

The Knowledge Economy

**What it is,
where it comes from
and what it means to Technology
Education in Australian schools.**

If you don't have time to read all of this document, here are the main points:

The single most decisive factor in influencing a country's living standard is economic growth. The engine of this growth, above all else, is innovation – almost regardless of other economic factors. This innovation, along with the knowledge development and management that drive it, are the building blocks of an information society and a knowledge economy.

How societies promote, manage and disseminate knowledge are the keys to economic and social development. The unique characteristics of knowledge and the dynamics of the knowledge economy mean that a cultural change is required from thinking in terms of production to thinking in terms of innovation.

Inevitably, many of the capabilities, dispositions and knowledges needed to participate in the information society will be acquired and renewed through formal education. Relevant lifelong education will become the centre of the knowledge society.

If the vision statement articulated by educators in the *Technology Education Action Plan (2002-2006)* is realised, technology educators are poised to play a crucial role in determining Australia's future. The systems, processes and cognitive skills that technology education imbues are critical determinants of Australia's ability to compete and succeed in the 21st century knowledge economy.

1. A VISION FOR TECHNOLOGY EDUCATION

The following vision statement was developed by members of the technology education community in Australia in a *Technology Education Action Plan (2002-2006)*¹. It proposes a vision for technology education that is future-oriented and ambitious; a vision that articulates a role for technology education in a 'knowledge economy'.

Technology Education in 2012²

Setting Statement

The increasingly technological nature of society and its unpredictable long-term impact means that Australia is constantly facing new and diverse lifestyle, environmental and economic challenges and opportunities. With this comes a growing demand to commit to an education that fosters new knowledges, capabilities and dispositions. Examples of these include responding positively to rapid change, embracing technological understanding, developing critical awareness, thinking in new ways that cross traditional boundaries like culture or subject discipline and imagining many futures. Education that nurtures and promotes these qualities in individuals must be a national priority.

Vision Statement

Technology education provides the new learning needed to engage in a rapidly changing, knowledge economy. It is education for an increasingly global and culturally diverse community where ideas, innovation and enterprise are central to the design and development of sustainable, socially responsible, preferred futures.

Consistent with this vision, technology education empowers and inspires the community, teachers and learners to:

1. recognise and create opportunities for innovation in diverse and rapid-change settings;
2. foster creativity and the power of ideas;
3. design, develop and communicate holistic solutions;
4. enhance practical knowledge and capabilities;
5. critique past, present and emerging technologies;
6. apply new, different and appropriate technologies and mental tools; and
7. evaluate and embed values to promote environmental and social sustainability.

"Technology education provides the new learning needed to engage in a knowledge economy"

This document introduces the concept of the knowledge economy

This document aims to introduce technology educators to the concept of the knowledge economy. It outlines the foundations underpinning a knowledge economy, the implications of this to modern society and the unique characteristics of knowledge that differentiate a knowledge economy from an industrial economy. The document also identifies 'life skills' that people will need to actively participate in an information society, and outlines the increasingly important role that technology educators will play in determining Australia's ability to compete and succeed in this environment.

¹ A copy of this Action Plan will be available to download from the website of the Commonwealth Department of Education, Science and Training at: <http://www.dest.gov.au/schools/TE2012/> in coming weeks.

² This vision statement provides a generic framework for the future of technology education in Australia that stimulates new thinking paradigms, new approaches and new interpretations. It intends to set a broad direction and 'spirit' for technology education that will guide the next generation of Technology syllabus and curriculum development.

2. THE FOUNDATIONS OF THE KNOWLEDGE ECONOMY

a. Growth By Producing 'Stuff'

Productivity and growth were functions of land, labour and capital

Two hundred years ago an agricultural economy existed where land and labour were the key elements of production. Since then five waves of technological development, starting with early mechanization in the late 18th century, have changed the way we work and live. During the industrial revolution *capital*³ became a major competitive advantage. In a simplified model, productivity and growth were seen as functions of combinations of land, labour and capital.

At this time production was the key to economic growth. Output was measured in 'stuff' produced; the more a nation produced, the more the economy grew. Scarcity of natural resources and inputs was inevitable and was a major economic concern. Even at this early stage technological development was recognised as impacting on growth and productivity, but it was seen as a largely unexplained external factor that occurred by chance. There was no attempt to identify the source of technological development and the distinctive ways it was used.

Technology was seen as producing temporary growth only

The indifference toward technology was partially explained by the view that growth generated by technological development was seen as temporary. It was believed that technology advances led to population growth which would negate any production benefits. In addition, technological development at the time was focused on plant and equipment, which resulted in diminishing returns on production and reached a point where the costs of the additional capital would outweigh the return.

b. The Role of Innovation

It was not until the 1930's, through the work of an Austrian economist named Joseph Schumpeter, that innovation was identified as a key contributor to economic growth. He saw the entrepreneur as an innovator who could increase growth by, among other things, efficiently combining resources and adopting new technical improvements.

Innovation could create increased productivity and therefore profit

Schumpeter showed that internally generated innovation could increase productivity and therefore profit for the entrepreneur. However, this internal innovation also had its drawbacks. The knowledge production required in order to innovate was fraught with uncertainty and experimentation, and consumed large amounts of resources. Moreover, the resulting innovation introduced imitation from competitors which ate away at profits. This would lead to diminishing returns on innovation investment and what Schumpeter called 'creative destruction' – the creation of new profit opportunities and the destruction of currently profitable businesses.

Whilst highly influential, Schumpeter's model could never explain why countries and firms that invested in innovation seemed to continue growing faster than their competitors.

c. A Virtuous Cycle of Growth

Stanford University Professor Paul Romer was the first to identify technology, along with the knowledge on which it is based, as an intrinsic part of the economic system and a key to long-term growth. Romer's **new growth theory** has transformed perceptions of economic growth. Some of the key points are:

- Technology is a central part of the economic system, along with labour and capital, because it allows us to find value by combining inputs in new ways. Rather than producing additional 'stuff', we have learnt to combine and rearrange a fixed quantity of inputs in ways that add value. For example, a computer chip is of much greater value than the silicon and metals that go into making it. We add value by

³ Capital refers to the plant, equipment, buildings and goods used to produce other goods and services.

The recipe has become more valuable than the ingredients

innovating combinations of inputs, rather than by increasing the amount of matter used, making the recipe more valuable than the ingredients.

- Ideas are the instructions that let us combine limited physical resources in arrangements that are ever more valuable. The combinations of inputs are limited only by our ability to innovate.
- While new technological developments like the computer chip provide a one-off benefit, they also create **technical platforms** that act as springboards to further innovation. Ideas build on each other and lead to increasing rather than diminishing returns on technological investment. For example, investment in the knowledge of genes has opened profitable opportunities in areas like biotechnology. Similarly, the development of new intelligence systems has enabled rapid improvements in city transport and manufacturing technologies.
- Investment can make technology more valuable and technology, through these technical platforms, increases the value of investment. This creates a **virtuous cycle** that raises a country's economic growth rate permanently. The growth rate depends on people's ability to innovate and the rate of return on innovation.

Ideas, not objects, stimulate growth

In short, ideas - not objects - stimulate growth. New growth theory emphasises that people have the capacity to innovate faster than any diminishing returns. The potential for discoveries and continual improvements are endless, and innovation - almost regardless of the condition of the larger environment - powers long-term growth.

3. THE IMPLICATIONS FOR SOCIETY

a. Knowledge as a Competitive Advantage

Poor countries of the future will be those that lack ideas

Knowledge has become the primary resource of production, while land, labour and capital are secondary resources. In the past, poor countries lacked resources and capital, while countries like Australia developed wealth by successfully exploiting their natural resources. However, poor countries of the future will be those that lack ideas and the motivation or stimulus to create ideas. As futurist Peter Drucker notes, there may be no poor countries, only ignorant ones.

"Knowledge and information is being reproduced today like cars and steel were produced a hundred years ago. Those like Bill Gates who know how to produce knowledge and information better than others, reap the rewards, just as those who knew how to produce cars and steel a hundred years ago became magnates of that era."

- **Joseph Stiglitz**, - Senior Vice President and Chief Economist,
The World Bank Group

Leading countries will derive value from information

Comparative advantage now comes from the process of innovation more than any other factor. As technologies help us to seamlessly capture, process and manipulate information, people will be asked to move from just handling information to converting information to knowledge which can then be applied to problem solving⁴. Firms and countries will solve a never-ending stream of societal, environmental and competitive problems by combining technological know-how with the creative talents of their people. The leading organisations and countries of the future will be those that are best able to derive **value** from information.

A shift has taken place from reliance on *physical* tools to reliance on *mental* tools. We live in an information society and in a knowledge economy.

⁴ The Institute for the Future sees this as a movement 'up' the information value chain, from data → information → knowledge → innovation. (From *Information to Knowledge: Harnessing the Talent of the 21st Century Workforce*, 1998).

4. WHY KNOWLEDGE IS SPECIAL

a. The Characteristics of Knowledge

The unique characteristics of knowledge provide clues to help us better understand the challenges and opportunities that citizens, organisations and nations will face in the information society.

- Knowledge, ideas and concepts are nonsubtractive and independent of space. Their use by one person does not exclude their use by another. Unlike a *Bonds* t-shirt or a seat at the movies, my obtaining and using knowledge does not diminish your ability to.
- Knowledge is unlimited and renewable. Whereas scarcity of natural resources and capital were fears of the old economy, the potential exists to create new knowledge every day. Scarcity comes only through the inability to use or renew the knowledge base.
- The cost of knowledge is unaffected by how many people eventually use it. The cost of preparing this document is the same whether 1 or 1 million people read it.
- Production technology can replicate knowledge easily and quickly. Intellectual property is easily reproducible as a market commodity and, as Microsoft has shown, can provide enormous economic benefits.
- Similarly, there is little correlation between knowledge inputs and outputs. The value of knowledge is unrelated to the cost of creating it. Large profits can result from creative discoveries with negligible cost.
- Knowledge is time dependent and ever changing. While physical assets depreciate reasonably slowly over time, the value of financial advice may lose all value in minutes. Knowledge makes itself obsolete quickly, and competitive advantage based on knowledge will always be challenged.
- Globalisation and the lowering of technical barriers to accessing information move knowledge across borders more quickly than ever before. Imitation is becoming faster and better, and competition fiercer. For developing countries, enormous gains are made simply by purchasing the ideas or 'recipes' of others. This, in part, explains the growth achieved by many developing nations in the 1980-90's. However, developed countries have less opportunity to stay ahead by adopting ideas. These countries must continually innovate, rather than imitate. In short, innovation and the knowledge underpinning it are increasingly becoming the keys to local and global competition. Countries that foster societies where innovation can flourish will lead economic and social development in the next century.

The potential exists to create new knowledge every day

Leading countries will foster societies where innovation can flourish

b. Knowledge Economy Inputs

Romer uses a computing metaphor to re-categorise how we view economic inputs. Traditional categories of inputs like capital, raw materials, production and non-production workers are replaced by:

- Hardware - physical equipment, structures, raw materials and infrastructure.
- Software - codified and transmittable knowledge like manuals and instructions, computer codes, books, scientific and technological principles and routines. Software is the *know-how* of performing a particular task that, once created, can be stored, easily reproduced and used simultaneously by a large number of people.
- Wetware – the tacit knowledge, creativity, human networks and cognition stored in the 'wet' computer of a person's human brain. The wetware provides the innovation capacity that enables us to create and exploit software.

Production makes hardware, education makes wetware and innovation makes software. According to Romer, software is the currency of the knowledge economy, and educators are now charged with developing in their students the 'wetware' that will foster 'software' innovation.

Students will need to develop the 'wetware' that will foster innovation

5. WORK & EDUCATION IN THE KNOWLEDGE ECONOMY

a. The Life Skills of the Future

Renewal of knowledge is more important than the actual stock of knowledge

Success in an information society requires a change in the way people think and a shift in the cultural emphasis from one of producing objects to one of fostering and managing knowledge. The 'quarry mentality' that still exists in Australia will need to be replaced with one of continuous and vigilant innovation. Long-term growth depends on how efficiently knowledge is used and how well new knowledge is continually produced, codified and disseminated. More important than the actual stock of knowledge is the ability for countries to renew this stock.

Peter Drucker is one of those who believe that education will become the centre of the knowledge economy. The acquisition and distribution of knowledge in the information society, he says, will become as central as the acquisition and distribution of property and income were in the capitalist society.

Successful nations will create a society of skilled, flexible and creative people. They will support their citizens to develop their innovation potential. Some of the identified skills⁵ that contribute to this will include:

- **Interpreting** situations, needs, possibilities and procedures;
- **Generating** alternatives, innovations or solutions;
- **Collaborating** with others;
- **Reflecting** on situations, procedures, needs and opportunities;
- **Representing** ideas or suggestions;
- **Evaluating** merits and disadvantages.

A lot of knowledge work will require advanced manual skills; architects and surgeons are two examples. However, these skills will supplement specialist knowledge. Manual skills alone will never be sufficient, regardless of how advanced. Knowledge workers will be increasingly expected to:

- Work with intangibles, rather than physical products.
- Innovate with teams of people in 'knowledge clusters', often from different backgrounds and in virtual environments.
- Possess high degrees of specialisation, and work and communicate effectively with people who do not share their knowledge base.
- Learn how to assimilate specialised knowledges from other areas and other disciplines into their own work.
- Select and screen relevant information and discard obsolete knowledge.
- Critically assess the short- and long-term impact of technologies and innovations on their work and lifestyle, and on society and the environment.
- Develop willingness to change and experiment.
- Establish capabilities in problem solving, innovating and conceptual technological understanding, more so than the operational know-how.
- Develop higher order cognitive skills⁶.
- Learn how to learn, and undertake on-going education for much of their working life.

Knowledge workers will develop willingness to change and experiment

⁵ Australian National Training Authority (2002) Innov@tion– ideas that work, ANTA, Brisbane.

⁶ Stiglitz, Joseph - Senior Vice President and Chief Economist, The World Bank Group, (27 January 1999) Public Policy for a Knowledge Economy, remarks at the UK Department for Trade and Industry and Centre for Economic Policy Research, p 21.

b. The Increasingly Important Role of Technology Education

The emerging society and economy based on ideas, not objects, will require different educational forms and priorities. Educators must employ strategies to effectively build the 'wetware' that their students will use to engage in a knowledge economy, or risk being obsolete.

If the vision statement articulated in the *Technology Education Action Plan (2002-2006)* is realised, technology educators are poised to play a crucial role in determining Australia's future. The technological processes, systems, creativity, higher order cognitive skills and future-orientation that technology educators can bring to the classroom will become increasingly significant tools. Technology – above all other learning areas in the current school curricula - has the potential to imbue many of the 'life skills' required to actively participate in the information society.

Technology educators will provide the critical capabilities needed to survive in the knowledge economy

The vision statement, therefore, maps a future where technology educators will be asked to arm the workers of the future with the critical capabilities they need to survive in the knowledge economy. Technology educators may become the central hub of 'wetware' education in schools around Australia, and are likely to be significant influencers of Australian society, economic prosperity and government policy. However, for technology education to remain relevant it must also anticipate and reflect the changing needs of the information society. The transition into the future as captured in the vision statement will not be easy, and introduces challenges for teachers, school leaders, communities and education jurisdictions alike.

The industrial revolution lasted well over 100 years and affected every aspect of our family, social and working life. There is no reason why the knowledge revolution will not have the same impact. The potential role of technology education in this revolution is enormous. This places great responsibility on, and creates exciting opportunities for, all technology education professionals.

6. SOME RELEVANT READING

The following resources have been used in preparing this document. While the list is by no means comprehensive, these texts provide a great introduction to new growth theory, the knowledge economy and the role of innovation in an information society.

- **Australian National Training Authority** (2002) *Innov@tion— ideas that work*, ANTA, Brisbane.
- **Building Knowledge Economies: Opportunities and Challenges for EU Accession Countries**, Final Report of the Knowledge Economy Forum, Paris Feb 19-22, 2002.
- **Dodgson, Mark** (2000) *The Management of Technology Innovation: An International and Strategic Approach*, Oxford University Press, Oxford.
- **Drucker, Peter** (1995), *Management in a Time of Great Change*, Butterworth-Heinemann Ltd, Oxford.
- **Parkin, Michael** (1997) *Macroeconomics 4th Edition*, Addison Wesley, Massachusetts.
- **Romer, Paul** (1995) *Beyond the Knowledge Worker*, *Worldlink*, January/February 1995.
- **Saveri, Andrea** (1998) *From Information to Knowledge: Harnessing the Talent of the 21st Century Workforce*, Institute for the Future – 1998 Ten-Year Forecast.
- **Stewart, Thomas A.** (1997) *Intellectual Capital: The New Wealth of Organisations*, Nicholas Brealey Publishing, London.
- **Stiglitz, Joseph** - Senior Vice President and Chief Economist, The World Bank Group, (27 January 1999) *Public Policy for a Knowledge Economy*, remarks at the UK Department for Trade and Industry and Centre for Economic Policy Research. Final report of the Knowledge Economy Forum, Building Knowledge Economies: Opportunities and Challenges for EU Accession Countries, Paris, February 19-22, 2002.
- *The Knowledge Economy*, A submission to the New Zealand Government by the Minister for Information Technology's IT Advisory Group, August 1999.
- **Trott, Paul** (1998) *Innovation Management & New Product Development*, Pearson Education Limited, Essex.