retention, with speed and effectiveness as the basis of their payment. Teachers and students must be part of a team where the teacher is a coordinator of information collection.

---

[4] References given for this possibility in the RT Delphi were: 1) Computerworld: Just-in-Time Learning, 2000 http://www.computerworld.com/news/2000/story/0,11280,44312,00.html ; 2) Just-in-time Learning; the acquisition of knowledge or skills as they are needed. http://www.wordspy.com/words/just-in-timelearning.asp

2.3 What prevents this from happening?

The technological collapse of the Internet; too much computer hacking, information manipulation and other forms of information warfare would make people uncertain of what to trust. The costs might be prohibitive. Ignorant, backward, stubborn prejudices within traditional education systems where the teacher is the only active subject and the student a passive element, along with conservative religious leaders could discourage this possibility. Worries about bias and shallowness, as well as problems in teaching robust information gathering skills, might also slow its adaptation.

In a world where everybody can look like a specialist there will be more risk of decisions being made on shaky grounds and less respect for true expertise, and there would be fewer good ways of validating actual competence. Slow and old educational validation systems may slow the adaptation of this possibility.

2.4 What are some negative consequences?

Just-in-time knowledge and learning could produce a very practical, but a very superficial world of knowledge. Innovation could suffer. This could create poor learning habits; self-centered lazy-thinking; a less engaged public in the political process, leading to more government control; the inability to see the "big picture" for the good of the planet, and a reduction in problem-solving reasoning, much like many people's current inability to concentrate or focus on a topic in-depth without intermission or a commercial break. Some rote learning will be necessary to reduce these negative consequences.

While this development could certainly lead to advancements in science and technology, other fields like history and civics might suffer. It would increase the rich-poor gaps, since it might be impossible for lower income countries to implement. Those with the advanced technologies for "Just-in-time Learning" will evolve differently from those in the least-advanced societies caught in the divide and left behind.

3. Individualized education[5]

Through tests of various sorts, including simulations, the needs of individual students are being assessed and curricula and instructional methods are tailored to individual students. It is recognized by 2030 that all students have special needs and those needs are being largely met in many places in the world. The average of 179 respondents' estimates of the likelihood of this by 2030 was 64%.

3.1 What might make this happen?

The convergence of advances in the Internet, cognitive sciences, medicine, artificial intelligence,

---

5 References given for this possibility in the RT Delphi were: 1) Special Education Resources on the Internet, 2001 http://www.wordspy.com/words/just-in-timelearning.asp

continuation of Moore's Law, just-in-time learning, plus the success of the $100 laptop will make this more available. Young people who want to function more intelligently and teachers with advanced technology skills are already driving this process

If facilitated by mentors, it could be the core of the new educational paradigm. The proper use of IT and "coaching on-line" to address individual learning not only in elementary, secondary, and tertiary education, but also of adults for "life long learning" should be included. This can also be made more likely by the assumption that everyone is potentially a genius, and that each genius is different from the others; and by teachers who awaken the curiosity and creativity in each student; improved low cost individualized educational software; proliferation of reusable learning modules at all levels of society; and standards and single-sourcing for learning modules at all levels, so that there is no confusion or overlap in what has been learned.

3.2 What are some positive consequences?

This should lead to more satisfied students, greater respect for individual uniqueness and innovative achievements, changes in ideas about equal schooling rights, better use of genetic information to customize learning, and more special "geniuses" nurtured to their potential. The academic arrogance about who should be taught could also be reduced.

Increasing numbers of people will be leaders in different aspects of life. Leaders will need leaders among them to be coaches and referees so that teams work effectively and help competition to be fair, and to help different teams to be able to live together.

3.3 What prevents this from happening?

New ideological or religious movements that sweep the world into mono-thematic curricula; lower student-teacher ratios that could raise costs too high for poorer educational systems to afford; teacher shortages; standardized examinations; teacher unions that abhor the prospect of rewarding their superior colleagues; difficulties in reliable diagnoses and evaluation of results; and the desire to preserve standard courses based on a lower than average student capability, giving priority to teaching material rather than learning, can prevent this from happening. Until teachers have tools to read students' minds there will never be fully "individualized" education. Since learning is a social activity, there will continue to be needs for common goals for learning.

3.4 What are some negative consequences?

Widespread use of very individualized learning could reduce social cohesion; individualized learning could lead to more individualized vs. team or group acting within society. Such individuals could create new ways of learning that might divide society over how best to conduct education. The results of individualized education depend upon the intellect, objectivity, empathy and intent of the people involved and the artificial intelligence systems used. This could be a great way to "brainwash" people into adopting a particular ideology or way of acting.

4. Use of simulations[6]

In 2030, virtual reality simulations with programmed learning are available and used internationally, accounting for nearly a third of the tele-educational experience in elementary and secondary schools. These simulations allow people to progress at their own pace, alone or in groups. They are designed on the basis of insights derived from cognitive science. They diagnose and adapt to the individual's and/or group's learning style and need for hints and other forms of prompts. This is a means of providing artificial experience and social experimentation in a safe environment. The average of 168 respondents' estimates of the likelihood of this by 2030 was 70%.

4.1 What might make this happen?

The interplay of the VR game industry and educational systems; leadership willing to commit the funds over enough time to demonstrate the benefits; the continued advance of Moore's Law, nano processes, increased bandwidth, popularization of high-tech VR; the spread of video games and easy-to-use software creation tools (will X Bot become a teaching tool?); growing acceptance and participation in simulated societies like Second Life; using wiki-like approaches to creating simulations for specific learning environments; applying new insights from cognitive science; and the needs of the knowledge economy, could make this possible. Simulations of all kinds are a widespread and vital part of military training today.

As scientific collaboratories force standardization of data and simulation formats, educational simulations can be a lowered-cost byproduct. Costs could also be lowered by global cooperation and subsidized wiki-like development of simulations with common modules used worldwide. Future generations of 'Second Life'-type simulations could also lower educational subsidies as these applications become commercialized. Open source standards should be considered for educational simulation software to become more accessible. Computer-smart students will be best reached through the uses of social networks such as Facebook and MySpace which will morph into avatar-based VR worlds. VR design and implementation costs are going to improve, and once the interface becomes more natural, the numbers of people using many new applications will accelerate around the world.

4.2 What are some positive consequences?

This immersive experiential learning will have a continually growing impact, making larger numbers of truly educated people, opening eyes to new experiences, stimulating creativity, improving tacit knowledge of the behavior of complex systems, providing space for individual personality development, and furthering the evolution of humanity. It will challenge people to believe that if a problem can be solved in virtual reality, then in can be solved in the "real world".

---

[6] References given for this possibility in the RT Delphi were: 1) Jong-Heon Kim, et al., Virtual Reality Simulations in Physics Education http://imej.wfu.edu/articles/2001/2/02/index.asp , 2) Virtual Reality: History; Expo/Theater/Virtual Environments, 1995 http://archive.ncsa.uiuc.edu/Cyberia/VETopLevels/VR.History.html, 3) Wikipedia, Virtual Reality, 2006 http://en.wikipedia.org/wiki/Virtual_reality.

Simulations can satisfy both individual needs and collective learning experiences. Continuous real-time science, governance, and learning simulations will connect real-time public intelligence and information to government budgets, making simulations a basis for dialog and decision. Simulations will become a more normal mode of interaction,lowering costs of high performance hardware. This will evolve into new forms of individualized educational platforms.

See Holopticism http://www.thetransitioner.org/wiki/tiki-index.php?page=Holopticism

4.3 What prevents this from happening?

Concerns about video game violence, limited home access and/or understanding by parents, lack of leadership, high costs, difficulties of implementation, and disagreements about what values and content to include could inhibit its acceptance. Serious VR educational applications are more difficult to create than that experience today in Second Life.

4.4 What are some negative consequences?

This could lead to cyber "addiction," loss of touch with reality and face-to-face human contact, and disconnections between learning in simulations and actual activities in reality. Cults of brilliant but socially backward individuals with little sense of team spirit and sharing could grow. It could also limit thinking about possibilities in the "real world" to those options offered in the "virtual reality" systems. It might encourage selfish and unrealistic perceptions as people achieve status in cyberspace that they cannot achieve in reality. It could limit the face-to-fact communications needed especially by younger people; even though simulations will be come very vivid. To make educational simulations universally acceptable, they could become shallow, conveying little sensibility and moral character, and be poorly used by teachers who do not add the complexity and interactivity of real experiments that can be lacking in "edutainment."

The gap between those nations, regions, and cultures that use simulations and those who don't will widen through time. There could be a backlash to this trend. Some groups will assert the value of 'real' interaction and deny the benefits of virtual simulations. Whether this backlash becomes violent will partly depend on the proportion of population with access to this technology. Cyber crimes and purposeful design of immersive VR technologies to negatively influence human behaviors are also possible. See Edward Castronova's excellent book "Synthetic Worlds."

5. Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.[7]

The objective of these programs which have appeared in several countries is to identify persons who seem likely in later life to exhibit antisocial behavior including terrorist activities and

---

[7] Reference given for this possibility in the RT Delphi was: Jean-Pierre Voyer, The Pre-conditions for a Constructive Social Inclusion Research Agenda, 2003 http://www.ccsd.ca/events/inclusion/papers/voyer.pdf.

violent criminality. Special nurturing programs are provided to people identified in this way to help keep them from becoming unstable or mentally ill in later life.

The average of 170 respondents' estimates of the likelihood of this by 2030 was 43%.

5.1 What might make this happen?

The increasing awareness that single individuals can become massively destructive (SIMAD) could bring this about, but great care should be taken to ensure that these activities are in the public interest and that they do not drift into totalitarian applications. Perfecting the theory and methods of psychological evaluation and the use of Maslow's hierarchy of needs should be used to guide the development of such programs. The evaluation systems used would have to be validated by many individuals and the samples would have to be significant. The programs will have to be self-evidently beneficial, and very creative and engaging to encourage widespread adoption.

If developed in a humane environment, this activity could identify young people at risk. Alice Walker's work showed that those who led troubled lives but still did well had one thing in common: they all had found someone who loved them. A program like this could identify and match these youth with appropriate mentors.

5.2 What are some positive consequences?

It could help make for more harmonious and stable societies; reduce social problems like suicide, drug abuse, and terrorism; provide deeper knowledge of human nature; and increase investments into preventive mental health and medicines. It could also be a relatively inexpensive way to deal with certain mental health issues - especially as people live longer.

5.3 What prevents this from happening?

Perceptions that it could be a one-time classification system used by governments to control or eliminate deviant behavior or that it could be implemented by more dictatorial paranoid societies to reduce creativity and innovation would prevent this from happening. All geniuses are always a little crazy! Although proposed with good intentions, it is full of too many negatives such as "profiling" to find universal acceptance. Antisocial behavior including terrorist activities and violent criminality is not just a problem of individual nurture, it has also has social causations. No one knows how to do this, especially to make it work in very large populations. The increasing evidence that most mental illness has a genetic or physiological cause indicates that these programs might have limited effectiveness compared to genomic analysis.

5.4 What are some negative consequences?

This program might result in group speak, less privacy, reduced freedom of speech and thought, and strengthening of intelligence-gathering/police organizations in those nation-states with the worst histories of human rights violations. This could lead to neo-socialist realism, preventing more new forms of art.

Some of the world's brightest thinkers would have been classified in a negative fashion by such programs - what would have happened to them and their breakthroughs? In the future, if we begin to "cure" or isolate individuals with deviant personalities, are we going to destroy something that could have been of benefit to the world? Who decides what is "deviant"?

6. Improved individual nutrition[8]

Self-administered diagnostic tests identify individualized nutrition requirements for improved cognitive development. These tests are used in the more affluent areas and are beginning to be used in lower income areas with government and insurance company support. The average of 162 respondents' estimates of the likelihood of this by 2030 was 63%.

6.1 What might make this happen?

Alliances among health insurance companies, education programs, and businesses could promote self-administered tests and help educate the consumer about new nutritional foods. Insurance companies could lower premiums to those who use the tests and new foods. Scientific breakthroughs in nutrition, DNA testing, improved understanding of the "nature and nurture" factors in health, individualized medicine, and "nutrigenomics" would also increase the chances of this possibility. NGOs and UN agencies would be necessary to help in poor countries.

6.2 What are some positive consequences?

It could greatly improve a nation's health and cognitive development; reduce the cost of health care, and increase longevity and physical strength and performance.

6.3 What prevents this from happening?

Poverty, cultures with bad nutrition habits, lack of political will, costs of converting food production to more individualized and nutritious foods, and fear that the diagnostics could be faulty. Yet the overall beneficial effects of full and diverse nutrition may overshadow the high cost-benefit of individual effects. It may not be financially possible for poorer areas. The sensual pleasure of inherited eating habits could override such prescriptions. If DNA tests were required, then some people will oppose it.

6.4 What are some negative consequences?

This could further the separation between the rich smart people who can afford special diets and the poor less smart people who can't.

---

8 References given for this possibility in the RT Delphi were: 1) Foods that Build and Foods that Drain the Brain, 2000 http://www.askdrsears.com/html/4/T040400.asp#T040405; 2) Foods and Vitamins that Help Brain Development and Repair Damage http://www.yourfamilyclinic.com/nutrition/brainboost.html; 3) UN FAO, Fish is food for the brain as well as good protein, http://www.fao.org/FOCUS/E/fisheries/nutr.htm

7. Genetically increased intelligence[9]

Genes that contribute to increasing intelligence and learning have been identified and used by many parents in the upper and middle classes of the world to change the potential intelligence of their future children. Treatments have been subsidized for many people in the poorer regions. The average of 159 respondents' estimates of the likelihood of this by 2030 was 39%.

7.1 What might make this happen?

Future synergies among neurosciences and genetics, parents who want a better life for their children, and initial successes of cognitive enhancements through pharmaceuticals, could make this happen. The main form of near future genetic intelligence enhancement would be Preimplantation Genetic Diagnosis (PGD), selecting away genes involved in pathologically lower intelligence. This would lead to a reduced number of the lowest performing, in turn increasing the average. But PGD would have to become more common, which requires improvements in technology, automation of the process to bring down the price, creation of standards that make different treatments comparable, and, most importantly, attitudinal shifts that make genetic selection more acceptable.

Genetic enhancement of intelligence should be combined into a single procedure that would also reduce affect genes associated with criminal behavior. Just as we "correct" our eyesight with glasses, we should also correct our low intelligence. Once a safe procedure is available for increasing intelligence, parents will take their child to the country that first offers it. Genetically increased intelligence should be accompanied with or preceded by the development of social ethics, acceptance of differences, and respect for others.

7.2 What are some positive consequences?

Cure mentally retarded children. As with most advances richer people would have this for their children, but eventually the price will come down to make future generations more intelligent.

7.3 What prevents this from happening?

Insufficient progress in genetics, high costs, fear of genetic mutations caused by incorrect use of genetic technology, and the belief that life is an unalterable gift from God will discourage this possibility.

7.4 What are some negative consequences?

Naive selection criteria may lead to favoring a few detectable "intelligence genes" although they do not represent the full range of human capacity (on the other hand, even assuming broad

---

9 References given for this possibility in the RT Delphi were: 1) Wesley Smith, Biohazards Advances in biological science raise troubling questions about what it means to be human, 2005 http://www.discovery.org/scripts/viewDB/index.php?command=view&id=3005; and 2) Everett Mendelsohn, The Eugenic Temptation, Harvard Magazine, 2006 http://www.harvardmagazine.com/on-line/0300126.html

approval and use of the technology, this limitation is unlikely to affect a very large number of people by 2030).

It could increase the rich-poor gap, possibly leading to a divided society of intelligent managers and less intelligent consumers, or used by future dictatorships wishing to manipulate people or develop a "super race," or providing it just for "world leaders." Children might no longer have 'time' to be children.

8. Use of global on-line simulations as a primary social science research tool[10]

Virtual realities like Second Life (which in 2006 had more than a million and a half inhabitants) are used by leading cognitive scientists, curriculum experts, and behavioral scientists to evolve the equivalent of natural laws for social behavior and new tele-virtual educational simulations. In these e-universes, people act as societies, form laws, build new cultures and provide a means to experiment with the glue of society without the concerns that might accompany human experimentation. The average of 161 respondents' estimates of the likelihood of this by 2030 was 62%.

8.1 What might make this happen?

Initial use may be for business market research and political forecasting, and then when the cost comes down it could be used in teaching social science. This will evolve naturally from phenomena such as Second Life.

8.2 What are some positive consequences?

It could reduce research costs; provide superb 'strawmen' for comparative analysis; and stimulate the imagination to promote development of creative cultures. Anyone anywhere will have access advanced social science research education.

8.3 What prevents this from happening?

It is almost impossible to reproduce real social situations in cyberspace. People may not provide enough accurate information for the simulations, hence reducing their value. Acceptable controls using such tools may be a bit of challenge. Abuse of people in cyberspace is possible, the same way experimenters have abused humans in research in the past. If results show that political directions are headed in the "wrong" directions, then future applications could be suppressed.

8.4 What are some negative consequences?

---

10 References given for this possibility in the RT Delphi were: 1) Second Life Home Page, 2006 http://secondlife.com/; 2) Popular Science, Your Second Life is Ready, 2006 http://www.popsci.com/popsci/technology/7ba1af8f3812d010vgnvcm1000004eecbccdrcrd.html; and 3) Roger Segelken, Artificial worlds used to unlock secrets of real human interaction, 2003 lihttp://www.news.cornell.edu/releases/Feb03/AAAS.Macy.hrs.html nk

Virtual realities could result in a kind of split personality— one focused in the cyber world and the other in the conventional world — that could work against the evolution of human society. "Second Life" could have conflicts with real life in culture, ethics, morality and other aspects.

9. Use of public communications to reinforce pursuit of knowledge[11]

In 2030, social marketing of learning concepts or memes is widespread. Some of the themes have been: Intelligence is Sexy; Knowledge is Cool; Knowledge Matters; and Ignorance Equals Poverty. Public media leaders often meet with educational leaders, cognitive scientists, and entertainers to discuss promoting the message that learning is a central pursuit of life. The average of 161 respondents' estimates of the likelihood of this by 2030 was 71%.

9.1 What might make this happen?

With the coming knowledge-based economies, the importance of knowledge and intelligence would be highlighted, and the media and entertainment industries could be enlisted to play a role in the pursuit of knowledge, such as Project Red for AIDS with celebrity Bono. Informal meetings like this already happen in the USA with the Ad Council, so it seems likely that in 25 years public communications will be even more widespread.

9.2 What are some positive consequences?

It should promote the development of people's imagination, creativity, and innovation; produce a better educated population, and improve the knowledge economy; enhance democratic governments and promote the general well being of societies; and be an essential part of reducing poverty, increasing social justice, and accelerating progress.

9.3 What prevents this from happening?

Too many diverging viewpoints within the media, public conformism, and lack of a professional ethic within the public media could prevent this. Societies would have to become more pro-education first. With the success of individualized learning there might not be as much need for public media, and it could be seen as a new form of social engineering by less enlightened governments and therefore would be opposed by free societies.

9.4 What are some negative consequences?

The messages might become dull and overused, negatively reinforcing education.

---

[11] References given for this possibility in the RT Delphi were: 1) The Social Marketing Institute, http://www.social-marketing.org/sm.html ; 2) Wikipedia: Social Marketing, 2006 http://en.wikipedia.org/wiki/Social_marketing ; 3) Center for Disease Control, Social Marketing, 2003 http://www.cdc.gov/communication/practice/socialmarketing.htm

10. Portable artificial intelligence devices[12]

Most people carry tiny computers that contain extensive personal memories, and interact with their owners in human fashion. Meet a person on the street and the ear buds whisper on the basis of facial pattern recognition," That's Billy Johnson whom you met at a party three years ago. He is a pilot and his wife's name is Angie"' More seriously, the machine also participates in personal decision making and on the spot need for information. Some individuals have been technologically augmented with nanobots, brain chips and nanotech transceivers in clothing. The average of 158 respondents' estimates of the likelihood of this by 2030 was 61%.

10.1 What might make this happen?

Maturity of recognition technology (voice, face and retina, etc.), nanobots, brain chips, and other forms of nanotech transceivers used by early adopters among very rich individuals will make this happen.

10.2 What are some positive consequences?

These devices will improve memory, analysis, and decision-making, and make human competence advance rapidly. Naturally, the richer nations will get this first, but just like the hand calculator, as the price comes down, their use will spread worldwide.

People's lives and experiences will be recorded allowing them to better manage their lives, learn from their experiences, and re-live their happier experiences as they grow older. Personal AI should also reduce crime significantly. Imagine a very advanced Google in your pocket to which you ask it to identify someone walking down the street, or point out others in the area with similar interests. The AI devices may also tell with whom to interact and help you to interact with them.

10.3 What prevents this from happening?

Complexity of facial pattern recognition, and privacy issues involved in face recognition and other information requirements for decision making could restrict this. Certain uses of the devices might be restricted because of defense and military intelligence considerations.

10.4 What are some negative consequences?

Potential loss of privacy, continually arising ethical issues, widening of the rich and poor gap, potential uses by criminals, a race to build portable 'anti-artificial intelligence devices' to protect privacy, and reduced intellectual and emotional capabilities of people who have become dependent on these devices are some potential negative consequences.

---

[12] References given for this possibility in the RT Delphi were: 1) Stanford Research Center, Artificial Intelligence Center, 2006 http://www.ai.sri.com/; 2) MIT, Computer Science and Artificial Intelligence Laboratory, 2006 http://www.csail.mit.edu/index.php ; 3) Journal of Artificial Intelligence Research, 2006 http://www.jair.org/

11. Complete mapping of human synapses to discover how learning occurs and thereby develop strategies for improvement of learning[13]

Just as the gene was decoded so was the connection pattern of the synapses in the human brain. From this complex map came information about cognitive development, intelligence, emotion, how to design artificially intelligent machines, and ultimately how to improve the speed and depth of learning. The average of 152 respondents' estimates of the likelihood of this by 2030 was 43%.

11.1 What might make this happen?

The realization that increased intelligence is the key competitive advantage in the knowledge economy will stimulate massive brain research by several countries that fund the research over sufficient time to make breakthroughs. The Allen Brain Atlas project is an example of what is quickly happening in neuroscience [an interactive, genome-wide image database of gene expression in the mouse brain]. Complete understanding of mental functioning requires improvements in dynamic scanning methods (like extending the scope and resolution of such techniques beyond what we now have in functional MRI) database management, image processing, computational neuroscience, and automated research that may not be enough to finish the job by 2030; nevertheless, even partial results are likely to produce important neuroscience insights about learning. Advances in complexity theory, acceptance that it will take incremental advances to achieve this, and the need to make great advances would also help to bring this about.

11.2 What are some positive consequences?

A more complete understanding of neuroscience could result in extraordinary progress in robotics and empower most fields of cognition, from AI to learning enhancement drugs. It would be a great advance in life sciences, provide a qualitative leap in learning theory and human and machine intelligence, and establish a significant benchmark in human history.

11.3 What prevents this from happening?

This is a very complex task, which could be blocked by the belief that it is far too complex and expensive to complete in 25 years. Other inhibiting factors include the belief that intelligence and emotions go far beyond patterns of synapses or that insights from this research might not be very helpful in understanding how learning occurs on a personal level for an individual. The dominant educational establishment and ethical issues over human testing could also prevent this.

---

[13] References given for this possibility in the RT Delphi were: 1) Mapping miniature synaptic currents to single synapses using calcium imaging reveals heterogeneity in postsynaptic output, 2006 http://www.ionchannels.org/showabstract.php?pmid=7619520 ; 2) Society for Neuroscience, Scientists Map Maturation Of The Human Brain; Make Advances In Understanding The Lasting Effects Of Stress, Nicotine And Alcohol, 2006 http://www.sfn.org/index.cfm?pagename=news_11082003a ; and 3) Allen Institute for Brain Research, 2005 http://www.alleninstitute.org/content/about_the_institute.htm

11.4 What are some negative consequences?

If this were to occur, it could result in the abuse of power and prestige by the scientists and doctors at its forefront and a series of problems with human and animal testing. It might also trivialize human emotion and being—is love only a set of chemical reactions?

12. Means for keeping adult brains healthier for longer periods[14]

In our time (2030) we have techniques for keeping adult brains healthier during the aging process. For example, adult neural stem cells have been cloned and injected into adult brains to keep them far healthier for longer times then formerly believed possible, making old age learning and an older knowledge-based work force possible. The average of 158 respondents' estimates of the likelihood of this by 2030 was 69%.

12.1 What might make this happen?

Rising standards of living, aging populations with increasing political power, and falling fertility rates will speed medical science to make this possible. People used to think that adults could not grow new nerve cells. Research has now shown that new brain cells are created every day. Many of the new cells born each day die off, but exercise and a more stimulating environment reduce the death rate of brain cells. Some research indicates that continued adult learning may be associated with the growth of new brain cells. Research in neurogenesis (adult growth of new brain cells) should keep brains healthy longer, certainly by 2030, and this is only one line of research. Some background is available in these resources:
http://www.wellesley.edu/Biology/Concepts/Html/neurogenesiswhat.html;
http://www.medterms.com/script/main/art.asp?articlekey=18200;
http://en.wikipedia.org/wiki/Neurogenesis
Adult brains will stay healthier longer, as a result of training, biofeedback, behavior modifications, medications, and other stimulants. These processes may make people "better than well."

12.2 What are some positive consequences?

This has the potential for elimination of brain diseases, including reducing mental illness, Alzheimer's and Parkinson's diseases, and hence avoiding large numbers of elderly with dementia, while adding the elderly to the work force, reducing the economic effects of falling fertility rates.

---

[14] References given for this possibility in the RT Delphi were: 1) Monika Guttman, The Aging Brain; Scientists are amassing a greater understanding of the long-term risk factors that adversely affect the brain, with the goal of halting cognitive deterioration, 2001. http://www.usc.edu/hsc/info/pr/hmm/01spring/brain.html ; 2) The Brain Aging Journal, 2006 http://www.brainaging.ro/Pub-BAJ.htm ; 3) Medical News Today, With Few Factors, Adult Cells Take on Characteristics of Embryonic Stem Cells, December 9, 2006 http://www.medicalnewstoday.com/medicalnews.php?newsid=49405

12.3 What prevents this from happening?

People believing it is not possible and hence not investing in the necessary research, ethical issues, ageist assumptions that decline is inevitable, and the fear of tampering with "order of nature" and the brain – the most complex structure in the known universe – could delay some developments in cognitive sciences. The potential costs could limit the widespread use of the relevant techniques to extend brain functioning. Techniques like functional magnetic resonance imaging (fMRI) may take longer to produce results than expected.

12.4 What are some negative consequences?

This development could leave a group of non-treatable elderly behind, while vital elderly might feel locked out of a youth-directed society, possibly becoming discontented or forming isolated subcultures or enduring other imbalances in the quality of life.

13. Chemistry for brain enhancement[15]

Brain chemistry research has led to safe drugs that enhance intelligence, improve memory, increase attention span, and improve visual acuity and hand/eye coordination. The average of 154 respondents' estimates of the likelihood of this by 2030 was 74%.

13.1 What might make this happen?

Changes in the perception of enhancement are needed for enabling this, and development of an "enhancement culture" among people will be needed to set the social norms of when they are proper or not proper to use. Positive evaluation of the ethical consequences, current research by DARPA, spreading to civilian uses, and increased awareness of sources such as: http://books.google.com/books?hl=en&lr=&id=9ykQOkpFFuEC&oi=fnd&pg=RA1-PR9&sig=qKHKN5wzw88tl2IzgZN0eYM8vtk&dq=%22Pardridge%22+%22Brain+Drug+Targeting:+The+Future+of+Brain+Drug+Development%22+#PPP1,M1 and http://www.smart-kit.com/s59/brain-enhancement-with-flax-seed-oil-and-vitamin-c// will increase the likelihood of this possibility. Ritilin, Valium, and Prozac are examples of new psychoactive drugs that do not "enhance" human intelligence, but allow one to function normally, despite mental problems. Adrenalin has been used to erase traumatic memories.

13.2 What are some positive consequences?

This could result in enhanced human intelligence and physical functioning, plus those positive consequences from the previous possibility.

13.3 What prevents this from happening?

---

[15] References given for this possibility in the RT Delphi were: 1) Wikipedia: Psychoactive Drug, 2006 http://en.wikipedia.org/wiki/Psychoactive_drug ; 2) World Health Organization: Psychotropic Drugs, 2006 http://www.who.int/topics/psychotropic_drugs/en/ ; 3) Psychotropic Drugs and Children; Use, Trends, and Implications for Schools, 2004 http://www.healthinschools.org/sh/psychotropic.pdf

Medical regulations on testing and marketing, ethics of usage, suspicion of drugs, high value placed on "the natural," medical monopolies, and the fear of the unknown effects of "wonder drugs" would discourage the possibility.

13.4 What are some negative consequences?

Thinking that "miracle drugs" will solve all human problems will yield dangerous consequences such as luring people into a competitive drug race, overdosing, and ignoring the complexity of the human psyche.

14. Web 17.0[16]

By 2030 the trend toward data integration on the Web that started around the turn of the century (Google Earth, Wikipedia, the MIT course material) has progressed to the point that a large part of the world's knowledge - data, analyses, discussions - has been integrated into Semantic Web 17.0. That structure is organized according to a logical framework of concepts (both precise and fuzzy ones), has a natural language interface, is dynamically maintained, and contains an intelligent subsystem that 'understands' the logical rules that govern the interactions of entities. The interface makes heavy use of virtual reality type graphic techniques for presenting knowledge and processes. The average of 151 respondents' estimates of the likelihood of this by 2030 was 78%.

14.1 What might make this happen?

The progression from teaching children to teaching adults, and then to self-directed learning, together with progress in semantic analysis, and the realization that knowledge must be worked on cooperatively will make Web 17.0 the place where people will go to learn when and how they choose to do so.

14.2 What are some positive consequences?

It should make the networks intelligent, make query and analysis more exact, break down barriers to knowledge cooperation, stimulate co-creation for massive co-development, and reduce complexity, confusion, chaos, and error. It could change the economic paradigm of payment for access to intellectual property to the paradigm of income from the 'act of knowledge working' with some shared property. Douglas Englebart's Open Hypertextdocument System (OHS) and Pierre Levy's Information Economy Meta Language (IEML) could combine with XML Geo, and other open innovations to make it possible for any individual to immerse themselves in the diversity of information, inclusive of historical information, multi-cultural and

---

16 References given for this possibility in the RT Delphi were: 1) The Futurist: The Intelligent Internet http://www.gcn.com/online/vol1_no1/26338-1.html; 2) Bill Gates, Now for an Intelligent Internet, 2000 http://www.microsoft.com/presspass/ofnote/11-00intelligenti.mspx; 3) Artificial Intelligence Foundation, 2006 http://alice.pandorabots.com/

alternative perspectives, real-time serious games/games for change, and practical rigorous dialog and consensus building. Human collective consciousness will greatly advance as networked intelligence is always on and instantly accessible and ways of knowing are no longer a struggle.

14.3 What prevents this from happening?

The current illegal and unethical uses of the net are likely to increase if more ethical means are not implemented. Some bottlenecks would be the ability for improved semantic analysis, "individualistic vs. group solutions," and industries that fight open source software initiatives.

14.4 What are some negative consequences?

New kinds of viruses and methods of manipulating information delivery could be used to distort knowledge on the Semantic Web by those who don't like the new knowledge. In the past, cigarette companies distorted cancer research, today an oil company is distorting global warming research, and, in the future, some groups might want to distort research that counters their ideologies. As ideological wars were fought by industrial means in Korea and Vietnam, future ideological wars could be fought by information warfare means yet to be invented, making the Semantic Web a battle zone and hence less trusted. Major geopolitical problems, terrorism, ideological conflicts, and even open source arguments could become foci for, or versions of, information warfare.

15. Integrated life-long learning systems[17]

Today (2030) education ranges across all age groups from pre-natal programs to programs for the elderly that provide knowledge, work, and leisure enjoyment. The average of 158 respondents' estimates of the likelihood of this by 2030 was 77%.

15.1 What might make this happen?

Life Long Learning is already a trend reinforced by longevity as well as the further development of knowledge and learning society; Elderhostel is a contemporary example. To some degree the Internet is providing life-long learning now, although few see it that way yet. More people are devoted to education (teaching and learning) and for more years than ever before in history. Improved classification of competences required by different occupations for all ages groups; better understanding of HOW we learn from elementary school on up; and increased attention to the spiritual needs of people via more humanistic educational approaches would promote the emergence of such a possibility.

15.2 What are some positive consequences?

---

[17] References given for this possibility in the RT Delphi were: 1) Elderhostel; Adventures in Lifelong Learning http://www.elderhostel.org/ ; 2) Life in the USA- Retirement and Aging New Careers, 2005 http://www.lifeintheusa.com/aging/careers.htm

Reformation of education, increased curiosity, self-improvement and learning become more a part of life, helping the evolution of society. Greater attention will be paid to prenatal care as a necessary condition for better overall physical and mental performance.

15.3 What prevents this from happening?

Economic and cultural retrogression, growing generation gaps, and the widening divides between rich and poor could increase conflicts that would interrupt the evolution of education.

15.4 What are some negative consequences?

Too much dependence on computers and learning systems that might suffocate people if they are too conservative and the educational managers are too complacent. It could also create a gap between those who use the systems and those who opt out.

16. Programs aimed at eliminating prejudice and hate[18]

Our psychologists in 2030 believe that many wars and extremist activities are fueled by overt or subtle teachings of parents, peers, and teachers. Significant efforts have been made to reduce these influences in the education of young people. The average of 154 respondents' estimates of the likelihood of this by 2030 was 45%.

16.1 What might make this happen?

Universal curricula created by some internationally accepted body like UNESCO or Wikipedia 8.0 is more likely to be universally accepted and used by parties to an educational treaty. It has to be developed with the sense that it will be taught in Chicago as well as Jeddah. Curricula should include emotional as well as intellectual development, and acknowledgement of individual potential to contribute to society, as well as a respect for cultural diversity, the value of 'soft' knowledge, and more accurate history. In addition, better integration of insights from psychology would contribute to understanding the need for unlearning, re-cognition, and commitments to new beliefs and emotional change. Special attention should be given to the learning that occurs during adolescence when students form their personal philosophies and world views. Reduction of violence in media and entertainment would help the curricula be more effective.

16.2 What are some positive consequences?

Society becomes more auspicious, respectful, democratic, free, equitable, harmonious, and stable. Such programs are essential for the survival of humanity, as increasingly destructive capabilities become more available to small groups and individuals.

---

[18] References given for this possibility in the RT Delphi were: 1) US Department of Justice, Preventing Youth Hate Crimes, http://www.usdoj.gov/crs/pubs/prevyouhatecrim.htm ; 2) Kathleen Cotton, Fostering Intercultural Harmony in Schools: Research Finding http://www.nwrel.org/scpd/sirs/8/topsyn7.html ; 3) Canada's Fourth Report under the International Covenant on Civil and Political Rights, 2006 http://www.canadianheritage.gc.ca/progs/pdp-hrp/docs/iccpr/notes_e.cfm

16.3 What prevents this from happening?

If it is created within an atmosphere of "I will tell you how to teach your children," it will fail. As long as there are significant gaps between rich and poor, and limited resources, prejudice and hate will continue to be inflamed by extremists. Some governments will want to intervene and control people's behavior. It may take at least a generation beyond the Westphalian "state-above-all"; thereafter, there may be 'space' to begin significant efforts to design and offer educational means with less emphasis on extremes in society.

16.4 What are some negative consequences?

If it is possible to reduce or eliminate hatred and prejudice, then it means that others can control human minds for ill as well. For example, cult leaders, totalitarian states, or new forms of ideological political correctness might use these methods or technologies to control the public. Education alone would not be enough to eliminate prejudice and hate; programs must include specific means to achieve social justice.

17. E-Teaching[19]

Most of the poorer areas, as well as the more affluent ones use global outsourcing for e-teachers on-demand. These e-teachers are increasingly artificial constructs using artificial intelligence, rather than live humans. The average of 159 respondents' estimates of the likelihood of this by 2030 was 70%.

17.1 What might make this happen?

E-teaching can be encouraged by the increasing realization that e-teaching is good for both affluent and poorer regions of the world, that it can make the best teachers available to many people regardless of location, and can be cost-effective. It can address both the diversity in knowledge levels and the unevenness of access to knowledge in education systems. Outsourcing to the best e-teachers will increase their income to the point that they can hire computer programmers, cognitive scientists, and others to make really brilliant programs to reach even more people around the world. Continued improvements and cost reductions in virtual reality, bots, and tele-education collaboration among educational institutions, governments, business, and NGOs will also help. Today, Homework Help from India charges US$18 an hour for tutoring on any subject. Knowledge can be shared and built upon at no cost. It is inevitable that the cost of communications will go to near zero and the cost of e-teaching will be within the reach of all, especially if the government subsidizes e-learning. Special interests will have to be defeated by firm and wise government policies.

---

[19] References given for this possibility in the RT Delphi were: 1) John Harris, Why We Need Better E-Teaching, Not More E-Learning, 2005 http://meld.medbiq.org/divergent_views/better_eteaching_harris.htm ; 2) Wikipedia, e-learning, 2006 http://en.wikipedia.org/wiki/E-Learning ; 3) Wikipedia, Advanced Distributed Learning, 2006 http://en.wikipedia.org/wiki/Advanced_Distributed_Learning

17.2 What are some positive consequences?

E-teaching will help education to become more democratic, increase access to more people around the world, reduce financial and environmental costs per student, and thus help reduce poverty, popularize science and culture, increase the joy of learning, facilitate the exchange of information among educational institutions, and open new methods of education. It will also lead to customized one-on-one instruction, and make knowledge acquisition easier, faster, more individualized, virtual, and more globalized. With continuing development of advanced interfaces, it is likely that educational opportunities in virtual or synthetic worlds will be perfected as tools for teaching. Avatars or 3D holographic recordings will allow top teachers to send their lessons to all including the underprivileged. Appropriate levels of funding and an R&D emphasis on education (and not just "gaming") could advance this. It's possible that by 2030 accelerating technologies could lead to a point at which the elite will be educated in part through direct brain downloads or novel nanotechnology applications and the people in poorer areas will have to "settle" for 3D VR teachers and learn the "old-fashioned" way, by listening and trying to remember. The live teacher is one of the least efficient, and perhaps least effective ways of teaching; artificial constructs will become more and more the norm.

17.3 What prevents this from happening?

E-teaching could be delayed by entrenched monopolies, educational system inertia, lack of access to computers with high speed Internet, governments and other institutions that do not value education enough, and the lack of cooperation in exchanging information.

17.4 What are some negative consequences?

Although it is a useful tool for distant publics, it may not be a substitute for face-to-face education that provides the human dimension. The personality of teachers and experience of interpersonal communication is an important part of the educational process; e-teaching might not be able to take personal differences into account. Education is more than exchange of information. The poorest areas might not be able to afford e-teachers, perpetuating the knowledge gap.

18. Smarter than human computers[20]

Machines exist today (2030) which are clearly smarter than humans in any way that 'smartness' can be measured. With this threshold having been passed, the roles and methods of education and learning are being reassessed everywhere. The average of 155 respondents' estimates of the likelihood of this by 2030 was 52%.

18.1 What might make this happen?

---

[20] References given for this possibility in the RT Delphi were: 1) The Singularity Institute for Artificial Intelligence http://www.singinst.org/overview/whatisthesingularity/ ; 2) Nick Bostrom, Futurist Magazine, When Machines Outsmart Humans, 2000 http://www.nickbostrom.com/2050/outsmart.html ; 3) Raymond Kurzweil, Will My PC Be Smarter Than I Am?, 2000 http://www.kurzweilai.net/meme/frame.html?main=/articles/art0354.html?

Moore's Law seems like a good indicator that artificial intelligence will overtake human intelligence by 2029, as forecasted by Ray Kurzweil. In effect, the Internet is already a 'smarter' than human computer; this depends of course on how one defines 'smartness.' If 'smarter' means memory or specific functions, then the Net has already surpassed the individual human brain. Advances in the fields of artificial life and nanotechnology will continue and it is likely that machines will pass the Turing test and extend into ways of machine 'understanding' beyond simple information processing. The fulfillment of this and other scenarios in this vision of 2030 could eliminate the need for conventional schools and human teachers. If superhuman AI emerges, these entities are also going to require some form of education, which most likely would be extremely different from human learning in terms of learning facts, social interactions, relations with the physical world, and growing up from childhood to maturity.

18.2 What are some positive consequences?

This development could dramatically increase human development and be regarded as the best tool or co-agent ever created by humanity. The integration of artificial intelligence and the human intellect in micro-devices would dramatically enhance the efficiency of learning, the nature of work, and fundamentally change the methods of education and learning. This processing power may yield very different kinds of "thinking" from that of humans and provide an interesting cross-reference to understanding reality.

18.3 What prevents this from happening?

Computers may surpass "intelligence" as we define it today, but they will never be able to compete with the other learning areas of individuals such as emotional and social where the interests of individuals reside. There could be a backlash from people who feel threatened by robots and computers that might grow beyond our ability to control, or who believe that such computers would be used by powerful evil forces. Frustration at not being able to achieve this goal could lose support for further development, as some believe that it is impossible to make machines which are clearly smarter than humans in any way. The knowledge and intelligence of the physical, psychological, social, emotional domains could be mimicked but not the thinking intelligence, and if it could be, who would trust it?

18.4 What are some negative consequences?

It might increase unemployment, and lead to the division of humanity between the "technologically enhanced" and the "naturals," a constant worry in the development of artificial intelligence and its direct application to human beings. As the future will continue to be "unevenly distributed" - a select few will benefit before everyone else; and the outcome will depend upon the benevolence of the people in control of the technology. We might not recognize superhuman intelligence for what it is, especially since it may be distributed and not a single perceptible being per se, which could lead eventually to the science fiction image of intelligent machines controlling humanity before humans realize it.

19. Artificial microbes enhance intelligence[21]

Genetic codes have been written for new microbes which improve neural performance when co-habiting the brain. The average of 148 respondents' estimates of the likelihood of this by 2030 was 30%.

19.1 What might make this happen?

Craig Venter's work on writing genetic code to create unique lifeforms might develop some lifeforms by 2010, then it might take another ten years for creating the microbes able to live in and assist the brain, then add another ten years to test on other mammals. Hence, by 2030 it could be possible to have safe microbes assisting the brain in keeping neurons healthy. It would be wise to dedicate some of the research money to public education, as was done for the Genome Project, so that public understanding evolves with research developments. Gates-type foundations funded by the nouveau-super-riche in countries like India, Russia, and China could accelerate the research.

Symbiotic organisms have many advantages over gene therapy, but they require ways of circumventing the immune system. Symbiotic gut bacteria producing drugs seem very plausible, and could probably be used for enhancement. Anti-cavity mouth bacteria have already been demonstrated. Psychopharmacology, nanobots, and computer brain interfaces may also increase human intelligence.

19.2 What are some positive consequences?

This development would revolutionize life sciences. Healthy brains will last much longer, reducing medical costs, and could make for a wiser civilization.

19.3 What prevents this from happening?

There is a normal "human" fear about the unknown; many people will be afraid of artificial microbes, new bacteria, and nanobots. Those behind the anti GMO-regulations might also oppose this, as would those who consider altering human biology unethical. A global human review board might be created to help prevent this.

19.4 What are some negative consequences?

Microbes might mutate and cause mental disease or other unknown side effects; therefore, a series of research trials over years would have to be conducted.

---

[21] References given for this possibility in the RT Delphi were: 1) Antonio Regalado, The Wall Street Journal, Biologist Venter aims to create life from scratch, 2005 http://www.post-gazette.com/pg/05180/530330.stm ; 2) David A. Relman, The human body as microbial observatory http://www.nature.com/ng/journal/v30/n2/full/ng0202-131.html; 3) Michael Purdy, Gut microbes' partnership helps body extract energy from food, store it as fat, 2006 http://mednews.wustl.edu/news/page/normal/7328.html

2. Analysis

2.1 Summary

The study questionnaire presented the participants with a list of 19 future education and learning possibilities and asked for:

- Estimates of the likelihood that the possibilities would be realized by 2030.
- Factors that might encourage or discourage the possibilities
- Consequences, both favorable and unfavorable, that might follow the achievement of the possibilities
- Other possibilities that might be added to the list.

The developments found to be most likely ($> 70\%$) were:

- Web 17.0
- Integrated life-long learning systems
- Chemistry for brain enhancement
- Just-in-time knowledge and learning
- Use of public communications to reinforce pursuit of knowledge
- Use of simulations

And the least likely were judged to be ($< 40\%$):

- Genetically increased intelligence
- Artificial microbes enhance intelligence

Several suggestions were received for other developments that might be added to the list. (See Appendix I) These generally fell into the following four categories:

- Curriculum (e.g. teach morals, rational scientific thinking)
- Methods and Tools (e.g. universal translators, contests involving student projects)
- Administration and Institutions (e.g. tapping the capacity of groups, tele-commuting)
- The Students (e.g. early childhood development, flattening of the demographic pyramid)

The respondents made many contributions when commenting on the factors that might encourage or inhibit the possibilities and their possible consequences. (See Appendix I) In general, these comments raised questions about:

- The costs and distribution of advantageous possibilities.
- How the developments might conflict with culture and thus affect their acceptability.
- The threat of unexpected consequences (particularly for biologic possibilities)
- The use of the developments to promote evil intent
- The reactionary impediments by existing institutions

2011 State of the Future

There were some 274 people who signed in, and of these 213 provided at least one answer to the questionnaire (77.7%). Almost half (48%) of the people who answered at least one question visited the site more than once. Some of the people who visited the site more than once did so many times, the record (excluding the organizers) being a dozen.

Each participant, on the average, answered about 11 questions. The maximum number of answers to any question was about 181 and the minimum, about 100. (See Section 8 for details on the sample).

While every possibility in the study had its supporters and detractors, the levels of agreement about likelihood were generally high. It was found that agreement was highest at the highest and lowest likelihood extremes and lowest in the middle range of likelihood.

Among the key conclusions are:

> It is possible that the advances discussed in this study will not be available to all students, thus creating gaps in knowledge and capacities that are not present today. The lack of universal availability may be due to cost, political pressures (including the politics of academia), or reactions from existing institutions.

> Since some political regimes will view new educational capacities as a threat to their power, one can expect that some of these techniques will be outlawed or distorted to perpetuate the existing regimes, ideologies, and belief structures in various places in the world.

> The advent of learning enhancing drugs may result in a drug competition race and raise questions about the distribution and the ethics of charging for so important a commodity.

> It is possible that an international competition in intelligence may develop.

> The shift to a collective intelligence appears to be already underway, as evidenced by (paraphrasing one respondent) mass on-line collaboration, open source software, knowledge creation communities, and social sharing of learning resource (e.g., Wikipedia, YouTube, MySpace, FaceBook, and SecondLife) often without overt individual financial compensation or incentives

> The drive toward collective intelligence may give rise to its counterforce and effort by outstanding individuals to opt out of the "collective" (anti-borg)

> Developments lead to their counter developments and safeguards, even in education. For example the advent of portable artificial intelligence devices may lead to a 'race' to build portable 'anti-artificial intelligence devices' to protect oneself as an individual.

> Improvements in intelligence will make even the bad guys smarter.

> A "trickle down" strategy might be exploited to obtain new educational technologies; one respondent said, for example: "Standard data and simulation formats … allow cut-down versions of scientific simulations to be used in education." Perhaps the military and industry could be "mined" for similar applications.

> When teaching goes on line, computer hacking into the curriculum and information will be an issue.

> Just-in-time information can make everyone who has access look like an expert and true expertise will become hard to find and take on new meaning.

> Since nutrition is "natural" compared to (say) cognition enhancement drugs, it is likely to be easier to accept for many.

CHAPTER 10. EDUCATION AND LEARNING 2030   31

Cultural differences may lead one nation to adopt technologies and practices that lead to increased intelligence while other countries reject them based on cultural taboos or beliefs.

Rather than being used to enhance the intelligence of many people, genetic techniques might be used to remove or modify genes that result in lower intelligence

Any intervention may have unexpected medical and social consequences

Attempts to change curricula will inevitably bring questions about the ideologies that drive the changes

Respondents raised interesting and important questions about some of these possibilities:

Can simulations be so real and captivating that real life looses its significance?

Will intelligent machines think and reason in ways that are different than human thinking?

Will people migrate to countries that offer a means of increasing intelligence?

Does everybody become smarter, or does the gap grow?

Are the less intelligent made smarter, thereby raising the average or is everybody boosted?

2.2 Newly Suggested Developments

The RT Delphi form offered the participants the opportunity to suggest other possibilities that might be included in a list of potential 2030 changes. Some significant suggestions offered by the respondents (edited) appear below. A complete list is in Appendix I:

Curriculum

- Teaching of morals, routine measurement of characteristics other than intelligence (e.g. emotional intelligence) will be commonplace.

- Emphasis on the need to learn how to learn. Not merely the acquisition of new facts and inputs, but the capacity to discard the unnecessary and to transform the useful information into effective and productive realities.

- I think that much more emphasis has to be given to ethical considerations. Some of the new technologies might produce a significant "yuck" factor and will make some people talk about the dangers of "playing God."
  By 2030 cross-cultural and cross-religious teachings should be available, if only to enable young minds to build their own opinions and make their personal decisions in these crucially "formative" areas.

- Training in rational scientific thinking will be part of basic education
  With a quickly globalizing world, more consideration should be giving to tolerance and understanding of different cultures. Religions themselves will be under increasing threats, and most other basic beliefs will have to be reconsidered among countries.

- Truth will not come anymore from religion but from science.

- Future studies are necessary since human action is future-oriented, to the extent that it is goal-oriented.

- It strikes me that the words "culture" and "religion" are totally absent at this point. By 2030 (hopefully), cross-cultural and cross-religious teachings should be available, if only to enable young minds to build their own opinions and make their personal decisions in these crucially "formative" areas.

- We will take issues like the teaching of wisdom much more seriously.

- A particular area of immediate improvement could be to give each infant the opportunity to develop at least 2 languages in their first 2 years of life (see Pinker for details). Natural multi-lingualism (as opposed to the much more difficult and less effective (but prevalent) path of learning other languages after the "infant window" has closed) has many other benefits for the development of individuals, including social benefits related to the early recognition of different cultures, etc...

Methods and Tools

- Virtual Reality simulations will extend to learning history in simulated, historically-accurate settings.

- Learning and education can be integrated in movies, games, and music in order to integrate learning and leisure. In this way a huge number of students can be reached, who in the "normal" education system is lost

- The use of brain imaging to fine-tune education by actually testing what modes of teaching work best.

- Universal translators available will make education international and global.

- Contests on specific projects to be performed by school students

- Live television brainstorming sessions with open participation from the audience

- Social simulations will guide political decisions

- Increased use of gaming including on-line games for learning
Global access to internet becomes one of the global development goals

- Artificial intelligence-based software and devices would recreate, interpret, and analyze extinct languages. These would enhance enormously issues, facts, etc. not yet understood by pre-2030 times. Studies in History, Archeology, Egyptology, etc would be extremely buoyed by this technology.

- The developments in research of mental techniques [hypnosis, suggestion, and extrasensory perception] bring revolutionary improvements of human learning capacities.

- The right to equal access to information becomes one of the globally recognized human rights. By 2030 knowledge might be unified in one universal knowledge base, in the form of modular units with a management tool so that every student could download what they need. The management tool will bring together only the contents of all necessary units in one document to create a new book that consumer will order.

- Sub-100 dollar student computing devices which will provide the building blocks/foundation for individualized instruction

- Artificial microbes totally un-harmful to humans would add specific and temporary comprehension capabilities to an individual: i.e. pre-programmed artificial microbes labeled "PT" would permit an individual to temporarily understand and speak fluently the Portuguese language.

Administration and Institutions

- The State must guarantee inclusion of all of society first and specially in the educational system-, to each member of the country. Then an equal standard of education can be guaranteed to everybody. Personally we are quite far away from many e-tools, technology and nanotechnology instruments that are very useful and can perfectly incorporate in the educational item.

- Develop new models for collective knowledge and intelligence developments, a step ahead from cyberculture and towards a global brain and new stages of human consciousness

- Organized individual learning is considered less important than tapping the capacity of groups and communities (and whole societies) to take in, evaluate, effectively use, and creatively transcend the existing knowledge relevant to a given situation, creating new, potentially more powerful knowledge in the process. The results of such group and community "collective intelligence" will be broadly available to all individuals and groups, which makes individual "education" (as we commonly think of it re broad learning the lessons of the past) obsolete. Knowledge per se will be less important than today as society will be less prone to promote new knowledge

- The future that is being shaped by genetic engineering, weapons of mass destruction and unsustainable practices for the environment asks for a new spirituality for a transformation in human consciousness to cope with the global chaos and complexity. So, there may be a new relationship in the realm of education between teachers and students, or guru-disciple relationship that fosters a trustworthy effort to help accelerate change and prepare new citizens for a new future. New outcomes of teacher/student relationship could create new educational systems based on a new kind of learning cooperation.

- Due to urban congestion and global warming, government and employers will make it very attractive for more parents to tele-commute, which will increase the number of children being home schooled with the aid of tele-education and virtual schools.

- There may be a new relationship between teachers and students, a guru-disciple relationship; new teacher/student relationships could create new educational systems based on a new kind of learning cooperation.

- The abolition of schools, home education becoming the norm.

- There is a mismatch between the rigid structure of schools and the new technologies of learning.

- Education will become more privatized.

- Education methods will be more equalized worldwide (e.g. globalizing of education)

- Due to urban congestion and global warming, government and employers will make it very attractive for more parents to tele-commute, which will increase the number of children being home schooled with the aid of tele-education and virtual schools.

- Countries will recognize with status and pay human teachers in all areas who act as mentors and source of inspiration for life and learning

The Students

- Flattening of the demographic pyramid (more and more people are becoming older, living much longer, and having fewer children) will significantly change the population dynamics around the world. The education of the future has to seriously consider the relative shrinking of fresh, young, new people.

- Much more should (and may by 2030) be done to recognize the crucial first 5 years of the development of the human brain/mind. It evolved to experience and understand all aspects of the real world, especially social behavior, dominated by the infant-mother bond. Yet we "protect" so many of our infants from that reality, restricting their experience to "safe havens" like prams, cots, nurseries, etc... Changing this approach will not only have a dramatic effect on individuals reaching closer to their potential level of intelligence, but will also significantly improve their physical and mental balance/health.

2.3 Judgments of Likelihood by 2030

The participants provided judgments about the likelihood of occurrence of the possibilities prior to 2030. The table below displays the judgments of the group and the ranges of agreement and disagreement. The columns labeled "quintile" show (at the top of each cell) the number of people who responded in each quintile range (shown at the bottom of each cell). Thus, in the case of the first possibility, National Programs for Improving Collective Intelligence, 14 people answered in the range of 0 to 20%, 11 people in the range of 20 to 40%, and so on. The total number of people responding is shown in the column labeled "Total." In addition, the maximum, minimum, average, median answers, as well as standard deviation, are shown.

No.	Likelihood by 2030	Max	Med	Min	Avg	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile	Total	Standard Deviation
1	National programs for improving collective intelligence	100.0	69.0	-0.0	61.68	14 -0.0 to 20.0	11 20.0 to 40.0	67 40.0 to 60.0	72 60.0 to 80.0	31 80.0 to 100.0	195	24.2
2	Just-in-time knowledge and learning	100.0	75.0	-0.0	71.15	5 -0.0 to 20.0	11 20.0 to 40.0	28 40.0 to 60.0	88 60.0 to 80.0	52 80.0 to 100.0	185	21.2
3	Individualized education	100.0	70.0	-0.0	64.30	5 -0.0 to 20.0	23 20.0 to 40.0	41 40.0 to 60.0	76 60.0 to 80.0	35 80.0 to 100.0	181	23.1
4	Use of simulations	100.0	75.0	-0.0	70.09	3 -0.0 to 20.0	10 20.0 to 40.0	33 40.0 to 60.0	85 60.0 to 80.0	40 80.0 to 100.0	171	20.1
5	Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.	100.0	40.0	-0.0	43.05	12 -0.0 to 20.0	65 20.0 to 40.0	63 40.0 to 60.0	26 60.0 to 80.0	6 80.0 to 100.0	172	21.5
6	Improved individual nutrition	100.0	66.0	-0.0	62.98	3 -0.0 to 20.0	15 20.0 to 40.0	54 40.0 to 60.0	72 60.0 to 80.0	19 80.0 to 100.0	163	20.5
7	Genetically increased intelligence	100	40.0	-0.0	39.43	20 -0.0 to 20	59 20 to 40	60 40 to 60	17 60 to 80 72.0	6 80 to 100	162	20.9

No.	Likelihood by 2030	Max	Med	Min	Avg	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile	Total	Standard Deviation
8	Use of global on-line simulations as a primary social science research tool	100.0	65.0	-0.0	61.73	9 -0.0 to 20.0	11 20.0 to 40.0	55 40.0 to 60.0	67 60.0 to 80.0	20 80.0 to 100.0	162	21.9
9	Use of public communications to reinforce pursuit of knowledge	100.0	75.0	-0.0	70.98	3 -0.0 to 20.0	5 20.0 to 40.0	31 40.0 to 60.0	88 60.0 to 80.0	30 80.0 to 100.0	157	17.9
10	Portable artificial intelligence devices	100.0	65.0	-0.0	61.18	11 -0.0 to 20.0	8 20.0 to 40.0	52 40.0 to 60.0	69 60.0 to 80.0	18 80.0 to 100.0	158	22.3
11	Complete mapping of human synapses to discover how learning occurs and thereby develop strategies for improvement of learning	100.0	45.0	-0.0	43.57	18 -0.0 to 20.0	33 20.0 to 40.0	78 40.0 to 60.0	20 60.0 to 80.0	3 80.0 to 100.0	152	20.6
12	Means for keeping adult brains healthier for longer periods	100.0	75.0	-0.0	68.51	7 -0.0 to 20.0	6 20.0 to 40.0	26 40.0 to 60.0	93 60.0 to 80.0	26 80.0 to 100.0	158	202
13	Chemistry for brain enhancement	100.0	80.0	-0.0	73.78	6 -0.0 to 20.0	3 20.0 to 40.0	21 40.0 to 60.0	73 60.0 to 80.0	51 80.0 to 100.0	154	20.2
14	Web 17.0	100.0	80.0	-0.0	78.39	2 -0.0 to 20.0	4 20.0 to 40.0	16 40.0 to 60.0	55 60.0 to 80.0	74 80.0 to 100.0	151	18.1
15	Integrated life-long learning systems	100.0	80.0	-0.0	76.57	3 -0.0 to 20.0	7 20.0 to 40.0	12 40.0 to 60.0	79 60.0 to 80.0	57 80.0 to 100.0	150	19.0
16	Programs aimed at eliminating prejudice and hate	100.0	45.0	-0.0	44.73	12 -0.0 to 20.0	41 20.0 to 40.0	78 40.0 to 60.0	16 60.0 to 80.0	8 80.0 to 100.0	154	21.2
17	e- Teaching	100.0	75.0	-0.0	69.82	7 -0.0 to 20.0	5 20.0 to 40.0	31 40.0 to 60.0	77 60.0 to 80.0	39 80.0 to 100.0	159	21.5

No.	Likelihood by 2030	Max	Med	Min	Avg	1st Quintile	2nd Quintile	3rd Quintile	4th Quintile	5th Quintile	Total	Standard Deviation
18	Smarter than human computers	100.0	50.0	-0.0	52.36	18 -0.0 to 20.0	19 20.0 to 40.0	70 40.0 to 60.0	28 60.0 to 80.0	20 80.0 to 100.0	155	26.5
19	Artificial microbes enhance intelligence	90.0	30.0	-0.0	30.37	37 -0.0 to 18.0	64 18.0 to 36.0	32 36.0 to 54.0	11 54.0 to 72.0	4 72.0 to 90.0	148	19.1

Working with the data contained in this table, we find that:

- The average judgments about likelihood range from 79 percent (Web 17, an advanced form of Internet) to 30 percent (artificial microbes for enhancing intelligence).

- Almost all items had individual at least a respondent or two who thought that the likelihood was zero; similarly, almost all items had at least a respondent or two who thought the likelihood was about 100 percent

- A relatively high order of agreement was achieved, with standard deviations ranging from 17.5 percent (lowest standard deviation was achieved in the spread of responses about the likelihood of an advanced Internet, Web 17). Similarly the highest standard deviation, 27% was achieved on the likelihood of smarter than human computers).

The likelihood of the possibilities was assessed as follows (presented in rank order by average likelihood):

| Possibility	Likelihood
Web 17.0	78.39
Integrated life-long learning systems	76.57
Chemistry for brain enhancement	73.78
Just-in-time knowledge and learning	71.15
Use of public communications to reinforce pursuit of knowledge	70.98
Use of simulations	70.08
e- Teaching	69.82
Means for keeping adult brains healthier for longer periods	68.51
Individualized education	64.30
Improved individual nutrition	62.98
Global on-line simulations	61.73
National programs for improving collective intelligence	61.68
Portable artificial intelligence devices	61.18
Smarter than human computers	52.36
Programs aimed at eliminating prejudice and hate	44.73
Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.	43.05
Complete mapping of human synapses to discover how learning occurs	42.83
Genetically increased intelligence	39.43
Artificial microbes enhance intelligence	30.37

And graphically:

Likelihood of Education Possibilities—year 2030
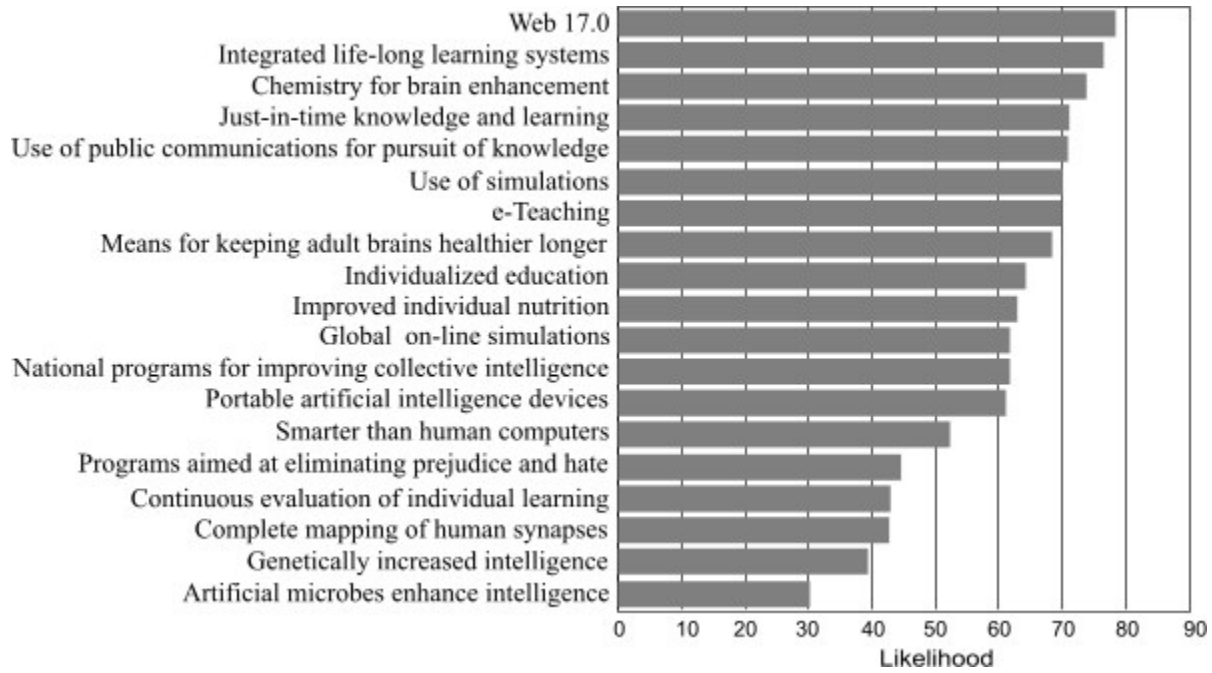
## 2.4 Distribution of Opinions

There is a unique relationship between the average likelihood and standard deviation. Agreement levels improved for both high likelihood and low likelihood possibilities; the possibilities in the middle range displayed the greatest levels of disagreement (although even for these, agreement was relatively high). The graph below displays this relationship:

Likelihood vs. Standard Deviation
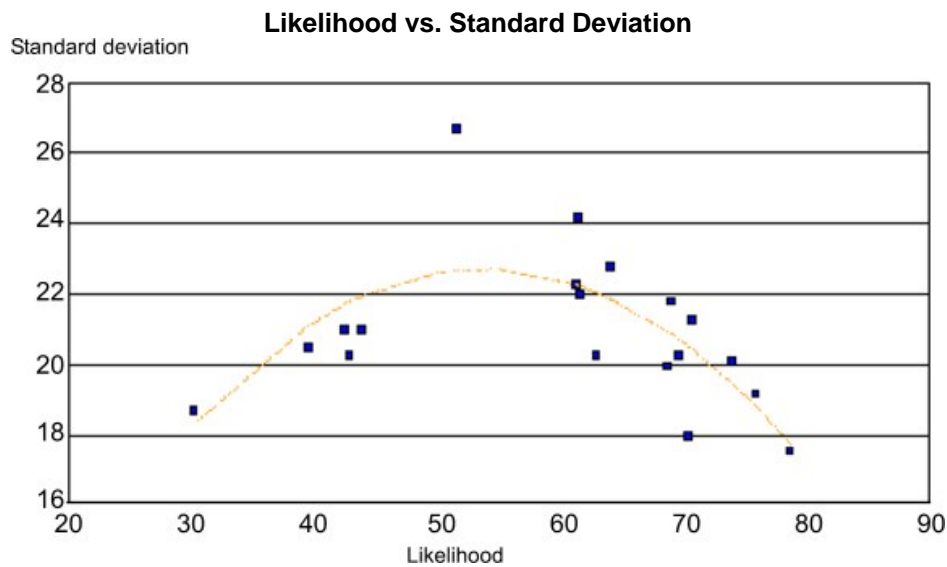
The curve shown is a quadratic which fits the data quite well; the correlation coefficient is 0.96.

As a further demonstration of the levels of agreement, consider the following graph which displays the percentage of people who answered in each quintile for three of the education and learning possibilities.
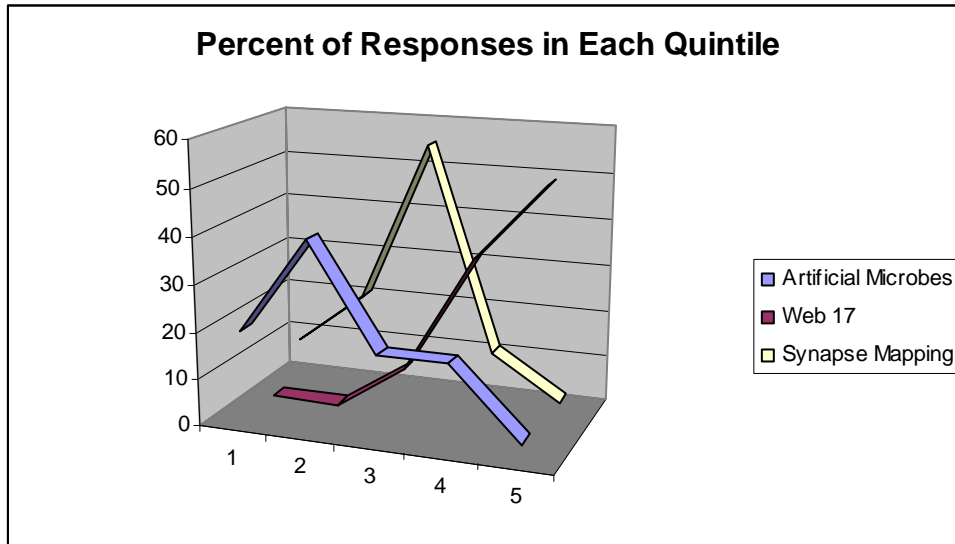
2.5 What Might Encourage or Discourage the Possibilities?

The respondents were encouraged to provide judgments about factors that could help or hinder the possibilities and assuming they occurred, to conjecture about consequences that might follow. The information provided by the participants was quite extensive and is contained in Appendix I. A space-limited number of (edited) excerpts are listed below:

1. National programs for improving collective intelligence

encouraging and positive

> I recently discussed this with senior officials in South Korea, who agreed that this would be a good goal to add to the Ministry of Education. It may not happen, but this increases the likelihood that it will occur before 2030

> Venezuela had such a program in the 1980's, which was unfortunately discontinued by the following governments. The opportunities are incredible, not just to increase human potential, but also human-machine capabilities.

> Leadership that respects and encourages free thought and the rights of the individual (male and female, and of all religious and political backgrounds) is necessary to foster the improvement of collective intelligence.

> I doubt that this will occur on a national basis in the USA. It may occur in some Asian countries as they will likely determine that this is a method to improve their standing in the world, both in terms of respect and economic power.

…You will still have the "haves" and the "haves not" of intelligence or information.

A smarter society will reduce some of the costs of low-cognition individuals (in terms of crime, wasted education effort, failed life projects), get larger groups able to handle jobs of a given complexity and might have the benefit of attracting more clusters of creatives.

More and more research is showing that learning … is fundamentally a social process. This is in marked contrast to very traditionally held views that intelligence and knowledge are situated only in individual's brains. If we look at just how rapidly global, open-source, knowledge creation communities and mass collaborations have resulted in very widely used information, social sharing and learning resources (e.g., Wikipedia, YouTube, MySpace, FaceBook, and SecondLife), we are seeing a major behavioral shift. People are using collective intelligence, knowledge and "social know-who" to collaboratively create resources for themselves and others--often with no overt individual financial compensation or incentives

It depends on the kind of intelligence: for example the emotional intelligence will be lower, but abstract-logical intelligence will be higher...

International competition among countries. As a tool for accelerating the absorption of immigrant populations. As a complement to formal education. As a complement to formal education.

inhibiting and negative

Lack of a single point in many countries which can determine curricula. This increases the chance that many people will be involved in the decision and hence it could be defeated.

Also, the concept of individual intellectual 'property' is diametrically opposed to collective intelligence. Societies will need to find a way to reward the knowledge creation act, which is the act of advancing society, without giving ownership to the resulting knowledge.

Entrenched despots, regimes, and institutions that fear evenly distributed power impede the improvement of collective intelligence because it is a threat to the status quo. Denial of access to information and to connections with people in intelligence networks will continue because of this. The negative consequences can be found at every level, from the nano-sized to the planet-ending disaster.

One consequence could be psychological affects over time of diminishing points for individuality and authorship talents which could cause a student-based revolt of being part of a "collective."

Ongoing propagation of propaganda and group-think through media and politicking with primarily economic motives by few. The primary consequence being more and more sound-byte information with less and less "intelligence" (or even pursuit thereof) about what it all means.

(What could delay it :…) social inequalities, corruption in the public sphere and (lack of funding)

(Any…) intervention into cognition (mat be) politically controversial: issues of group cognitive differences, gender differences in cognition, the heritability of cognitive abilities, the use of biomedicine for enhancement and the relationship between individual and state

Even a successful cognition improvement program might have many unexpected side effects, both medical and social. If improved cognition for example reduces acceptance of traditional values it might be politically disruptive, while other forms of cognition enhancement might be supplied with subtle or not-so-subtle attempts of manipulation towards ideological ends.

(This development) …flies directly in the face of longstanding competitive, highly individualistic and "proprietary ownership" models of knowledge-creation and intellectual capital development. This means it requires a major change in attitude of just how learning and value creation really happen-- Even in college faculty tenure decisions, there is still little incentive for cross-disciplinary or web-based collaborative work, as these decisions largely depend on assessing individual faculty's publishing and citation records...regardless of how many other people have really been involved in the research or writing process.

2. Just-in-time knowledge and learning

encouraging and positive

I believe much of what has been traditional government(public) education will be replaced by web based, managed learning provided by open source collaboratives or vendors who compete on delivering measurable knowledge acquisition and retention with speed and effectiveness as the basis of payment. This approach will initiate another renaissance as people are freed of the Madrassas of Government Education.

Rote learning will continue to diminish in the future leaving room for reflective thinking which is indeed the corner stone of significant learning. Again truly compr5ehensive development of learning areas, additionally to the Intellectual Area, such as the Emotional Area, responsible for attitudes, Physical Areas, responsible for skills and dexterities and Social Area, responsible for human interests and social ethics; will make possible "learning to learn" and "learning to change" to achieve "life long learning".

As people become more able to choose knowledge they will not just acquire knowledge useful for their jobs but also for private activities, political and cultural project. The result is empowered individuals, hard to pin down by specialty.

Such an educational system will certainly make business more efficient and allow countries to become more competitive. I am not certain that this is necessarily positive in every sense. It certainly leads to advancements in science and technology, but history, civics, and other subjects will suffer.

The confluence of … nanotechnology, neuroscience, artificial intelligence, and avatar-based synthetic online worlds will make education more experiential and engaged in the developed world by 2030. Social/education networks developed through the new technologies will have altered the fabric of all relationships, creating an exponentially advanced knowledge weave. This will not be true across the globe.

Positive consequences may include a reduction in the 'power' of academic arrogance.

The increasing rate of social advance will add pressure to make learning and learning technology more flexible, modular, and accessible, but will also demand that it be custom-fitted to a particular purpose/application and will simultaneously cause it to be seen as transitory.
In a vast sea of information, it's necessary to improve learning methods (to make them) more effective. "Just-in-time knowledge" would be widespread due to reducing rote learning and inefficient study. It might improve public educational systems.

inhibiting and negative

Computer hacking, information manipulation and other forms of information warfare.

The negative consequences will be felt most in the least-advanced societies; the type of intellectual and personal disconnect we see between radical Islam and the Western world of today will be magnified. Those who benefit from the new realities of advanced technologies will evolve differently than the humans who are caught in the divide and left behind.

Potential for further dumbing down of society. I think this will most likely create poor learning habits for lazy-thinking, much like many people's current inability to concentrate or focus on a topic in-depth without intermission or a commercial break

In a world where everybody can look like a specialist there will be more risk of decisions made on looser grounds and less respect of true expertise, unless good ways of validating actual competence are developed.

Traditional education proponents will discourage this effort. Negative consequences of implementing this will include a public less engaged in political processes

Dictatorships wishing to control their people's development. I believe that democracies, however imperfect will sponsor and strive for this development

It may… (inhibit) innovative capability...

3. Individualized education

encouraging and positive

Young people who need to function intelligently and in their economic interests are already driving this process of the Individual Learning Plan that used to be only available to special needs children provided by special education teachers.

Adults who expect to maintain or increase their economic well being will find it necessary to continuously learn in this type of learner and web centric, managed environment.

As computing and virtual learning and just-in-time learning all converge, this type of education will be more available in regular public schools and charter schools… I expect to see it closer to 2015 than 2030 in US private schools.

This is already taking place, but it is reserved for the elite. Individuated instruction will be more commonplace in 2030 thanks to AI and the acceleration of computing power, but it will still only be available to those who are willing and able to access it

Designer learning could be accepted as no different than designer jeans, designer drugs, and designer vitamins for each person based upon his or her *unique* physical, emotional and intellectual makeup.

I think this is the most likely of all the statements...it is doable, it will become affordable and (there will even be) a 'will to act' ….This is a win/win for everyone.

… education tells people to act alike, to decide alike, and to choose alike. Individualized education would be something different,

Based on the assumption that … every individual is potentially a genius, and there is nothing more different than one genius to another one, (with this development) each person can be special; and … then he or she can be the best in whatever he or she chooses to do. … It could help people to be more than followers…

inhibiting and negative

With the extension of the education cycle, overpopulation, and the elderly financial dependency, the education system is going to suffer (from lack) of financing …in many countries and individualization will be very expensive in poorer countries

Problems will exist where resources are an issue. Poorer countries and/or poorer school districts will be unable to fully implement this. It will require PCs for each individual, and oversight by teachers with advanced technology skills. Individuals meeting these criteria will command higher than normal salaries.

New ideological or religious movement that sweeps the world into mono-thematic curriculum could reduce the possibilities for individualized learning.

A negative consequence of the wide spread use of very individualized learning could reduce social cohesion.

The type of education you would get from these systems depends upon the intellect, objectivity, empathy, and intent of the people or the AI designing them. It could be a great way to "brainwash" people to adopt a particular ideology and even act upon it in negative ways as well as in a positive fashion.

Academic arrogance (could delay it): the professor says I know best, and I have tenure so I will continue to say what education is best.

4. Use of simulations

encouraging and positive

As the lines between games and learning grow thinner, this may emerge in industry in next generation 'Second Life'-type solutions

…Facebook and MySpace will morph into avatar-based 3D synthetic worlds like Second Life but much more advanced. VR design and implementation costs are going to improve, and once the interface becomes more natural these worlds will explode. We need to begin to plan now to leverage this technology to best advantage for all people. Immersive experiential learning will benefit society on every level.

With good simulations students can experiment beyond curricula, and acquire tacit knowledge of the behavior of complex systems.

I believe in soul...the ability of the human 'to be' not just 'to think.' I believe much of the thinking aspects (of existence) can be simulated but not the being aspects.

The diffusion of 3D and the social acceptance of parallel on line realities like Second Life (is important to this development) …by now a real alternative world is growing. …This will … evolve into new forms of individualized educational platforms.

Standard data and simulation formats enable more scientific collaboration, and in turn allows cut-down versions of scientific simulations to be used in education. The spread of virtual reality and online games makes simulation a normal mode of interaction, and enables high performance hardware at low prices. With good simulations students can experiment beyond curricula, and acquire tacit knowledge of the behavior of complex systems.

inhibiting and negative

Even though my children used gaming to learn to fly a jet fighter at a very young age, I wouldn't put them in a real jet without actual experience and human qualification...again we need clarity between knowing and the transition to actual doing built into our global learning systems...we need much more clarity in purposes/goals of learning.

The challenge will be getting it into the more formal education system, and blending it with other forms of learning.

Negative consequences can include what some people refer to as a cyber "addiction" or a loss of touch with reality and face-to-face human contact. Worse consequences can include the purposeful design of immersive VR technologies to negatively influence human behaviors.

Many simulations are little more than ways of avoiding teacher effort, edutainment that often lack the complexity and interactivity of real experiments or teaching. When teachers do not understand the simulation mode of experimentation and learning, they may not make the best use of it.

This possibility could be thwarted by concern about video game violence, and lack of access by parents to the video technology used in the simulations.

The greatest obstacle to successful serious games/games … is the refusal of many to work strictly with open source software and open code. The government should require that all software be open source, and that standards be established so that all information can have time and geospatial attributes that allow them to be digested by serious games/games for change.

Many simulations are little more than ways of avoiding teacher effort, edutainment that often lack the complexity and interactivity of real experiments or teaching. When teachers do not

understand the simulation mode of experimentation and learning, they may not make the best use of it.

5. Continuous evaluation of individual learning processes designed to prevent people from growing unstable and/or becoming mentally ill.

encouraging and positive

The increasing awareness that single individuals can become massively destructive (SIMAD) has brought this about. Some of these programs, in some countries, have been called totalitarian, but their implementation is generally seen to be in the public interest.

(This is encouraged by) the continuous increase of security standards in driving blocks of the Western World and the drive towards more extremist ideologies, and the persistence of highly pressuring control by governments in several Asian countries (e.g., China).

Programs will have to be very creative and engaging to encourage widespread adoption.

This is scary in one sense (Big Brother) … Alice Walker's work showed that those who led troubled lives but still did well had one thing in common...The all had found some one person who loved them. A program like this could identify and match these youth with appropriate mentors.

This is a truly whacky suggestion and will never be implemented by free thinking societies.

Progress in psychology would stimulate (this) possibility, which would reduce mental illness and antisocial instable factors.

inhibiting and negative

Such programs might reduce creativity and innovation. All geniuses are always a little crazy!

Personal freedoms will be at stake.

Like any other system of "profiling" this statement was posed with good intentions but it is rife with too many negatives to find universal acceptance

There would be an enormous amount of resistance to this due to privacy and personal-freedom issues. Intelligence-gathering/police organizations have already been doing this sort of thing for hundreds of years in the nation-states with the worst histories in regard to human rights.

…Some of the world's brightest thinkers would have been classified in a negative fashion by such programs - what would have happened to them and their breakthroughs? In the future, if we begin to "cure" or isolate individuals with deviant personalities are we going to destroy something that could have been of benefit to the world? Who decides what is "deviant"?

Antisocial behavior including terrorist activities and violent criminality is not the problems of individual nurture, it has social causations.

Authority and impartiality of evaluation organization, and the problems such as human right, racialism, etc would counteract the possibility. It might bring negative influence in the field of individual privacy, human right and racialism, etc.

6. Improved individual nutrition

encouraging and positive

At least in some third world countries like Chile monitoring childhood development from the nutritional point of view has helped a lot to improve physical and mental development

It will be easy to detect the kind of nutrients that each person needs according to their DNA and background: nature and nurture can both be addressed.

Developments in individualized medicine, nutria-genomics, and functional food may make diet tailoring popular, possibly in a faddish fashion. Given current concerns about obesity, health paternalist governments might also promote improved nutrition. Since nutrition is "natural" compared to (say) cognition enhancement drugs this is likely to be easier to accept for many.

This has potentially huge benefits beyond education. It could greatly improve a nation's health and reduce the cost of health care. Countries that can separate outcomes from politics have a reasonable chance of implementing this.

…"Food cures better than medicine;" improving nutrition would reduce diseases, prolong natural life, and enhance intelligence.

inhibiting and negative

Many research findings in this area are weak or suffer low (sample) sizes: improved nutrition might be cheap and simple, but also could have relatively little effect …. The overall beneficial effects of full and diverse nutrition may overshadow the individual effects.

As with anything those that stand to lose economically will oppose this. Giant food companies and health care lobbies (may) discourage this

To improve individual nutrition (will be) a challenge in some places where the customs include really bad nutritional habits...

…only one factor could hinder (this)…poverty. There would be lots of needy population living in 2030; the most important thing for them (would be) "survival" rather than "nutrition."

7. Genetically increased intelligence

encouraging and positive

The possibilities of biologically increasing our intelligence are almost unlimited. Nature has slowly evolved our brains, but now we can do it faster and better.

The main form of near future genetic intelligence enhancement would be PGD, selecting away genes involved in pathologically lower intelligence. This would lead to a reduction in the lowest performing, in turn increasing the average. For this to happen PGD needs to become more common, which requires both improvements in technology, a way of automate it to bring down the price, standards making different treatments comparable and, most importantly, a cultural shift towards regarding genetic selection as acceptable. This cultural shift might be specific to some nations and not others.

I believe that it is imperative that prior to this development a tremendous boost be given to the learning of humanities in general including art and overall, ethics in order for humanity to have more balanced individuals and not only science super-beings. It is true that intellectually developed individuals are needed but, this development must be accompanied by development of other human capacities such as social ethics, acceptance of differences, respect for others and the like.

Genetic enhancement of intelligence should be combined into a single procedure that would also reduced criminal behavior.

Just as we "correct" our eyesight with glasses, we should also correct … low intelligence. Imagine two worlds: one with average IQ of 100 and another with average IQ of 150. … Which world would work better?

Parents want the best for the children, and once a safe procedure is available for increasing intelligence, parents will take their child to the country that first offers it.

. It might (open the) furthest the potentialities of human intelligence.

inhibiting and negative

Major moral issues will surface. What is normal? What is human? What is ethical?

The belief that life is an unalterable gift from God will discourage this possibility. Without a concurrent improvement in more ethical behavior the "war" between good and bad will get more complex.

Intelligent free-thinking societies will discourage this effort.

Science and Tech are developing too fast in relation to Moral Development, so these may cyclically raise issues that delay Tran humanistic ideas.

… may bring big risk, including genetic mutation caused by incorrect use of genetic technology.

8. Use of global on-line simulations as a primary social science research tool

encouraging and positive

We are very close to doing this today. I wouldn't be surprised is some preliminary experiments are not occurring right now, but in 25 years from now? (This) seems inevitable.

A great tool for social science experimentation

Researchers will certainly want to tap into these efforts for research purposes. Degrees will likely be awarded (on the basis of such research

Virtual educational simulation depends on internet, but it is easy to be destroyed or influenced by an unforeseen incident. For example, Taiwan Strait had a big sea quake at the end of December 2006, optical fiber cables were ruptured, so as to block the internet between Asia and North American and it needs 2 weeks at least to repair. Isn't it the sorrow of the virtual world?

inhibiting and negative

I do not see any real positive consequences for this in education development. It may have other useful applications but not in Education.

There are minimal ways to actually monitor the inputs to these computer societies. Social science requires detailed information on the participants in a study. Virtual societies will not provide this background reducing the value of the data.

…it is almost impossible to reproduce real social situations in a laboratory

Virtual realities are unable to substitute real life in deed, and it's difficult as transforming human subconscious mind to reality and trying to control it. Virtual realities would result in the tendency of split personality…

… ideas like "knowledge is the power; knowledge is the fortune" have been deeply rooted among the people.

9. Use of public communications to reinforce pursuit of knowledge

encouraging and positive

Any legal, ethical means to awaken the interest of youth in particular, and the population at large, to pursue knowledge will enhance the possibility of democratic governments and generally well being to societies.

A very plain extrapolation from current strong trends in technology and society!

…public communications influences people, and several organizations around the world are interested in promoting the pursuit of knowledge... Knowledge Society is still an ideal of equal opportunities for everybody to access to a better life; that ideal could become real if more and more people, institutions and countries, decide to go towards knowledge societies, thanks to the use of public communications to reinforce pursuit of knowledge.

People would realize (the) importance of knowledge and be accustomed to getting the information from media, so that (the) public media can play a main role in the … pursuit of knowledge.

inhibiting and negative

Social marketing could be compared to social engineering and be considered a new class of communism to be opposed by free societies.

I am somewhat skeptical on this topic. It would be great if it happened, but there are too many diverging viewpoints to make it happen. If it did happen the benefits could be many, including a much better educated population.

Limits on civil liberties- whatever are civil liberties in 2030- (might be inhibiting)

Pursuit of knowledge cannot be developed to (the) extreme…. otherwise it would disturb (the) natural development rules of human society, counteract human progress, even promote un-peaceful factors

Professional ethics of the public media is not standardized yet, (there are) differences in ideology and faith, etc. Different media would give diverse judgments to the same matter, so I don't think it can be realized in 2030.

10. Portable artificial intelligence devices

encouraging and positive

That's my laptop now. It is an artificial memory, a brain prosthesis.

…people's lives and experiences will be recorded - allowing people to better manage their lives, learn from their experiences, and re-live some of their life in older age. "Little Brother" will emerge - individuals will be able to control behavior just by recording their interactions and what goes on around them. Crime will drop significantly.

Technological convergence, on cellular phones for example, and the psychology that leads to the widespread use of gadgets, are very powerful drivers. Adaptation to a very rapidly changing world is a positive consequence

The growth of Social Networking can be a driver. Imagine … a small device in your pocket will identify and tell you who on the street has similar interests to you and help you to interact with them.

Imagine that you have a very advanced Google in your pocket. You put a question, not a keyword - for example, who is this guy? Or what should I do in this situation? Google in 2030 will answer to these questions for you.

This will likely happen, but it will be exclusive to the intelligence communities.

Maturity of recognition technology on voice, face and retina, etc. is the basis on which these applications can be adopted. Sometimes new technologies are applied in the field of military affaires at first, if there were a war of global proportion within next 25 years, it maybe accelerate the rapid development of new generation of technology.

It might break … the bottleneck of human brain in the field of memory, analysis, decision-making, etc. and make human competence advance rapidly.

inhibiting and negative

While I agree with the thought that portable AI will become a reality, I don't think it is necessarily good for each of us to have so much of our personal information readily popping into anyone with a gadget in their ear.

I am afraid that … the propaganda efforts of IT corporations (will equate) "intelligence" with "information." These are two utterly different things.

A 'race' to build portable 'anti-artificial intelligence devices' to protect oneself as an individual.

Intelligence agencies will prevent the general public from having access to this.

This will likely take more than a generation for most people to have such devices. However, it does seem inevitable.

…face recognition and helping with decision making are questionable.....because of privacy issues and   pace of life.

But consider the level of the economy in different (geographic) areas… this is just a device for a few (rich) crowds

These devices might be used for criminal acts.

11. Complete mapping of human synapses to discover how learning occurs and thereby develop strategies for improvement of learning

encouraging and positive

The Allen Brain Atlas project is an example of what is quickly happening in neuroscience. Just like the genome, the brain can be understood scientifically, and this will help to improve education.

The realization that higher IQ is the key competitive advantage in the knowledge economy stimulates massive brain research by several countries that fund the research over sufficient time to make breakthroughs

Complete mapping requires not just improvements in scanning methods and database management, but also improvements in image processing, computational neuro-science, and automated research. These (will be) very likely getting well on their way in 2030, (but) they may still be far from complete mapping. However, even partial mapping is likely enough to deduce important neuroscience about learning.

A deep understanding of neuroscience will empower most fields of cognition, from AI to learning enhancement drugs

Knowing HOW the brain works greatly enhances the possibilities of "learning to Learn" thereby enhancing the possibilities of "life long learning"

Highly-developed biomedicine and pertinent sciences would decode the connection pattern of human synapses. It might bring a qualitative leap and development in capability of learning and intelligence...

inhibiting and negative

Knowing how learning occurs in the small and in general may not be helpful in understanding how it occurs on a personal level for an individual.

The key issue is how intrusive this mapping is, which in turn determines how problematic it will be to get ethical approval, test subjects, and to employ it.

Negative: incredible power and prestige for the scientists and doctors at its forefront.

Like the gene code, the connection pattern of the synapses is not a panacea. Intelligence and emotions go far beyond these patterns in this kind of complex system. Emergent properties are very elusive even within this time frame.

Continuation of the current education mode would be the biggest resistance to put forward new one. There are certain solid characteristics in national education system, advanced method and idea may be adopted. Thus perhaps it would implement in corporate training rather than ordinary education.

The human brain is a complex system, (and) … decoding the connection pattern of the synapses (at the) micro level (may not lead to understanding) human thinking … at the macro level.

12. Means for keeping adult brains healthier for longer periods

encouraging and positive

Advances in Neurosciences and discovery of new natural biochemical brain enhancement products are already on its way as well as biofeedback equipment for mental states monitoring and improving behavior.

Interest among the elderly for keeping active is already high, and the baby-boomer generation is reinforcing this with both numbers and money. There is also national interest in avoiding large numbers of demented elderly. A more vital elderly population will construct a new concept of what late life means, possibly getting involved in entrepreneurship, education and politics.

People used to think that adults could not grow new cells. Research has now shown that new brain cells are created every day. Many of the new cells born each day die off, but running and a more stimulating environment reduces the death rate. Some research indicates that continued adult learning maybe be associated with the news brain cells. The process of adults growing new brain cells is Neurogenesis.

This will very much meet the ageing trend in advanced economies.

inhibiting and negative

The fear of tampering with the brain, the most complex structure in the known universe, will delay some developments in cognitive sciences. Making older people healthy might take longer than expected.

The positive breakthrough of effective life extension that reduces ageing-related impairments might redirect research but leave a group of non-treatable elderly behind. Vital elderly might feel locked out of a youth-directed society, possibly becoming discontent or forming isolated subcultures.

Cost, and/or, the appearance of a global pandemic that demands all medical effort for common and shared survival.

We are already seeing ethicists of all kinds trying to decide, for us, whether it's "fair" to let rich kids drink brain potions.

13. Chemistry for brain enhancement

encouraging and positive

Such drugs currently exist, although safety and efficacy remain an issue. The improvement is in general about 10-20% on different psychometric tests. Currently no drugs are being developed

specifically for (brain) enhancement, since current medical regulatory systems makes developing, testing, and marketing of these hard.

Changes in the view of enhancement are needed for enabling this, and development of an "enhancement culture" among people will be needed to set the social norms of when they are proper or not proper to use.

More persons have realized that drugs and productions of health care can improve memory, increase attention span, etc. Progresses of science and technology would accelerate to come out more powerful drugs

Such drugs currently exist, although safety and efficacy remains an issue. The improvement is in general about 10-20% on different psychometric tests. Currently no drugs are being developed specifically for enhancement, since current medical regulatory systems makes developing, testing, and marketing of these hard. Changes in the view of enhancement are needed for enabling this, and development of an "enhancement culture" among people will be needed to set the social norms of when they are proper or not proper to use.

inhibiting and negative

(The search for promising) psychoactive drugs might start a race among parents to enhance their children. However, if not properly studied, some of these drugs might have negative effects and delay further research in other more promising drugs.

Drug use is highly controversial in many societies both due to puritan anti-narcotics concerns, a high value placed on "the natural" and medical monopolies. These factors can block or limit development of cognitive enhancer drugs strongly.

The use of drugs to improve (learning) is extra controversial since it is usually viewed as occurring among children with limited consent, raising fears of competition forcing everybody into a drug race. While the main problem in that case may be more a competitive school system the use of any medical technology among younger people is a cause of concern.

Thinking that "miracle drugs" will solve all of the human problems will yield dangerous consequences.

Chemistry had ever contributed to the development of human society and material civilization, but it brings also many sickness-causing substances to human health. Using drugs could enhance intelligence, improve memory, but never forget that any drug has always a few toxins.

Suspicion of drugs' security would discourage the possibility.

14. Web 17.0

encouraging and positive

What's happened in the past 10 years is just the beginning of how to leverage a global information web. Governments will

continue to invest heavily and private capital will continue as well since the cost-benefit ratios are so favorable.

A very plain extrapolation from current strong trends in technology and society, especially in this area that is in the hands of all of us: co-creation will lead to massive co-development, and we are likely to leapfrog to Web 17.0 much sooner than solving much more radical problems or meeting much more crucial challenges...

…speed and distance (will) be no longer a problem.

(Inhibiting factors include) … inconsonance of frequency, restrictions of policy in each country... What interests the people is not technology itself and logical rules, but the evolution of contents brought by technology.

inhibiting and negative

New kinds of viruses and methods of manipulating information delivery could distort knowledge on the semantic web by those who don't like the new knowledge. In the past, cigarette companies distorted cancer research, today an oil company is distorting global warming research, and in the future, ideologues might want to distort research that counters their ideology.

The already present misuse of the net, illegal and other unethical activities will be likely to increase if more ethical ways of use are not implemented.

Biological and/or natural catastrophes or manmade cataclysms (due to terror and/or error) could slow or stop progress. At any point in time progress can be stopped by these or a wildcard the origins of which we are now unaware

Industries will fight open source software initiatives…. The good of the group requires that industries focus on "services science" and on natural capital

15. Integrated life-long learning systems

encouraging and positive

Lifelong learning is already a reality. People continue learning throughout their lives…. Furthermore, learning is now combined with leisure and entertainment, and it is growing so fast as to become the largest industry in the world. More people are devoted to education (teaching and learning) and for more years than in any time in history before. Life has become learning, with a lot of leisure added

In knowledge-based society, the spiritual needs of people, as well as more humanistic educational idea would promote the emergence of such possibility.
Nowadays there is already the curriculum across all age groups, but its content would be much richer in 2030 and practical for the various stages of life to learn the necessary knowledge and skills.

inhibiting and negative

Increasing poor-rich, south-north gaps, may delay worldwide developments.

Too much dependency (on) computers trying to substitute the epistemological process of learning. We must not forget that computers are IT and are instruments for us to use to our benefit in learning.

The widening gap between rich and poor and imbalance in development of different countries would result in breaking out conflicts and interrupt the course of education.

Almost nothing can hinder the occurrence of this possibility.

16. Programs aimed at eliminating prejudice and hate

encouraging and positive

There have been programs of this kind (for example, to promote tolerance) for years, and there will be in 2030. The fundamental question is whether these programs in 2030 can be significantly more effective than existing ones.

Move the concept of diversity toward a concept of individual 'giftedness' and away from strictly a concept of race/creed. Positioning diversity as a race/creed concept simply creates new, though

perhaps more equitable divisions, while it fails to solve the core issue of division in the first place… A focus on personal giftedness with clarity for how one contributes in industry and/or society encourages engagement and cooperation at all levels without creating 'new social divisions.'

Changing emotionally learned material requires emotion, either pain or some positive feeling ..."for the good of others, my self, my children, the planet," I am not certain this can easily be taught in schools and may require generational growth. That is one of the reasons long term thinking should be built into an educational system so that we accept a pace of life that allows ideas to grow and mature into new generational beliefs.

Learning from parents, peers, religions, etc is a much different process than from data bases. It carries all the emotional content and meaning that most people build their lives and behaviors around. So changing this learning (of hate) requires recognition, unlearning, commitment to a new belief and then emotional change. Whereas learning educational material simply means adopting a new idea that is recognized as better than the first.

 Left brain use and so called "intelligence" alone will not do it; emotional learning capacities must be tapped for success in this area.

To avoid the war and extremist in dealing with the conflicts among various countries or regions with might and main and reduce violence in media and entertainment programs, it would conduce to build a harmonious world.

inhibiting and negative

If this were successful, (it would mean)… that you can control human mind …. Somebody will try to control people for his or her own benefits. For example, cult leaders might use these methods or technologies to have people behave in a way they desire.

For both the better and the worse, some programs might want to interfere too much with people's knowledge, believes, feelings and emotions. Totalitarian States might want to control people like "Big Brother."

There is one danger-that such programs would become part of routine political correctness and its institutionalized hypocrisy. I.e., they won't become efficient, but only ridiculous.

Entrenched values, extremists view and age old hatred will continue to endanger this development.

Extremist would hinder this possibility.

Just with education, it would not be enough to eliminate prejudice and hate. The programs must include specific means to achieve social justice.

17. e- Teaching

encouraging and positive

… It is likely that educational opportunities in virtual or synthetic … will be perfected as tools for teaching. Avatars or 3D holographic recordings will allow top teachers to send their lessons to the underprivileged.

It's possible that by 2030 accelerating technologies could even advance humans to the point at which the elite will be educated through direct brain downloads or nanotechnology and the people in poorer areas will have to "settle" for 3D VR teachers and learn the "old-fashioned" way, by listening and trying to remember.

Education is becoming a commodity. As such, basic economics will force providers toward methods that are more effective and/or more efficient. The live teacher is one of the least efficient, and perhaps least effective way of teaching. The artificial constructs will become more and more the norm.

E-teaching might help to exchange information among educational institutions in a country, and with those in other countries. … What might encourage this possibility is to focus efforts among the educational institutions, the governments, the companies, the banks, and other organizations, cooperating and collaborating together

It might (help) to eliminate poverty, popularize science and culture, and make everyone enjoy advanced education.

inhibiting and negative

…evil regimes and entrenched institutions are likely to either: a) stifle the proliferation of educational technologies, which they generally (and rightfully) perceive to be a threat to their power; or b) utilize the technologies in a limited fashion only to further inculcate belief systems tied to their own narrow ideologies.

… Education could loose the human dimension. The personality of teacher and experience of interpersonal communication is an important part of the educational process

…why not use humans..?

Existing groups and systems providing learning today will oppose the change. Self interest controls much of what we have in education. Overall, I foresee a huge political battle, with the learner being the eventual winner. But this is not a certainty

Education is not only teaching the knowledge, but also how to be an upright person.

Rigidity of the educational system and backward of reformation of teaching system would delay the realization of the possibility.

18. Smarter than human computers

encouraging and positive

If Moore's Law continues, then this is clearly possible by 2030, but processing power may yield very different "thinking" than humans and provide an interesting cross-reference to understanding reality

There is …. (confusion about the) difference between intelligence (smartness) and genius. Intelligence is simply knowledge stored and accessed…Genius, on the other hand, is high-volume knowledge creation. This is totally distinct from storage and retrieval. This is commonly what people mean when they say "artificial intelligence," which is really a misnomer… Confusion of these concepts has stagnated AI … but clearly differentiating these will open up a new social era on many fronts, not just this one.

If you speak of memory or specific functions, the net has already accomplished that. If you speak of creative and conceptual knowledge that includes all the physical, psyche, social, emotional, sexual of the human (and all of humanity), I think it may be mimicked but never accomplished. And who would trust it?

If superhuman AI emerges, it is going to require learning. So besides AI's being copied, these entities are also going to require some form of education. Most likely that would be extremely different from human learning in terms of pure fact acquisition, but learning social interactions and dealing with the physical world (important skills even for a superhuman entity) they would require something not unlike schooling or childhoods.

It might … be the best working tool created by human beings

inhibiting and negative

Backlash by people who are threatened the robots and computers will grow in power to control our lives beyond our control

The fear of humanity splitting between the Enhanced and the Naturals (not Enhanced) will be a constant worry in the development of artificial intelligence and its direct application to human beings.

We might not recognize superhuman intelligence for what it is, especially since it may be distributed and not a being per se (compare how "the invisible hand of the market" and Google solve problems

It's impossible absolutely to make machines which are clearly smarter than humans in any way.

The difficulty of cognition would not be inferior to exploring outer space

Isn't there possibility that human world would be controlled by these intelligent machines like in some science fiction?

19. Artificial microbes enhance intelligence

encouraging and positive

There is little doubt in my mind that physical performance could be enhanced this way.

Besides artificial microbes, there might be nanobots that will also help increase overall human performance

Symbiotic organisms have many advantages over gene therapy, but also require ways to circumvent the immune system. Symbiotic gut bacteria producing drugs seem very plausible, and could probably be used for enhancement. Anti-cavity mouth bacteria have already been demonstrated.

I think this will occur in other ways -- through psychopharmacology and augmented cognition (through the use of computer brain interfaces) -- we are already seeing this in the military.

Another question, "Shouldn't there be a global human review board that challenges science that questions our humanness?" (i.e. human genetic engineering.) Another, "Shouldn't all science be required to be transparent so that all humanity can decide on any issue that affects large portions of all of humanity?" It is not the right of a few to decide the good of humanity challenging concepts without such input

Symbiotic organisms have many advantages over gene therapy, but also require ways of circumventing the immune system. Symbiotic gut bacteria producing drugs seem very plausible, and could probably be used for enhancement. Anti-cavity mouth bacteria have already been demonstrated.

inhibiting and negative

Many people will be afraid of artificial microbes, new bacteria, and nanobots.

(concern about mutating of) the microbes mutate and causing mental disease… Craig Venter's work on writing genetic code to create unique life-forms might develop some life-forms by 2010, then maybe another ten years to such microbes to live in and assist the brain, then another ten years to test on other mammals; hence, by 2030 (we might) have safe microbes assisting the brain keeping neurons healthy…

The good news is that it will eventually become available to everyone. The bad news is that it will eventually become available to everyone -- including those who wish to harm others or promote violence.

It might be condemned by ethical (considerations)

if genetic codes could really be written or modified, and this technology controlled by the person who wants to use it in illegal way or follow one's inclinations, it would be a tragedy for the human society.

2.6 Demographics of Participants

There were some 274 people who signed in for the education and learning study and of these 213 provided at least one answer to the questionnaire (77.7%). Almost half (48%) of the people who answered at least one question visited the site more than once. Some of the people who visited the site more than once did so many times, the record (excluding the organizers) being a dozen.

The respondents answered approximately 3,000 questions. Average number of questions answered per participant was 11.3. The maximum number of answers to any question was about 181 and the minimum, about 100.

Number of Responses

Employment
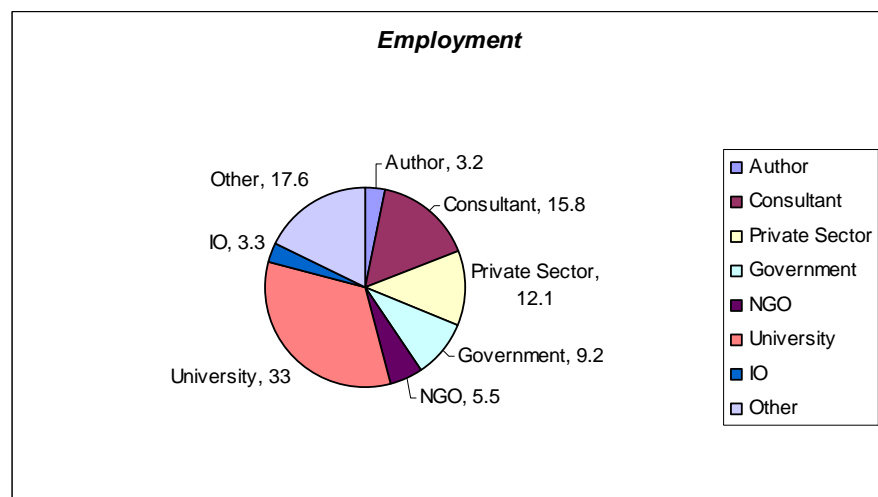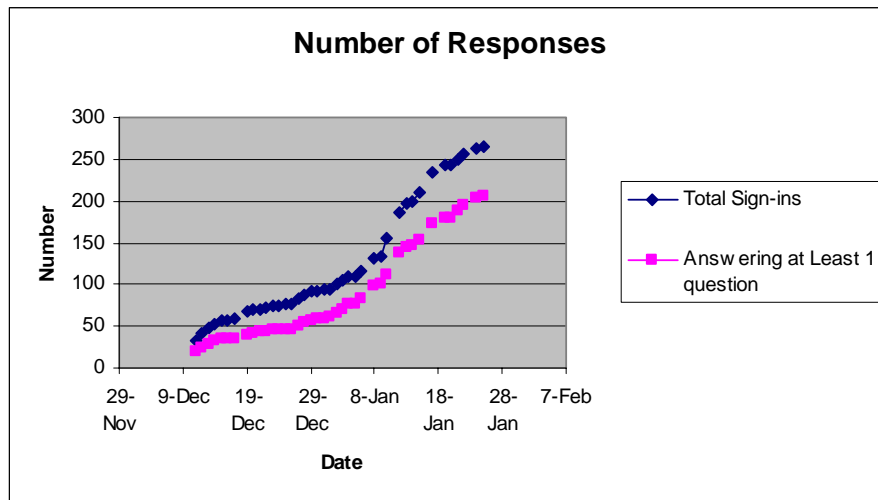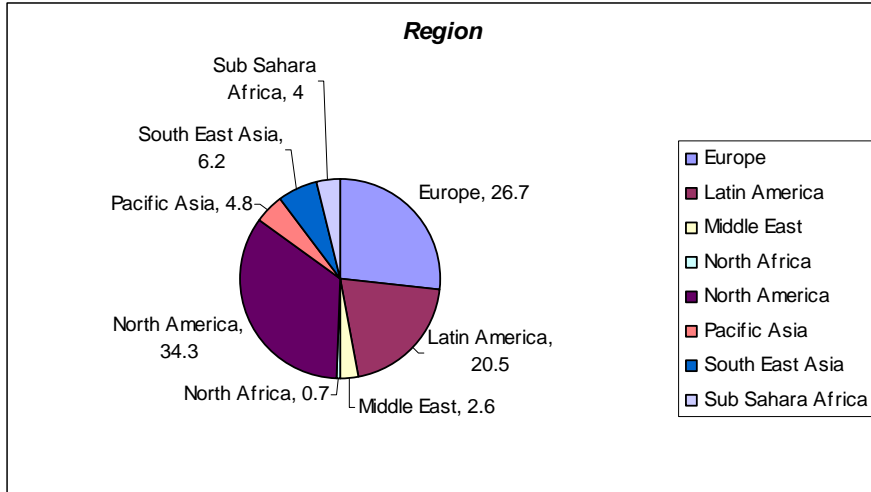
2.7 Insights and Conclusions

This study has covered a vast amount of material on the topic of future education and learning possibilities; it has attempted to avoid repeating commonplace knowledge about changes-in-progress and highlight those truly revolutionary developments that might appear in the next 25 years or so. Almost three hundred respondents provided about 3,000 answers to the questions posed in the Real Time Delphi questionnaire; the comments about factors encouraging or impeding the developments and the consequences of the developments were extensive (and even in a small type face covered some 40 pages). While many of these narrative answers expressed divergent views, the numerical judgments about the likelihood of the developments showed reasonable agreement.

Key conclusions and insights include:

> The most likely possibilities for education and learning (above 70% likelihood by 2030) from among those considered were judged to be
>> Web 17.0
>> Integrated life-long learning systems
>> Chemistry for brain enhancement
>> Just-in-time knowledge and learning
>> Use of public communications to reinforce pursuit of knowledge

> The least likely possibilities for education and learning (below 40 % likelihood by 2030) from among those considered were judged to be
>> Genetically increased intelligence
>> Artificial microbes enhance intelligence

> It is possible that the advances discussed in this study will not be available to all students, thus creating gaps in knowledge and capacities that are not present today. The lack of universal availability may be due to cost, political pressures (including the politics of academia), or reactions from existing institutions.

> Since some political regimes will view the new educational capacities as a threat to their power, one can expect that some of these techniques will be outlawed or distorted to perpetuate the existing regimes, ideologies, and belief structures in various places in the world.

> The advent of learning enhancing drugs may result in a drug competition race and raise questions about distribution and the ethics of charging for so important a commodity.

> Some of the techniques discussed here might be used as a tool for accelerating the absorption of immigrant populations.

> It is possible that an international competition in intelligence may develop.

> The shift to a collective intelligence appears to be already underway, as evidenced by (paraphrasing one respondent) mass on-line collaboration, open source software, knowledge creation communities, and social sharing of learning resource (e.g., Wikipedia, YouTube, MySpace, FaceBook, and SecondLife) often without overt individual financial compensation or incentives

> The drive toward collective intelligence may give rise to its counterforce and effort by outstanding individuals to opt out of the "collective" (anti-borg)

Developments lead to their counter developments and safeguards, even in education. For example the advent of portable artificial intelligence devices may lead to a 'race' to build portable 'anti-artificial intelligence devices' to protect oneself as an individual.

Improvements in intelligence will make even the bad guys smarter.

A "trickle down" strategy might be exploited to obtain new educational technologies; one respondent said, for example: "Standard data and simulation formats … allow cut-down versions of scientific simulations to be used in education." Perhaps the military and industry could be "mined" for similar applications.

When teaching goes on line, computer hacking into the curriculum and information will be an issue.

Just-in-time information can make everyone who has access look like an expert and true expertise will become hard to find and take on new meaning.

Since nutrition is "natural" compared to (say) cognition enhancement drugs, it is likely to be easier to accept for many.

Cultural differences may lead one nation to adopt technologies and practices that lead to increased intelligence while other countries reject them based on cultural taboos or beliefs.

Rather than being used to enhance the intelligence of many people, genetic techniques might be used to remove or modify genes that result in lower intelligence

Any intervention may have unexpected medical and social consequences

Attempts to change curricula will inevitably bring questions about the ideologies that drive the changes

Respondents raised interesting and important questions about some of the possibilities:

Can simulations be so real and captivating that real life looses its significance?

Will intelligent machines think and reason in ways that are different than human thinking?

Will people migrate to countries that offer a means of increasing intelligence?

Does everybody become smarter, or does the gap grow?

Are the less intelligent made smarter, thereby raising the average or is everybody boosted?

From a methodological standpoint, the Real Time Delphi technique worked well.

There appears to be a distinct relationship between the levels of agreement among the respondents and the likelihood of the items being considered. The highest agreement was achieved at the extreme likelihoods; the least agreement at the mid range of likelihood.

Several people wrote the administrator asking for the access code since they had forgotten it or misplaced it. Only one or two people expressed difficulty in using the system and at least in one case this was traced to a problem with the respondent's company firewall which didn't allow outgoing messages from a company computer.

Several respondents had problems or suggested changes that led to modifications in the study (e.g. minor rewording of a given possibility) while under way and possible revisions for consideration in a future study. Among these were:

> Use the median response rather than the group average to avoid distortion of the group response by far outliers.

> Hiding the average or median under an icon to reduce its influence on the first entry

> Providing translations on line

> Periodic publication of a list of respondents so that the node leaders could see who, from among their invitees, had responded in their areas

The request for a list of respondents by country was met in this study by downloading the names of the respondents and sending the lists by email to the appropriate nodes. In the future, this feature may be automated.

Several nodes asked for hard copies of the questionnaire so that they could be answered off line. These requests were met, although as was pointed out, using the hard copy prevented the respondents from seeing up to minute feedback.

Comments about the method included the following:

> I completed the exercise moments ago, spending four hours doing it fast, and could have spent 40 on comments.

> Like the original Delphi process, which is such a generic tool, RTDelphi now enables convergence of expert assessment (for decision support) in a distributed, asynchronous, and more timely manner. I see even greater value it can bring forth, when we get the chance to integrate it into the full SOFI system
> …we'll use ideas from and elements of the survey for start-up workshops on futures…

> You've developed a great system that serves a big need. Congratulations on a job well done.

> Thanks to all who are involved in this vital work, and especially to Jerry Glenn for the invitation to contribute to this discussion.

> Done my bit for your project. If I could understand it, anyone can. Pass my congratulations on to your web guy, I found nothing confusing. This now works easily for me. Always glad to support you.