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Role of Chess in the 21st Century Economy

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Executive Summary

Key Messages

- 600 years of economic evolution has transformed the world from an economic production system dominated by physical work to now intellectual work.
- This evolutionary trend is expected to continue in the 21st Century at an accelerated rate.
- National economic success in 21st Century will be dependent on a country's ability to maximise quality of human capital which includes cognitive capacity and creativity attributes.
- Evidence from developed nations such as US and Australia indicates that current education/training system is not producing the human capital required for 21st century economy.
- Structural education and economic reform required in developed economies to overcome existing challenges.
- Emerging evidence is that chess may be able to positively contribute to lifting a country's educational and human capital therefore economic performance.
- Further research is required to better understand to what extent chess may help and how.

“The formulation of the problem is often more essential than its solution”

Albert Einstein

Introduction

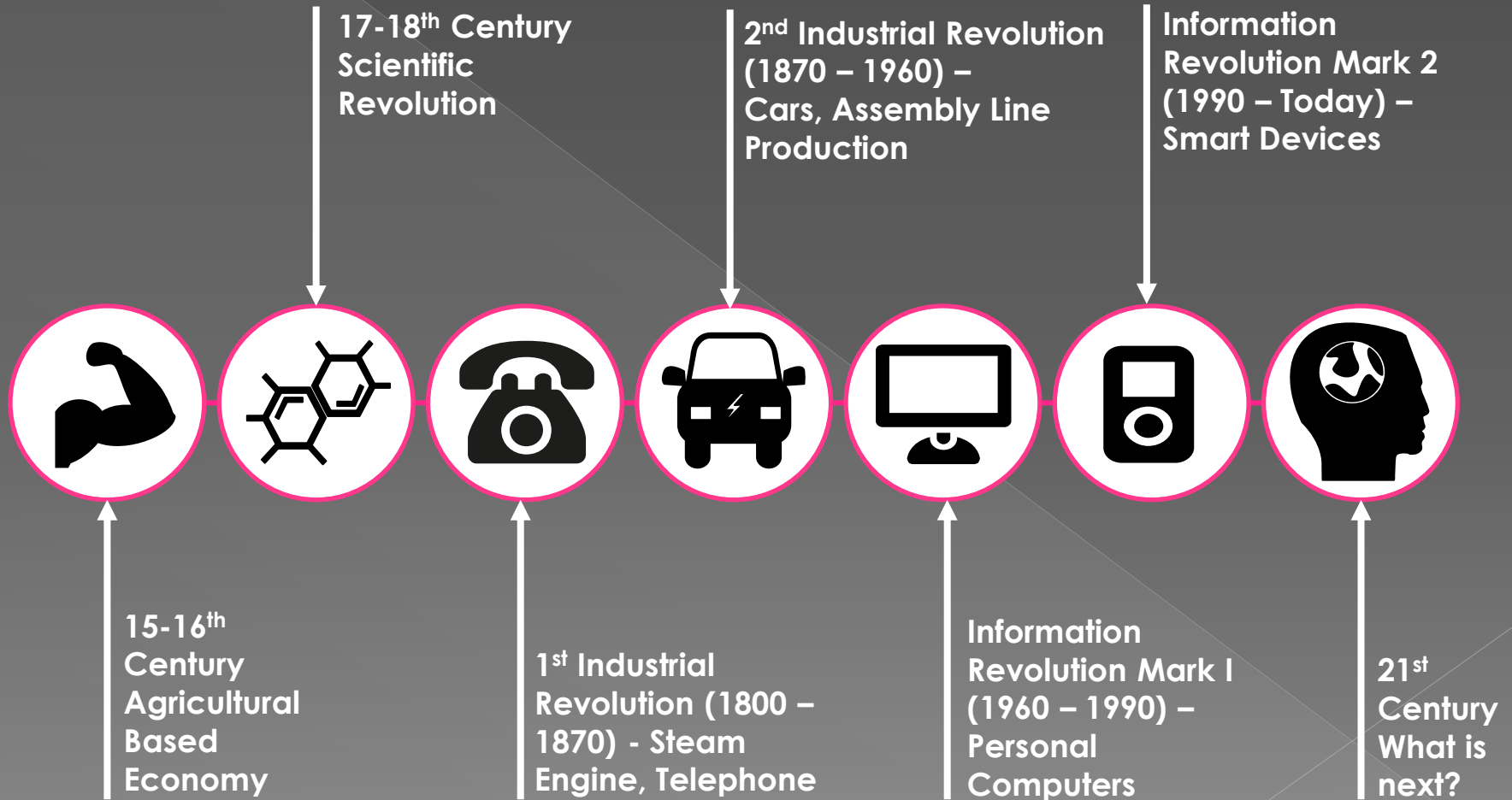
Why chess and economics?

Australian Chess Research Project

- Launched by John Adams in May 2015 who is now the Government Relations Director and Assistant Treasurer at the Australian Chess Federation.
- Purpose of research project is understand how chess is being used across the world by Governments, schools and other organisations to produce public benefits and to explore what relevance is there for Australia?
- Research report is expected to be produced and released in late 2016.
- To attract serious attention from government, public institutions and the private sector, a public policy case has to be developed that outlines what public value can be generated from chess.
- Research will consider the benefits of chess from both an economic, educational, social perspectives.
- This lecture pack covers preliminary research on the changing nature of the global economy in the 21st century and how chess may assist individual countries experience superior economic outcomes.
- This presentation presents a possible picture and poses a series of questions at the end.
- In many countries, government's are running large fiscal deficits and have accumulated large amounts of public debt. Chess is unlikely to obtain any serious commitment unless policy makers can be persuaded that chess can contribute to long-term economic and other public benefits.

600 years of economic history

From brawn to brains



15th – 20th century economy

Key trends

- **15-16th Centuries – Agricultural based economy (1400 – 1600)**
- **17th -18th Centuries – Enlightenment Period (1600 - 1800)**
 - Scientific revolution (e.g. Newton, Watt) led to free inquiry & learning, expansion of knowledge & reduction of superstition
 - Political Revolution/Civil War (E.g. UK, US & France – Locke, Voltaire & Jefferson) led to political system which encouraged free exchange of ideas, invention and innovation
 - Emergence of factory system in England fuelled by capital investment from wealthy merchants
- **19th Century – 1st Industrial Revolution (1800 – 1870)**
 - Contained to Western Europe (UK, France, etc.) & USA
 - Technology advances (e.g. steam engine, telephone) in both production, transportation, communication and printing led to significant increase in productivity which shifted labour from agriculture to large scale manufacturing.
 - Shift in population from countryside to cities
- **20th Century – 2nd Industrial Revolution (1870 – 1960)**
 - Industrial Revolution spread to Germany, Russia, Japan, etc.
 - Technological advances (such as electricity, cars, airplanes, radio, television) led to even greater productivity gains creating surplus labour that produced new sectors such as entertainment
 - Rise of corporations, assembly line production and advent of autocratic management techniques leading to production standardisation
 - Result: Mass production of goods, consumerism and expansion of world trade

Late 20th - 21st century economy

Key trends

➤ Information Revolution Mark 1 (1960 – 1990)

- Information economy created through creation of Information Technology (IT) such as the microchip, personal computer and the internet
 - IT – processing, storing and communication of information
- Global economy dominated by OECD (including US, UK, Europe, Japan)
- New Industries created anchored around tech sector - nature of work across many industries changes
- Surplus labour leads to creation and explosion of service sector

➤ Information Revolution Mark 2 (1990 – Today)

- **Globalisation** – Intense new wave of globalisation has profound impact on global production and international supply chains ('global redistribution of jobs' from outsourcing and offshoring)
 - Rise of China, India, Brazil, and East/South-East Asia has led to massive shift in global production based on competitive advantage
 - Internet – leads to global co-ordination, communication and production
- **Technological advancements** has increased in number and new advancements are coming faster and are being adopted faster
- **Automation** – IT, smart devices, robotics and new IT applications has led to destruction of low-skill/semi jobs and creation of high skill jobs
- **Digitalisation** – knowledge and services digitised through the internet and the cloud. Examples: search engines, books, journals, music
- **'Interaction Jobs'** - Advanced Economies are seeing a reduction in production and transaction based jobs (i.e. bank teller) and more 'Interaction' jobs. I.e. jobs that involve searching, coordinating and monitoring required to exchange ideas, goods and services. E.g. Lawyer - jobs involve complex problem solving experience

21st century economy

What are we to expect?

What are we to expect next on the economic horizon?

Hard to Predict - Some forecasts?

- **Global Urbanisation & Consumerism** – More humans will live/work in urban/city environments & greater number of consumers will come from emerging economies
- **More technological advances** – faster development and faster adoption/diffusion
- **Big Data/Data Analytics** – digitalisation creating large data sets that allow deeper level of analysis and more efficient ways of optimising production and serving consumers
- **Personalisation** – Demand for personalised products will replace standardised goods and services
- **Disruption** – Entrepreneurs and small start-ups with niche offerings will have more power to disrupt markets/industries
- **Mind Workers** – workers will be required to use their minds more at work – including the need to employ ingenuity, creativity, imagination and innovation
- **Workplace of the Future** – Greater collaboration, flexibility and agility & greater capability to use and employ technology effectively
- **Robotics/Artificial Intelligence** – futurists predict the 'singularity' – the amalgamation of humans and machines
- **New Science** – application of emerging areas of science will transform countries, industries and people – e.g. neuroscience, genetics, renewable energy

Economic growth

Why are cognitive ability & PISA scores important?

- **The Knowledge Capital of Nations** - 10 year study by Eric Hanushek (Stanford University) and Ludger Woessmann (University of Munich).
- Study involved statistical analysis over 1960 to 2000 period using international academic testing results in maths and science such as PISA Scores as a proxy for cognitive skills (or 'knowledge capital').
- Finding (1): *"Simple growth models considering knowledge capital (in addition to years of schooling and initial income levels) account for 75% of the international variation in long-run growth rates – a stark contrast to models excluding cognitive skills that can account for just 25% of the variation."*
- Finding (2): *"Cognitive skills of the population are the most essential to long-run prosperity"*
- Finding (3): *"Both the basic skill and the top-performing dimensions of educational performance appear separately important for growth."*
- Finding (4): *"A move of one standard deviation of individual student performance translates into a difference of 1.7% - 2% in annual growth rates."*
- Conclusion (1): *"Our models can be interpreted as saying that if a country finds a way to increase its knowledge capital... it can realistically expect its long run economic fortunes to improve."*
- Conclusion (2): *"Since the tests concentrate on the impact of schools, the evidence suggests school policy can, if effective in raising cognitive skills, be an important force in economic development."*

Economic implications

What does this all mean?

- 21st Century will see a significant change to both what goods and services are produced (i.e. economic production) and how they are produced (i.e. the nature of economic production).
- Intensification of global economic competition and pace of economic change will be faster relative to 20th Century.
 - Many products are becoming ubiquitous & commodities – meaning greater price competition across businesses/industries.
- Invention and innovation are critical for countries to produce high value products that command a price premium in the global market.
- These factors will carry significant implications for entrepreneurs, senior executives and the labour market regarding what skills, capabilities and attributes will be required to:
 - Start businesses in high-tech or new industries;
 - Lead and manage corporations; and
 - Secure employment.
- Hanushek and Woessmann study implies that cognitive skills will play a more important role given the change in the nature of economic production and use of technology we are witnessing in the 21st Century.
- Individual attributes and capabilities will be just as critical as technical knowledge and specialised skills - E.g. Agility and adaptability will be critical to respond to change and exploit new market/industry opportunities.

21st century economy

Developments in the labour market

Current Labour Market Trend:

- USA: Automation has led to the destruction of low skill jobs with the replacement of high skill/high paying jobs - many unskilled or semi-skilled workers are being left without sufficient economic opportunities.
- Labour market in advanced economies are being 'bifurcated' with high skill, high wage jobs vs menial low-wage jobs (particularly in the service sector).
- Emergence of truly global labour market - 1980 – 2010: 40% share that foreign born workers contributed to labour growth in advanced economies.
- Technological advancements has resulted in greater global demand for highly skilled labour: Foreign born workers accounted for 17% of all employment in STEM occupations in the US.

Future Labour Market Trend:

- McKinsey Global Institute estimates that by 2020 there will be a major global skills gap:
 - Unfilled 40 million high skilled jobs
 - Unfilled 45 million medium skilled jobs
 - A surplus of 95 million low skill workers.
- PWC Australia (2015) – Using Oxford University methodology, PWC estimates that 44% of current Australian jobs (or 5.1 million) are at 'high risk' of being affected by computerisation and technology over the next 20 years.
- US Bureau of Labor Statistics – estimated in 2012 that for 2008 – 2018 period growth in jobs with STEM skills will be 1.6% relative to 1% growth in overall job market.
- Emergence of 'smart creatives' – Google's hiring philosophy.

21st Century Economy

Skills Problems - Science, Technology, Engineering and Mathematics (STEM)

% of University Graduates with Science, Technology, Engineering or Mathematics (STEM) degrees

Country	%
Singapore	54%
China	42%
South Korea	35%
Germany	28%
France	26%
World Average	23%
UK	22%
Canada	21%
Australia	19%
USA	15%

Source: McKinsey Global Institute

- Research indicates that 75% of the fastest growing occupations now require STEM Skills.
- Given technological development and diffusion - More occupations require workers who have both specific STEM skills as well as general analytical problem solving skills and the ability to apply new forms of technology in producing goods or services.
- Research shows that biggest skills gap is in STEM areas.
- UK Employer Group CBI – found in December 2014 that nearly 40% of firms looking for staff with STEM skills have had difficulties recruiting, and about half thought the situation was only going to get worse.
- Emerging research states that spatial ability strongly predict who will go into STEM fields.
- Many advanced economies are not producing enough workers who STEM based skills who can fill the jobs of the future.

21st century economy

Key attribute & capability requirements

Technical Skills & Specialised knowledge (e.g. STEM) critical given technology developments, but 21st Century will require entrepreneurs, executives and workers to have a broader set of attributes and capabilities.

Alternative theories have been put forward on what these attributes/capabilities will be?

- **Ingenuity** – inventiveness, an aptitude for discovering.
- **Creativity** – ability to transcend traditional ideas, rules, patterns and relationships and to create meaningful new ideas, forms. and methods or interpretations.
- **Risk seeking** – courage to take on the status quo.
- **Critical thinking and problem solving** – the ability to ask good questions . Taking issues, situations and problems and going to root components.
- **Collaboration across networks and leading by example** – ability to work fluidly around the world, understanding how to leverage the globe, time zones, where the work can best be done, where there are skills that best match the task, either because of culture or the training.
- **Agility and adaptability** – to think, be flexible, change, and be adaptive, and use a variety of tools to solve new problems.
- **Initiative and entrepreneurship** – self-directed people who can find creative solutions to some very tough challenging problems.

21st century economy

Key attribute & capability requirements

- **Effective oral, written and multimedia communication** – to express one's views clearly and to communicate effectively across cultures. Requires clear thinking and finding 'authentic voice'.
- **Accessing and analysing information** – the ability to access and analyse information in order to discern new challenges and opportunities.
- **Design** – ability to shape and make our environment in ways without precedent in nature, to serve customer needs and give meaning.
- **Story telling** – the ability to transform information through encapsulating, contextualising and emotionalising in a story or narrative form.
- **Symphony** – capacity to synthesize, to see relationships between seemingly unrelated fields; to detect broad patterns and to invent something new by combining elements that no one else could see.
- **Empathy** – ability to imagine yourself in someone else's position and to intuit what the person is feeling. I.e. Feeling with someone else.
- **Playfulness** – ability to create play, laughter and joyful environments and experiences both at work and with customers.
- **Meaning** – to define one's life purpose and to align that purpose to one's occupation and work environment.

21st century economy

Public policy implications

- Greater proportion of 21st Century economic production in be intellectual/analytical based work. Human capital, therefore, will be the most critical factor to economic performance in 21st Century.
- 21st Century economic success will depend on government & private sector developing education and training systems & economic/societal culture that produces the right mix of skills, capabilities and attributes.
- Inappropriate public policy settings can potentially have significant long term detrimental economic consequences.
- Evidence suggests that in many developed economies (e.g. Australia) are producing substandard economic and educational outcomes.
- **Smartest Kids in the World (2013)-**
“All children must learn rigorous higher-order thinking to thrive in the modern world. The only way to do that is by creating a serious intellectual culture in schools, one that kids sense is real and true.”
- **The Global Achievement Gap (2014) -**
“In today’s highly competitive global “knowledge economy”, all students needs skills for college, careers and citizenship... Schools haven’t changed; the world has. And so our schools are .. obsolete.”
- **Most Likely to Succeed (2015)**
“Thriving in the twenty-first century will require real competencies, far more than academic credentials.”

Australian economic challenges

Slow growth and decline in productivity & PISA scores/rank

PISA Scores	2000 Mean Scores	2000 Rankings	2012 Mean Scores	2012 Rankings	Difference
Mathematical Literacy	533	6 th	504	19 th	Decline by 13 places
Scientific Literacy	528	7 th	521	16 th	Decline by 9 places
Reading Literacy	528	4 th	512	13 th	Decline by 9 places

Source: Australian academic scores according to the OCED PISA Results

Economic Indicator	Percentage
Multifactor Productivity (July 2004 – July 2014)	-4.35% Falling Productivity
Economic Growth July 2014– July 2015)	2.0% Below Trend Growth

Source: ABS

Given likely direction of the global economy in the 21st Century, Australia has significant economic challenges:

- Short Term – Below trend economic growth and falling multifactor productivity;
- Medium/Long Term – Fall in student academic performance despite significant increase in education spending by Federal and State Governments; and
- Gonski Report – Top students falling behind and Australia has one of the largest gaps in the OECD between the highest performing students and the lowest performing students.

All factors carry both medium to long term economic consequences for the Australian economy – Structural economic and educational reforms required

Decline in creativity and originality

Problems with modern education?

Given the importance of innovation to economic success in the 21st Century, it is critical that policy makers set the right conditions that allow creativity and originality to flourish.

Western economies (e.g. USA, UK and Australia) have implemented similar structural changes to their education systems including:

- Identification of core subjects
- Increased use of standardized testing
- Development of centralised curriculum standards
- Increased stakes to enforce standards of core academic subjects

Analysis by Professor Kyung Hee Kim, an education psychological professor at William and Mary College indicates that there has been a fall in creativity in the USA over a 20 year period among adults and children. Working hypothesis is that structural reform to education system has been a contributing factor to disappointing outcome.

While more analysis is required regarding the creativity quotient of people across the world, a decline of a country's creativity and originality ability has profound long term innovation and economic implications.

Creativity Attribute	Time Period	Decline %
Fluency Scores	1990 – 2008	7%
Originality Scores	1990 – 1998	3.74%
Creative Strength	1990 - 2008	5.75%
Elaboration Scores	1984 - 2008	36.80%
Abstractness of title	1998 – 2008	7.41%
Resistance to premature closure	1998 - 2008	1.84%

Questions for the chess community

- 1) What role is there for chess to play in the 21st century economic context defined above?
- 2) Is there a public policy case that can legitimately argue that public and private investment in chess can boost a country's innovation performance, productivity and economic growth allowing for a sustainable competitive advantage given globalisation and rapid technological development?

Is chess just a game or more?

Public policy history of chess



In the 20th /21st Century, chess has been used in a variety of ways including:

- USSR used chess as a tool of political propaganda to show the world the intellectual superiority of Soviet Communism;
- Given global professional chess circuit, chess has been promoted as a sporting activity; and
- Chess is now being promoted as an educational tool that can boost, in particular, mathematic and problem solving ability.

Role of chess

Studies on the impact of chess?

Research into the impact of chess is still in its infancy. Many claims by the international chess community have been made regarding chess' benefits including:

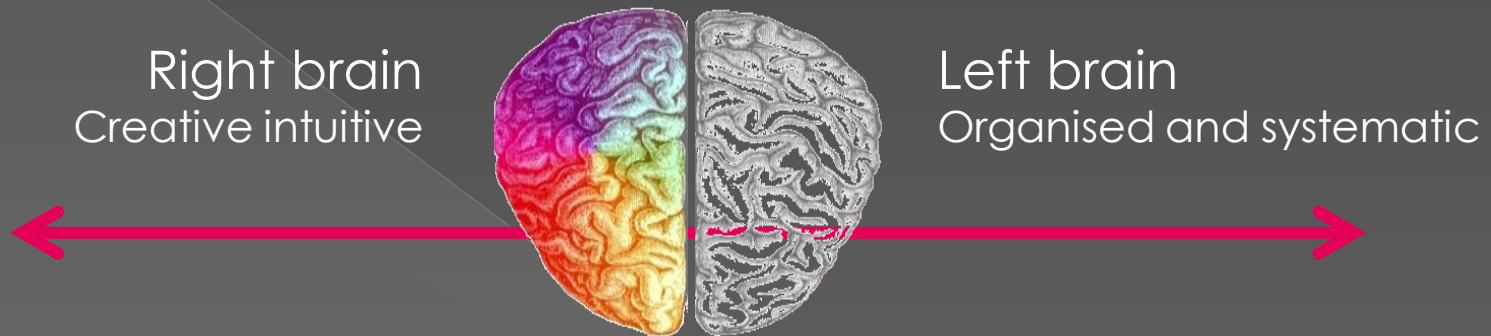
- Cognitive - Memory, critical thinking skills, complex thought, problem solving, IQ scores, organisation, creativity, verbal reasoning.
- Executive Control – Ability to reason, plan ahead, multi-task, switch between tasks, sustain attention, delay gratification, make complex decisions, metacognition
- Educational Benefits – Improved test scores, numerical and verbal skills reading, science.
- Emotional – Self-esteem, focus & concentration, impulse control, attendance.
- Some studies have shown that introduction of chess among school students can boost mathematical, reading, spatial and general cognitive analytical/logical thought process abilities.
- Evidence has also emerged showing that chess players have superior pattern recognition and selective search capabilities.
- Benefits of cognitive improvement from chess may be experienced more so in earlier stages of chess exposure. Improvement in benefits may incrementally reduce as chess skill improves.
- Optimal teaching methodologies of how to teach chess remains an open area of research.

Beneficial impact of chess

A sample of studies

- Gumedde & Rosholm (2015) – chess in Danish schools led to Improvement by 0.16 - 0.18 standard deviation in maths scores. Specifically, significant improvement among native Danish children, no effect on immigrant children.
- Trinchero (2013) – chess in Italian schools led to small but statistically significant improvement in PISA maths scores. Impact greater among students who had more hours of instructions.
- Gliga and Flesner (2013) – introduction of chess among novice children led to significantly improved performance in mathematics and language.
- Kazemi (2012) – chess tested among Iranian 5th, 8th and 9th grade students led to significantly improved maths ability and metacognitive capabilities.
- Aciego (2012) found among 170 students between age 6-16 years of age achieved significant improvement in problem solving capacity who received extracurricular chess instruction.
- Scholz, Niesch, Steffan, Ernst, Loeffler, Witruk, Schwarz (2008) – Chess can significantly improve the calculation and counting ability of children with learning disabilities.
- Smith & Cage (2000) – 120 hours of chess instruction led to significant improvements in academic achievement – maths, spatial analysis & non-verbal reasoning.
- Ferguson (1983) – study showed significant improvement through 1979 – 1983 of Pennsylvanian year 7 to 9 students in fluency (19.9%), flexibility (22.8%) and originality (70%) using Torrance Tests of Creative Thinking.

Why does chess deliver impact? Likely questions from policy makers?



- In most studies on chess, the chess community and researchers are not able to explain scientifically why chess has the ability to lift academic results or cognitive ability.
- Correlation vs Causalisation - Policy makers may be sceptical on the ability of chess to deliver purported outcomes. A sub-set of students who have intellectual gifts may be drawn to chess (i.e. self-selection).
- Chess Community needs to be able to explain why chess is having such as reported impact. Are the beneficial outcomes purely exclusive to chess or can other activities deliver the same outcome?
- How can policy makers have confidence that public investment will deliver intended outcomes and deliver educational/social return?
- Educational Neuroscience is a growing field. Researchers are seeking to understand how to design educational programs that best yield superior neurological capability and skill attainment outcomes .
- This area of inquiry is still in its infancy and significantly more research is required.

Potential answers?

Neuroscience?

- One potential field of explanation to why observed impact of chess is occurring is neuroscience which the chess community has largely ignored.
- Alternatively, a number of neuroscientists have conducted studies on highly rated professional chess players to understand what neurological differences are there between chess players and non-chess players.
- Some neurological differences have been observed but it remains an open question how expert chess players can exploit these difference in other situations.
- Neurological chess research is still in its infancy and requires significantly more research.

Key Research Findings:

Chess Grandmasters are likely to:

- experience 'localised shrinkage' – i.e. chess makes your brain smaller which indicates greater neural efficiency.
- have reduced grey matter volume in the occipital-temporal junction (OJT) – OJT is involved in representing objects and their relations to each other.
- have reduced 'diffusivity' in parts of the superior longitudinal fasciculus - major communication tract to send information from visual areas to executive areas.
- have smaller caudate nucleus volume (the caudate is used in decision making).
- use different part of their brain when playing chess – they use part of brain for memory recall - novice players use part of brain for processing new information .

Potential answers?

Neuroplasticity

Neuroplasticity

- Scientists have discovered that the brain had properties of plasticity – *“ability to adapt, to grow in relation to experienced needs and practices and to prune when parts become unnecessary.”*
- Kolb, Gibb (2011) – *“The development of the brain reflects more than a simple unfolding of a genetic blueprint but rather reflects a complex dance of genetic and experiential factors that shape the emerging brain.”*
- It is an open question as to the degree which brains are fixed due to genetics or changeable due to external environment – Some say 50/50 split.

- Experiments involving animals show that widespread neurological differences among animals housed in simple versus complex environments.
- The degree to which these neurological changes are transient versus persistent remains an open question.

Implications

- When chess is played, people’s brains are changed due to neuroplasticity.
- Questions remain how, why, to what degree and for how long?
- Neuroplasticity could be the justification for why chess leads to improved cognitive performance outcomes.

Findings & conclusions

- 600 years of economic evolution has seen radical changes in the nature of economic production from largely physically demanding work to intellectual work.
- This evolution is expected to continue throughout the 21st Century at an accelerated rate.
- Economic performance of individual countries in the 21st Century will therefore be significantly influenced by the quality of a nation's human capital.
- Human Capital that will thrive in the 21st Century will not only be dependent on cognitive ability and academic attainment, but also on the development of certain capabilities and attributes such as creativity.
- Many advanced economies appear to currently have inappropriate public policy settings that in some cases are leading to a decline in academic attainment among other educational and economic challenges.
- Evidence from the USA indicates a significant fall in adult and children originality and creative over the past two decades.
- Working hypothesis is that decline in creativity & originality has been influenced by structural reform to education system in the USA which other western countries such as Australia have adopted.

Findings & conclusions

- Advanced economies are experiencing a chronic shortage of workers with specific STEM knowledge and skills.
- Occupations requiring STEM skills is fast growing relative to general employment grow in advanced economies.
- Critics have questioned whether the modern education practice is relevant to the economic demands of the 21st Century.
- Unless addressed rapidly, inappropriate public policy settings and archaic educational systems will carry significant long term adverse economic consequences.
- Significant structural economic and educational reform in countries such as Australia are required to deliver long run economic benefits.
- Whether chess can deliver public policy benefits via boosting a nation's human capital and economic performance is a legitimate and open question.
- Research into the impact of chess remains in its infancy. Current research indicates that chess can deliver improved cognitive performance in areas such as mathematics, problem solving and reading as well as creativity and originality ability.
- The international chess community have claimed that the benefits of chess are wider than just academic attainment and includes 'ability to think outside the box' and improved attitudes to learning and other behaviour.

Findings & conclusions

- Improvements in spatial and cognitive ability resulting from chess may help overcome the long term shortage in students taking up study in STEM fields.
- Improvements in creativity and originality abilities resulting from chess may lead to improved invention and innovation performance.
- The international chess research community needs to explain to public policy makers how chess delivers the observed improvements in performance.
- Discoveries in neuroscience, particularly neuroplasticity, may provide a scientific evidentiary basis to explain the observed impacts of chess, particularly among children.
- Given emerging body of research, Governments in partnership with public institutions and the private sector should invest in further research to better understand how chess may assist in delivering public policy benefits.

Future chess research opportunities?

Where to next?

Research Questions? Given the findings and conclusions outline in this paper, where should the chess research community focus next?

Economics and Innovation

- How should chess be incorporated into an economy that yields in the greatest innovative activity and superior economic benefits? E.g. should chess be included exclusively among children or can organisations increase worker productivity by incorporating chess into their workplaces?

Education Reform

- How should chess be incorporated into modern education systems that delivers optimal academic and behavioural outcomes?

STEM

- To what extent can chess be used as an influence to students choices regarding the take up of study in STEM fields?
- What is the gender impact of chess? Can chess be used to attract more women to take up STEM related studies and careers?

Creativity & Originality

- How best can chess be used to increase the creativity and originality of participants?
- How can any increases in creativity and originality be leveraged to other fields of endeavour?

Neuroscience

- What impact does chess have on participants' brains? For how long is this impact, why does it occur, to what degree and for how long?
- How does a chess player's age impact the neurological benefit that an individual is able to derive from playing chess?
- Do different chess teaching and playing methods (including playing humans versus computers) have different neurological impacts? Which methods are most effective in delivering neurological benefits?

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