Envisioning the Potential of Fuzzy Logic Within Health Economics and Beyond

Friday, February 17, 2023

Canadian Centre for Health Economics - seminar series

Health Sciences Building, 155 College St., Toronto ON.

Toronto, ON

Presented by:

Kevin Willison, PhD

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Speaker:

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- URL: https://www.researchgate.net/profile/Kevin_Willison/

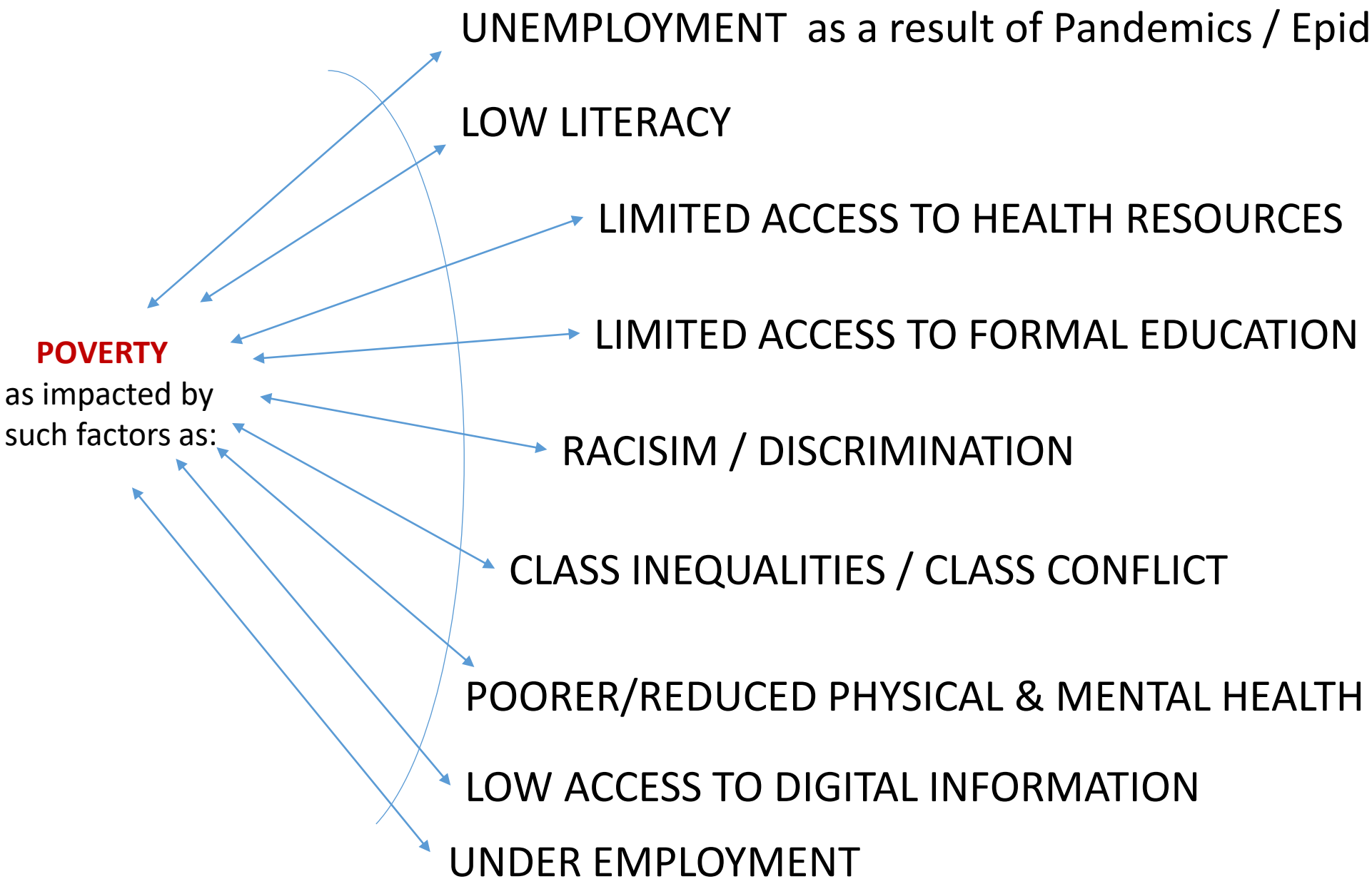
Speaker Disclosure

- There is no conflict of interest to report.
- This presentation is not funded and is intended to be non-profit oriented.
- The opinions expressed herein do not not necessarily reflect those of my employer, Lakehead University.

POVERTY

(it's causes are complex)

Unravelling the Multidimensions of Poverty



Unravelling the Multidimensions of Poverty – 2

BEING UNSKILLED / SEMI-SKILLED (in low-paying positions)

PRECARIOUS WORK // or part of THE WORKING POOR
[often leading to income insecurity]

DEBT / HIGH INTEREST LOANS

LACK OF TRANSPORTATION / ACCESS TO RESOURCES

SINGLE PARENT STATUS (+ lack of supports)

STATUS / PRESTIGE LEVEL IN A GIVEN SOCIETY (e.g. Age / Gender / Race / Ethnicity / issues of patriarchy).

JOB DESKILLING (leading to a reduction in wages)

DECLINING NUMBER OF UNIONS / ERODING LABOR RIGHTS

REDUCED / POOR “LIFE CHANCES” (in general)

Sample Ways of Understanding - 1

Introduction: Current Societal Trends Of Interest to Economists:

→ WAVE 1: **Disciplinary Integration**

→ WAVE 2:

→ WAVE 3:

Sample Ways of Understanding - 2

Introduction: Current Societal Trends Of Interest to Economists:

WAVE 1:

→ WAVE 2: **Intercollaborative Practices (ICP)**

→ WAVE 3:

Sample Ways of Understanding - 3

Introduction: Current Societal Trends Of Interest to Economists:

→ WAVE 1:

→ WAVE 2:

→ WAVE 3: **Citizen Participation / Emancipation**

WAVE ONE:

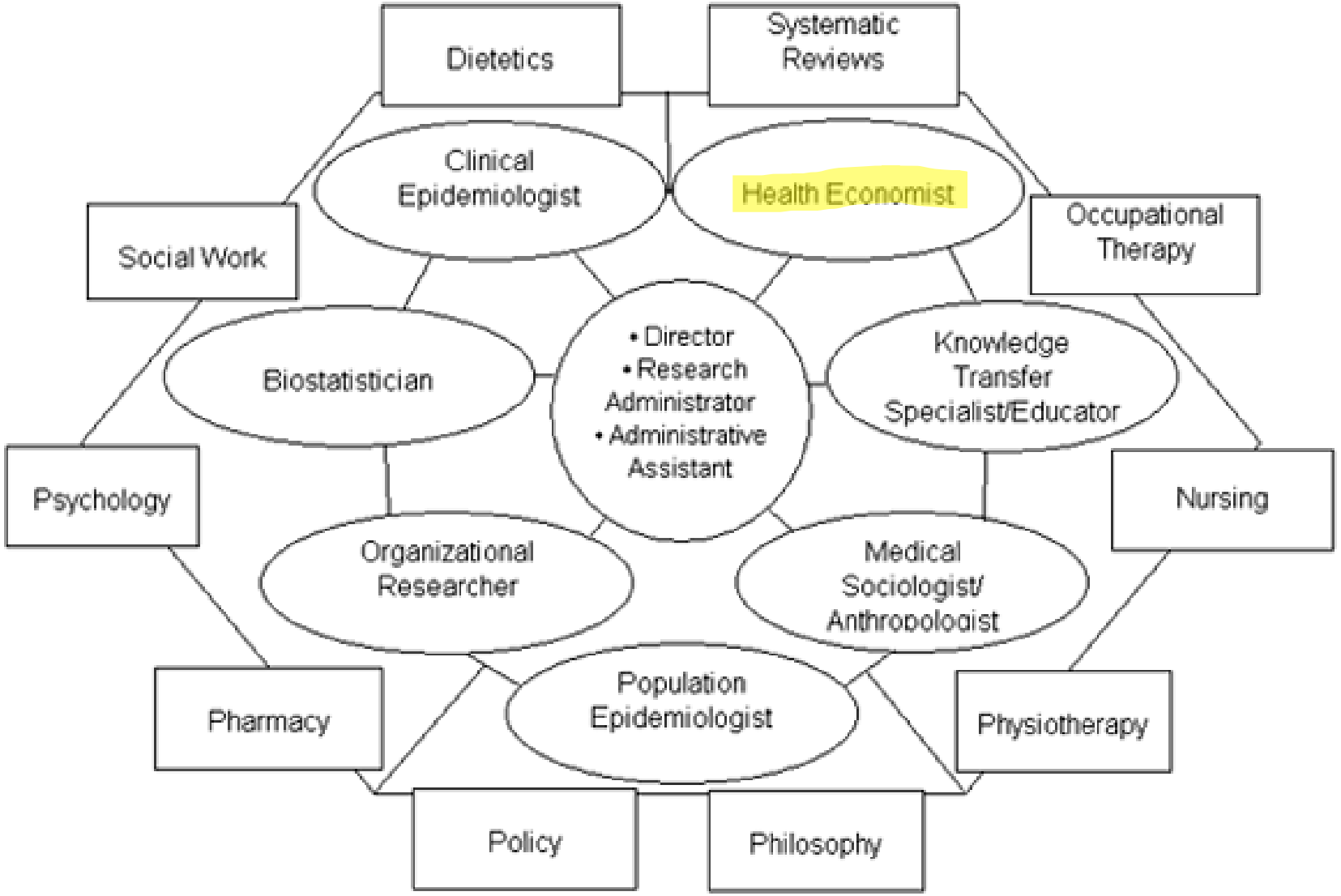
Inter-disciplinarity
[Disciplinary Integration]

A Dominant Societal Force / Trend

KEY WORD:

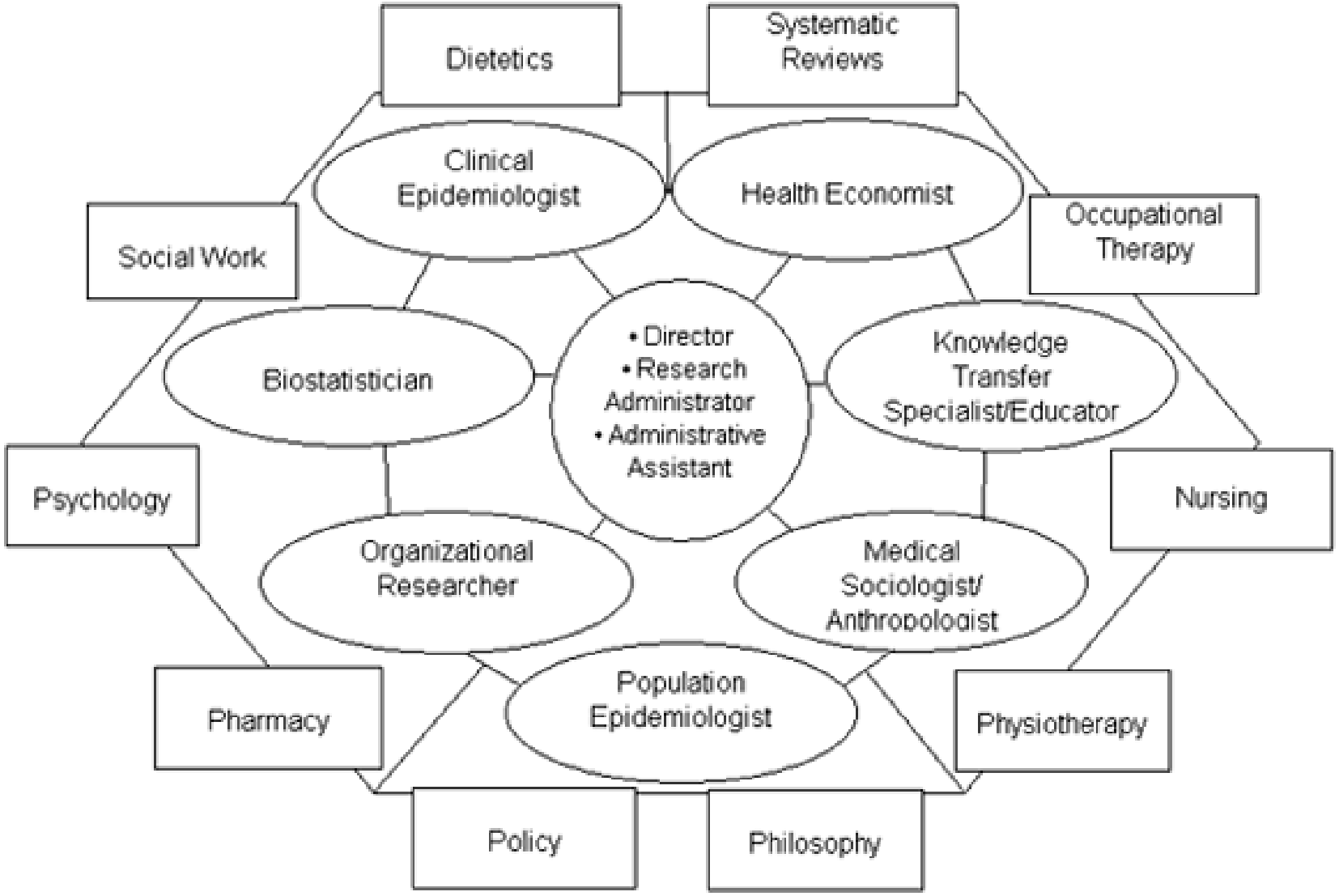
→ INTEGRATION ←

AN INCREASED INTERDISCIPLINARY / COLLABORATION EMPHASIS:



Source: Dept. Family Med. – U. of Calgary – Primary Care Research “HUB”

AN INCREASED INTERDISCIPLINARY / COLLABORATION EMPHASIS:



1

↔

Generates: IDEAS

In turn: enhances the potential for creativity & innovation

Primary source: Dept. Family Med. – U. of Calgary – Primary Care Research “HUB”

Thought:

- **“To develop a complete mind: Study the science of art. Study the art of science. Learn how to see. Realize that everything connects to everything else.”**

→ Leonardo da Vinci

PONDER / REFLECT:

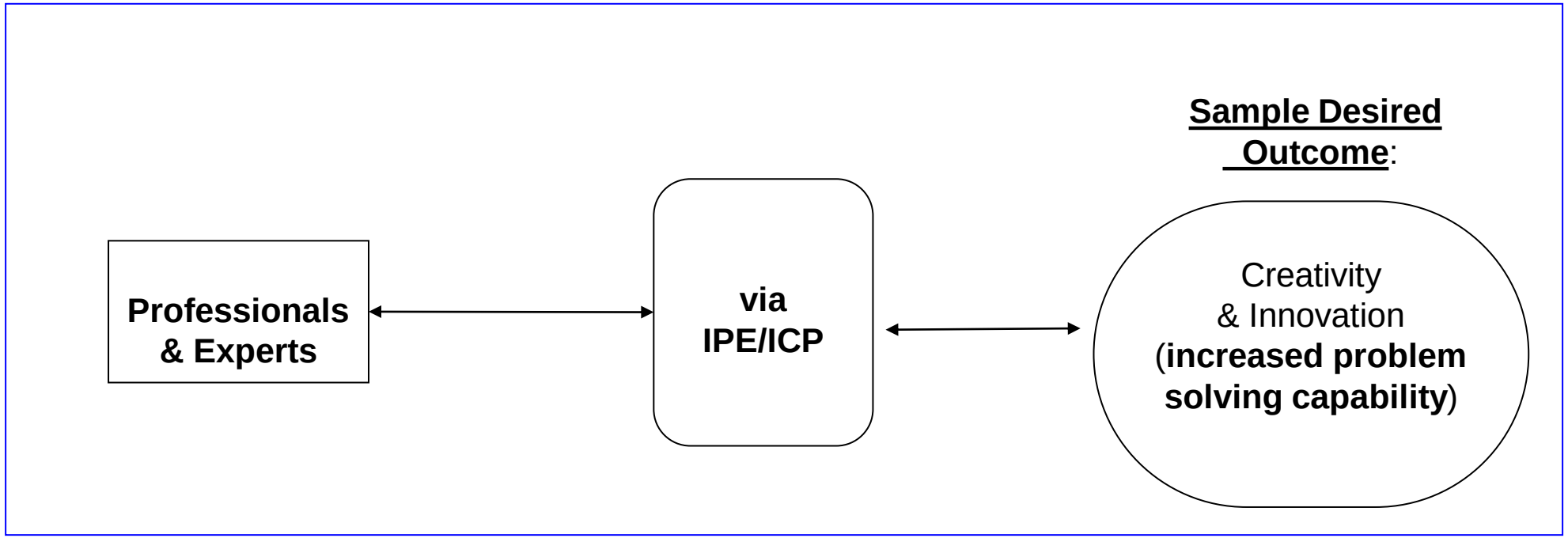
[1] Disciplinary integration is increasingly driving a need to draw from / use BIG DATA.

[2] Growth in AI (artificial intelligence) is driven by drawing from vast data sources (i.e. a variety of data bases).

WAVE TWO:

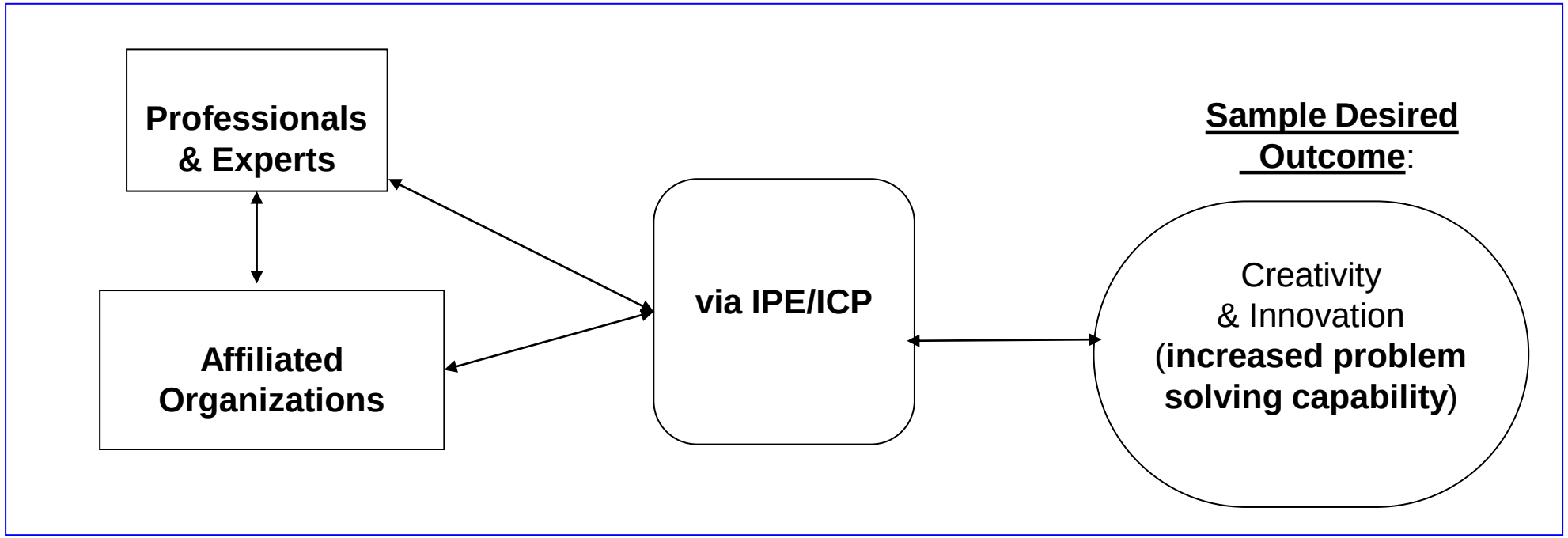
Intercollaborative Practices (ICP)

Calls for Professional /Expert Integration



Legend: IPE = Inter-professional Education; ICP = Inter-collaborative Practice(s);

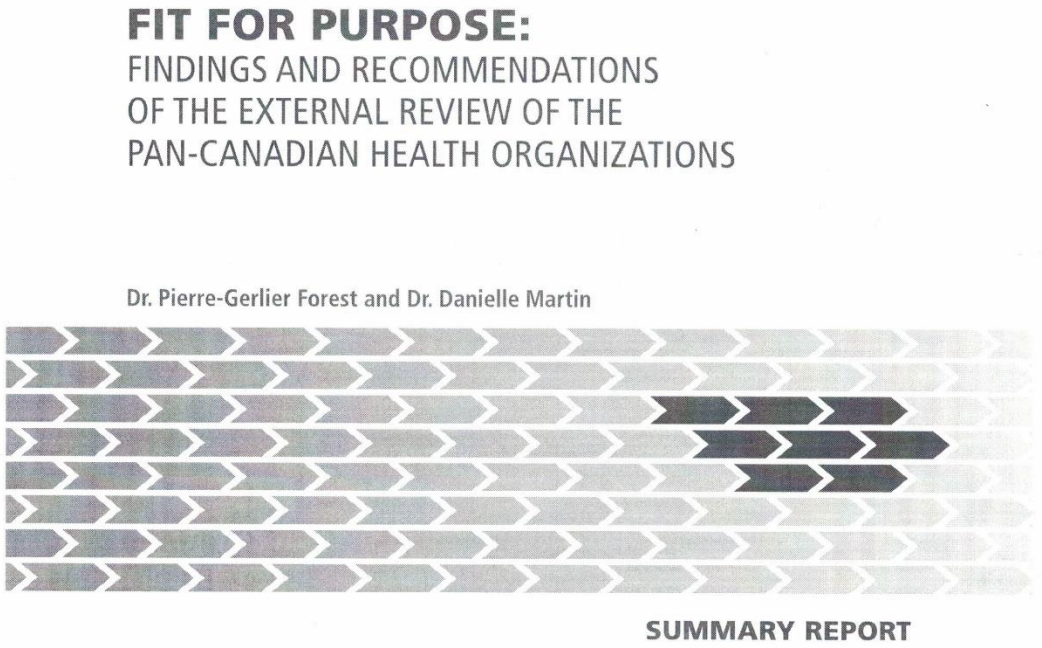
Calls for Professional / Expert & Organization Integration



Legend: IPE = Inter-professional Education; ICP = Inter-collaborative Practice(s);

2018 Report:

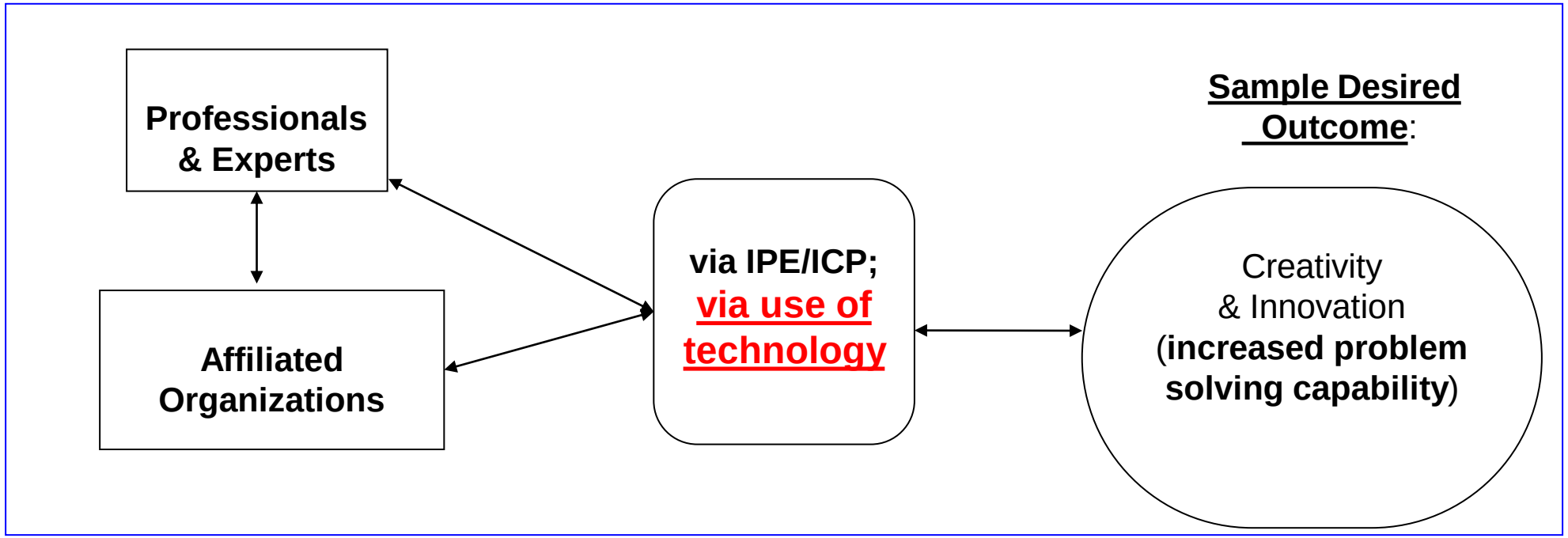
Example report: Pierre-Gerlier, Forest & Danielle Martin (2018). Fit For Purpose: Findings and Recommendations Of the External Review Of The Pan-Canadian Health Organizations. Government of Canada.



Key emphasis: organizational and professional collaboration.

Canada

Professional & Organization Integration



Legend: IPE = Inter-professional Education; ICP = Inter-collaborative Practice(s);

WAVE THREE:

Citizen Participation – [a]

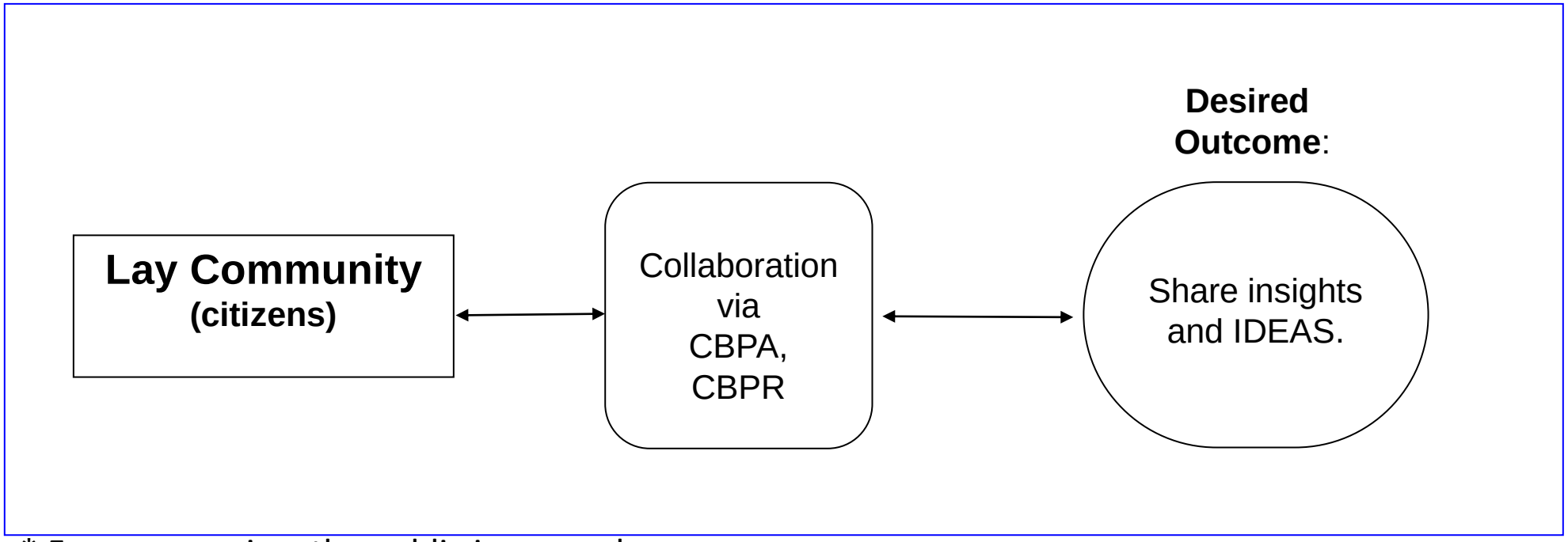
[An Increasing Public Demand for Empowerment]

Societal Force(s):

There is an increased demand by the general public for / to:

- → consultations
- → be informed / have information (“information economy”)
- → collaborate / build partnerships
- → accountability of those in power (e.g. use of their tax money)
- → transparency (e.g. an increasing public focus on governance)

Social Integration

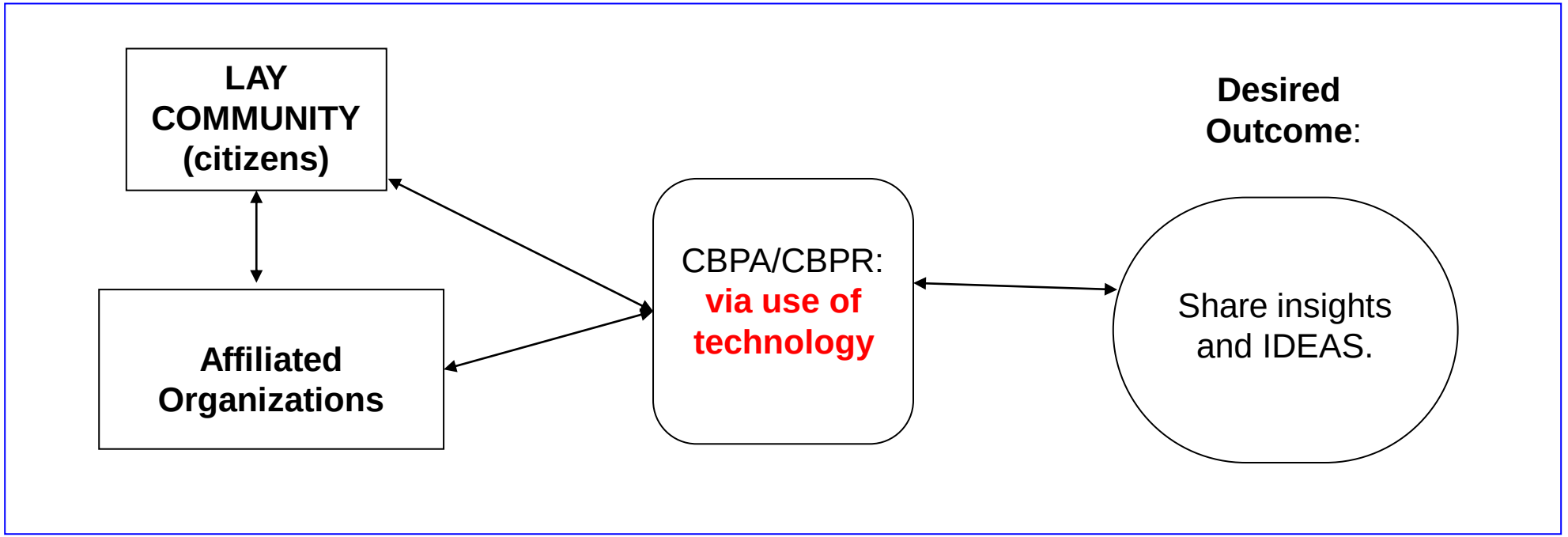


* Focus: engaging the public in general.

Legend: CBPA/R = Community-based Participatory Approach / Research

Example report: Baker, G.R., Axler, R. (2015). Creating a high performing healthcare system for Ontario: Evidence supporting strategic changes in Ontario. Ontario Hospital Association / University of Toronto.

Social Integration



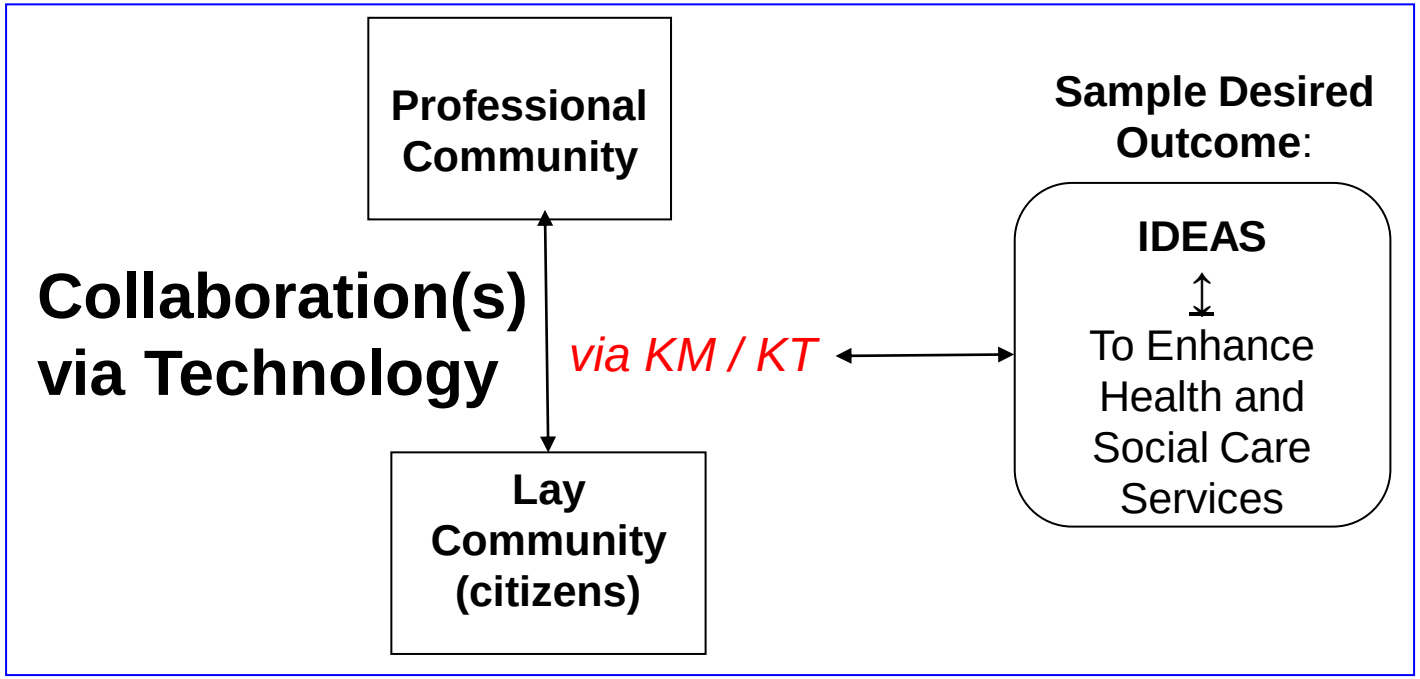
Legend: CBPR = Community-based Participatory Approach / Research
Example affiliated organizations: Community service clubs (Kiwanis Club; Rotary Club; Masons); Structured Recreational Clubs; etc, etc.

Citizen Participation – [b]

[An Increasing Public Desire / Demand among the general public to interact with the “experts.”]

Link: → Public quest to improve / enhance communication(s)
Link: → An increasing tendency by the general public, to question / be critical of authority.

Bi-Directional Learning



Legend: KM = Knowledge Mobilization; KT = Knowledge Translation; CBPA = community based participatory approach; IPE = Inter-professional Education; ICP = Inter-collaborative Practice(s).

Key Societal Trend

↑ INTEGRATION =
↑ need for technology.

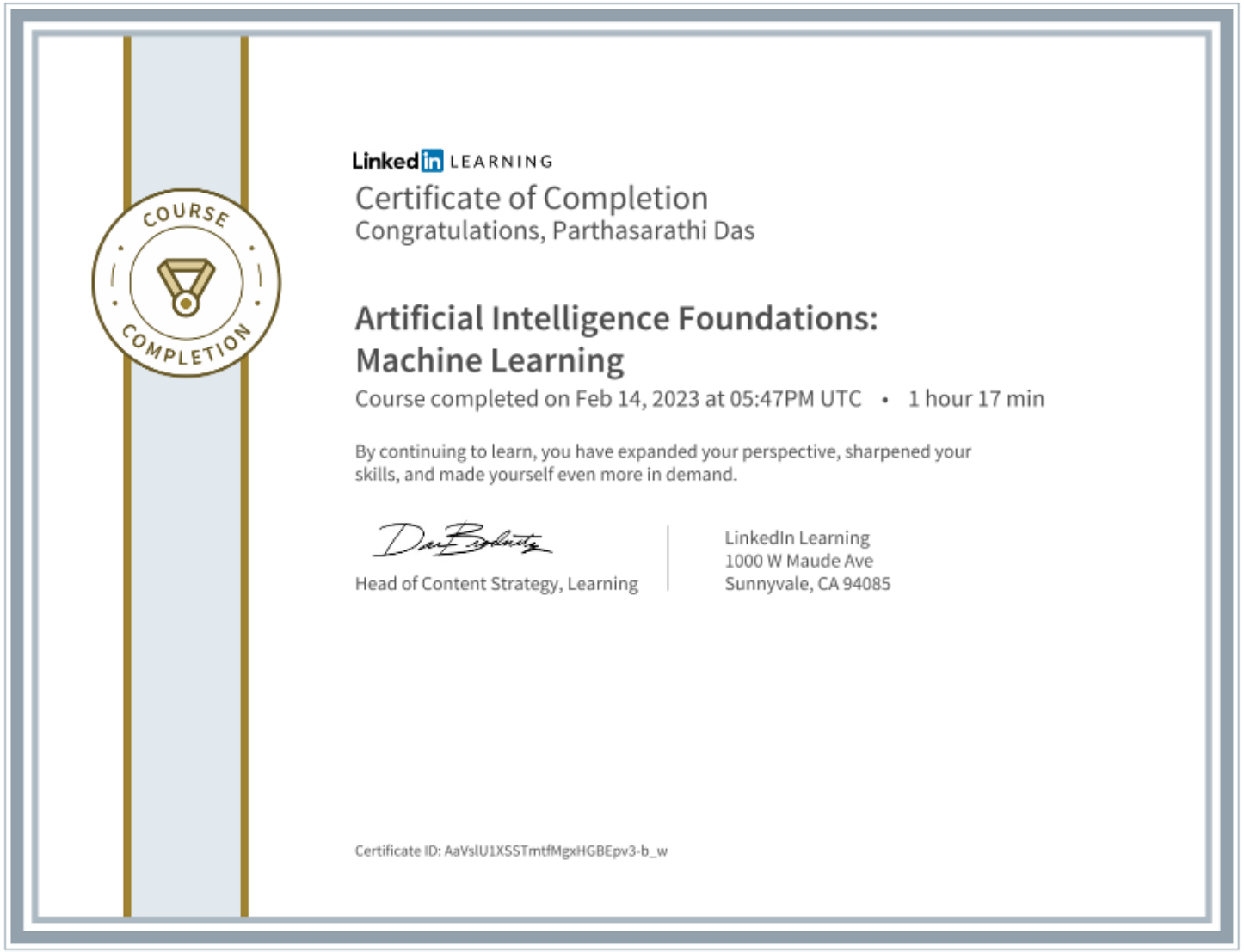
A.I. is Fast Evolving

- A McKinsey report estimates that by 2030 AI will potentially deliver 13 trillion to the global economy, or 16 percent of the world's GDP.
- The possible uses of AI in freight forwarding, for example, are both endless and exciting.

Recommended Resource: Meor Amer (2022). A Visual Introduction to Deep Learning
contact@kdimensions.com


USAGES OF
ARTIFICIAL INTELLIGENCE
Politics & Government
Banking & Personal Finance
Events
Transport
Insurance
Retail Spaces
Cybersecurity
Education
Smart Homes
Communication
Gaming
Defence
Media
Social Networks
Hospitality
Real Estate
Entertainment
Agriculture
Workplace
Healthcare
Mobile
Online Shopping
Sports
Aerospace

Sample Training Support:



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Journal of
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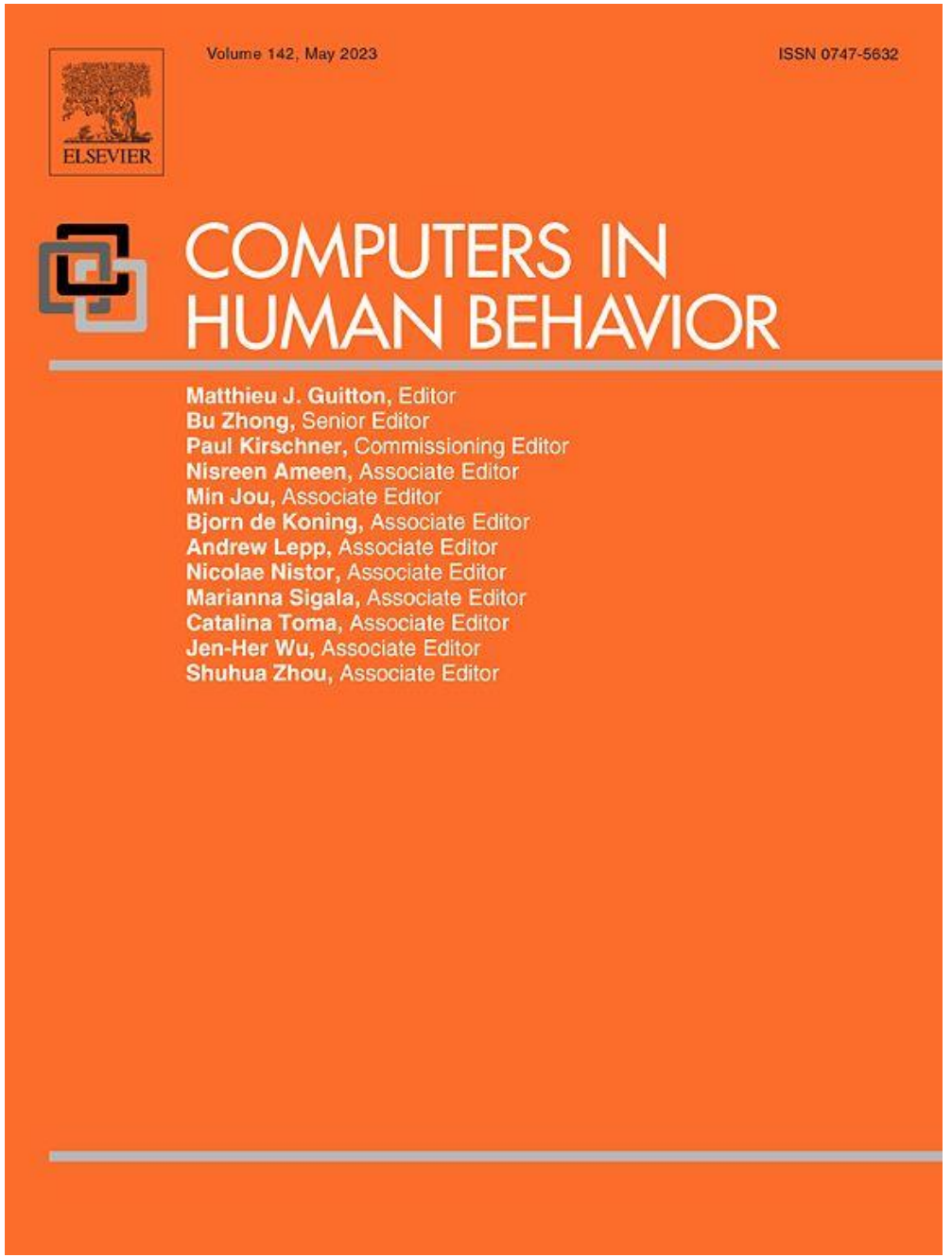
Springer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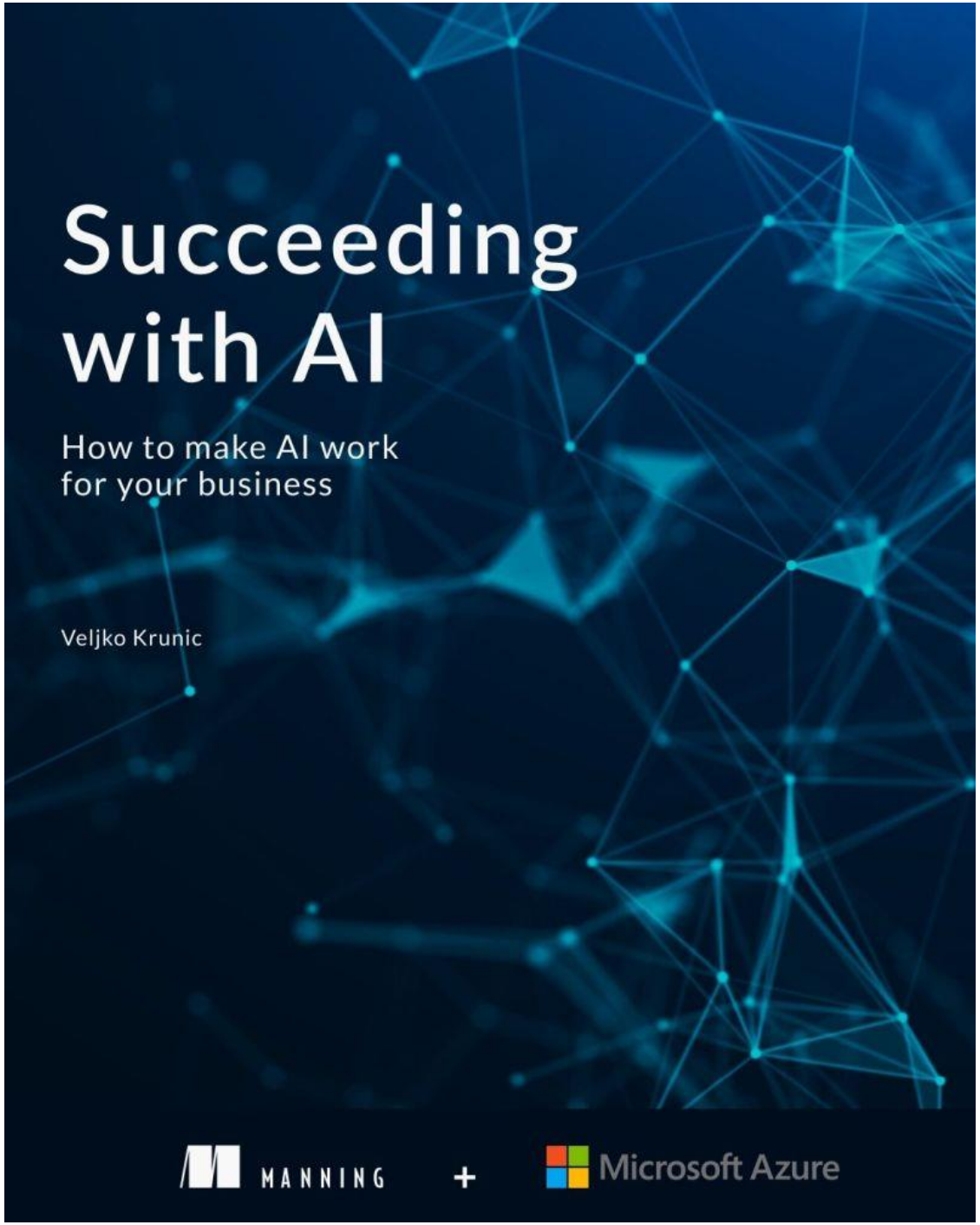


Free ebook:
https://lnkd.in/epphummt

AI - Link to Fuzzy Logic

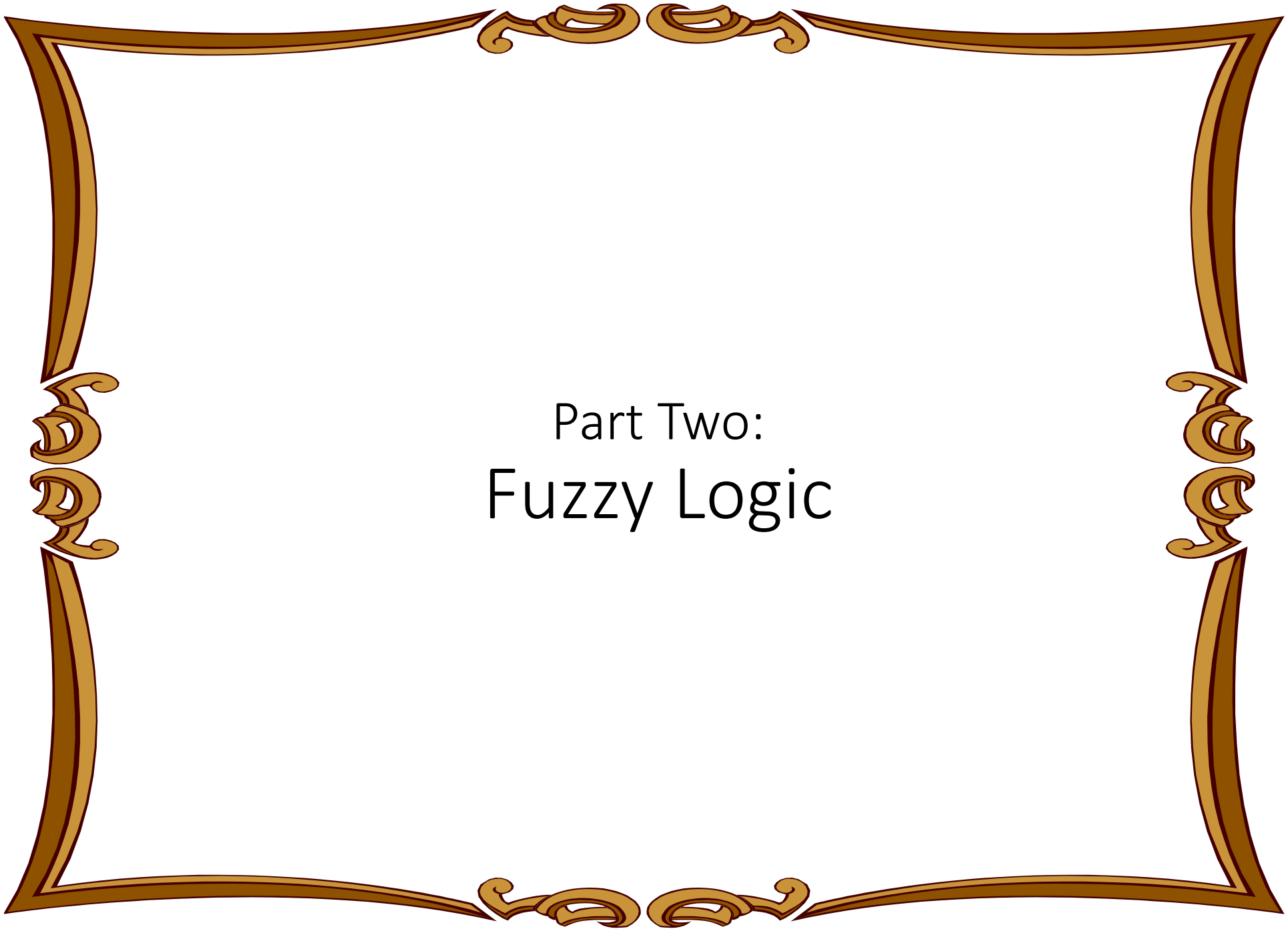
- Artificial Intelligence focuses on: Search and Optimization, **Fuzzy Systems**, Natural Language Processing and Knowledge Representation, Computer Vision, Machine Learning and Probabilistic Reasoning, Planning and Decision Making, and Neural Networks.

Source: Elsevier (Report) – Artificial Intelligence: How knowledge is created, transferred, and used. Trends in China, Europe, and the United States. 2019. URL: https://www.elsevier.com/research-intelligence/resource-library/ai-report

Fuzzy logic

- **"Paradoxically, one of the principal contributions of fuzzy logic is its high power of precisiation of what is imprecise.**
- **This capability of fuzzy logic suggests that it may find important applications in the realms of economics, linguistics, law and other human-centric fields."**

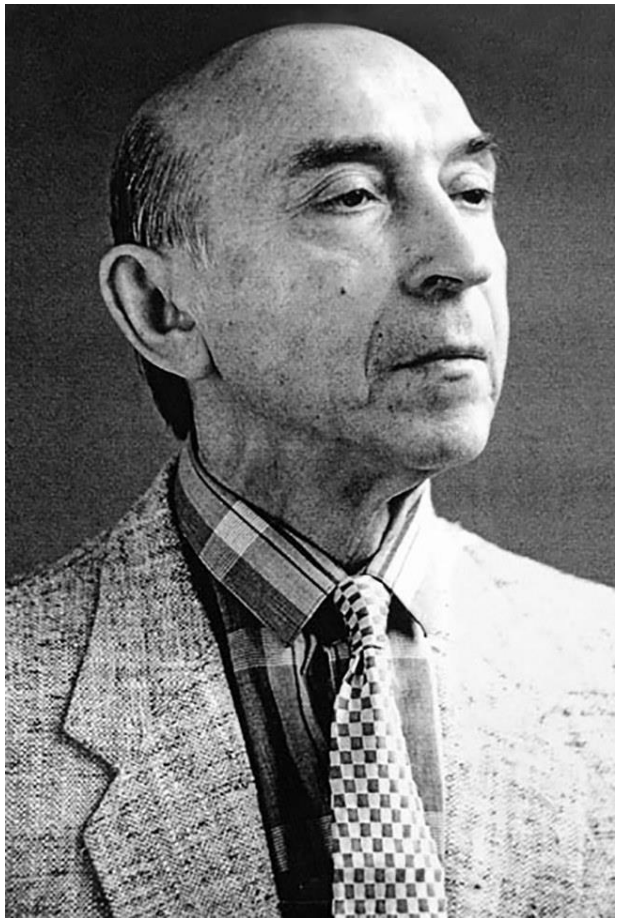
Source: Jecintha, I.R., Teena, M.O. (**2014**). Fuzzy Logic, Soft Computing and Applications. *International Journal of Computing Algorithm*, Vol. 3, May. Page 889.



Part Two:

Fuzzy Logic

Lotfi Zadeh: Feb. 4. 1921 – Sept. 6 2017
Pioneer of Fuzzy Logic



Fuzzy Logic – Zadeh's Goals:

- A system of theories [used in mathematics, computing, and philosophy] to deal with statements that are neither completely true nor false.

- Used when there is no clear definition or means to determine what is *exactly* true or *exactly* false.

- A method → to help manage uncertainty and/or impreciseness.

Fuzzy logic

- Fuzzy logic is not fuzzy.

- Basically, fuzzy logic is a precise logic, of imprecision and approximate reasoning. It is the **use of logical systems**, aimed at **formalizing approximate reasoning**.

Source: Jecintha, I.R., Teena, M.O. (**2014**). Fuzzy Logic, Soft Computing and Applications. *International Journal of Computing Algorithm*, Vol. 3, May, 889-893.

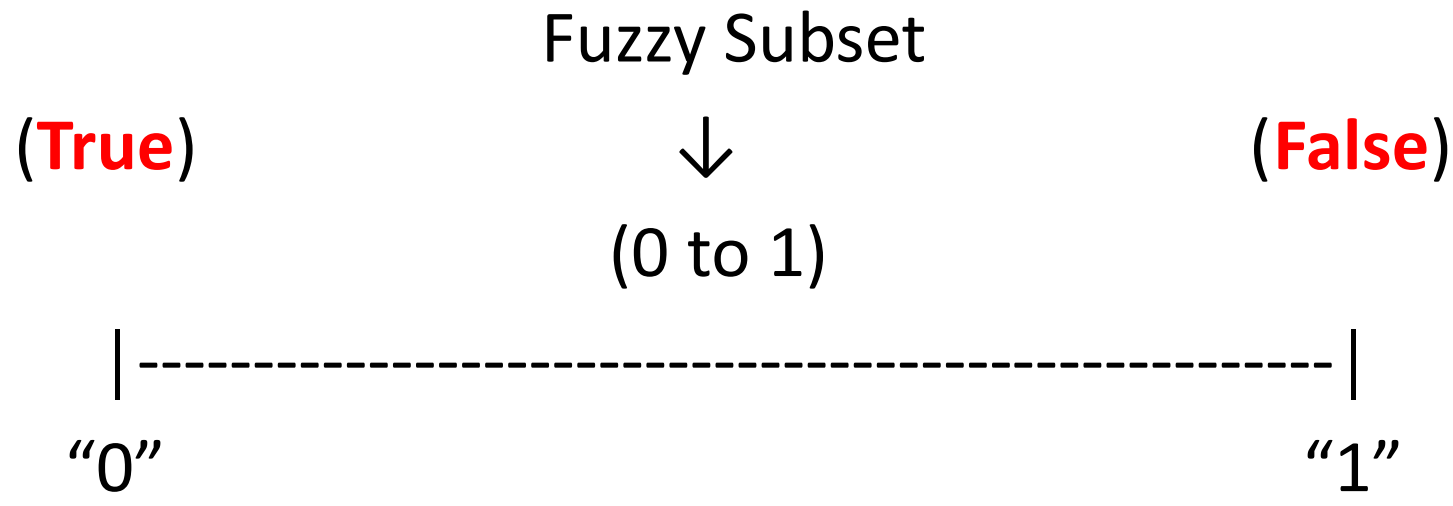
- Fuzzy logic originated from the dissertation of Zadeh (1965).

 * It is based on the principles that out of all things in the world, there is a small portion that is certain.

* Things are mainly uncertain. The things which are uncertain are characterized by two traits: random and fuzzy.

- The classical set is an undefined term, as it characterizes a group consisting of various members which are identifiable.

However, there are a lot of groups which cannot be explicitly identified. The group having such characteristics is called a fuzzy set. It refers to the set of things for which it cannot be identified whether each thing in question is a member of the set or not. Nevertheless, it is possible to indicate the tendency of something to be a member of a set through the membership function whose value ranges between 0 and 1.

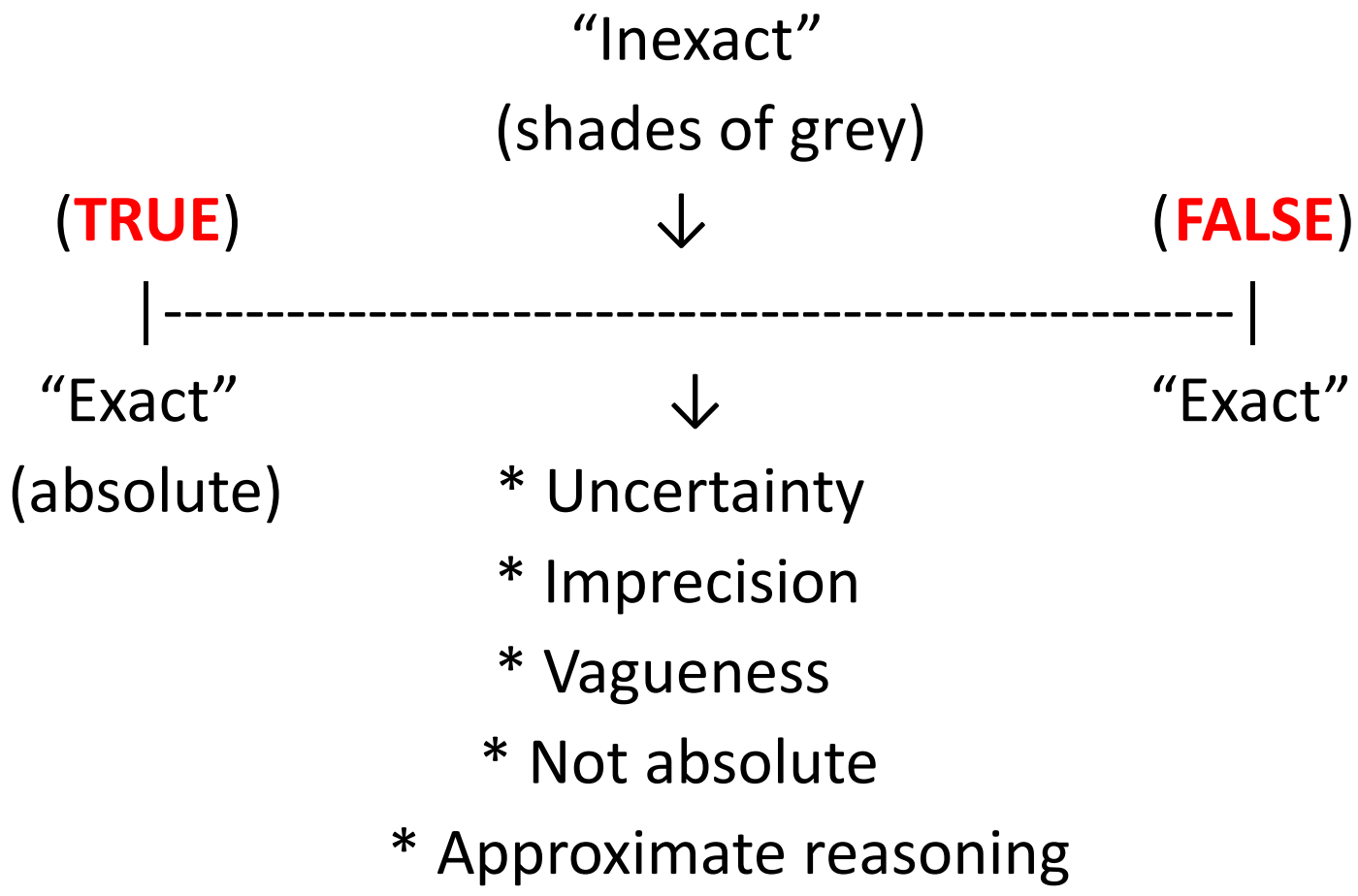

Fuzzy Subset
(True)
(False)
(0 to 1)
"0"
"1"

If the membership value of something gets closer to 1, that has a high level of membership. By contrast, if the membership value gets closer to 0, it has a low level of membership.

Fuzzy logic

- Fuzzy sets and logic have become a valuable tool either to model and handle imprecise data, or to establish flexible techniques to deal with precise data.

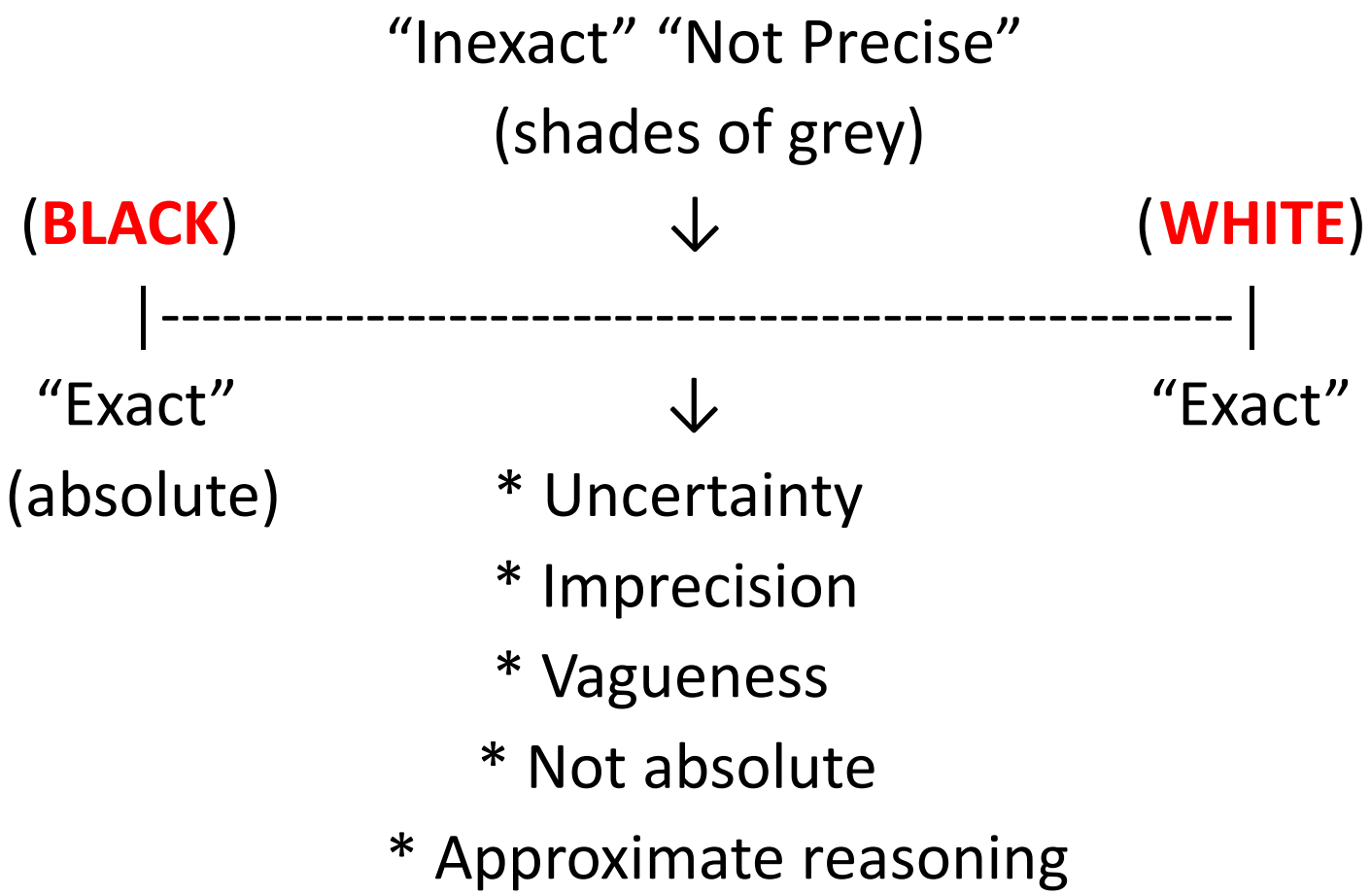
Source: D'Urs. P., Gil M.G. (2017). Fuzzy data analysis and classification. *Adv Data Anal Classific* Vol. 1: page 645.


"Inexact"
(shades of grey)
(TRUE)
(FALSE)
"Exact"
(absolute)
"Exact"
* Uncertainty
* Imprecision
* Vagueness
* Not absolute
* Approximate reasoning

Lotfi Zadeh

- The choice used to be between one [true] and zero [false]; now all the intervening numbers, a potential infinity, are available.
- That which rests between zero and one become bracketed into a "fuzzy subset", denoting *to a certain degree* – or *"soft membership"* (rather than being spoken of in absolute terms).

Social reality is grey rather than black or white.



Sole use of binary thinking is not adequate to analyze social phenomena.

Partial source: Uddin, M.F. (2017). Application of Yager's Fuzzy Logic in Sociological Research: An Instance Of Potential Payoff. European Scientific Journal, Vol. 13 No. 5: 227-237.

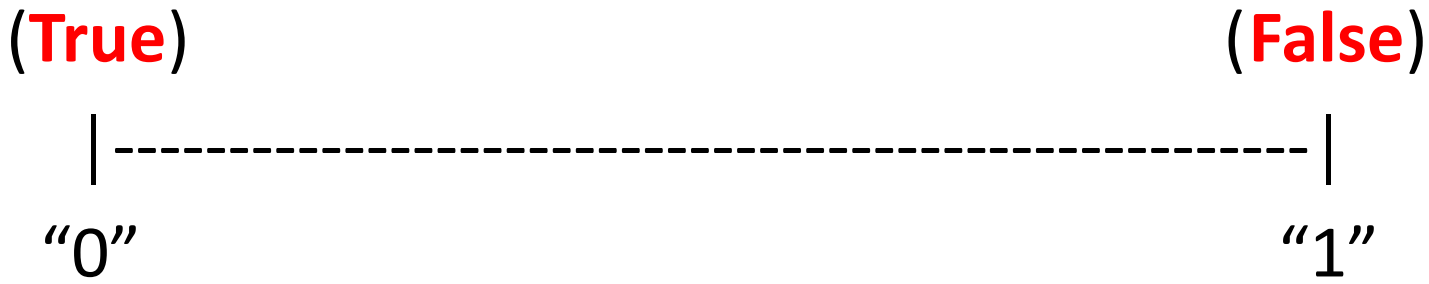
Mario Bunge (1983)

- Polar (binary) characteristics (black/white - true/false – yes/no) are rather exceptions and not a rule for every reality.

Partial source: Uddin, M.F. (2017). Application of Yager's Fuzzy Logic in Sociological Research: An Instance Of Potential Payoff. European Scientific Journal, Vol. 13 No. 5: 227-237.

Lotfi Zadeh

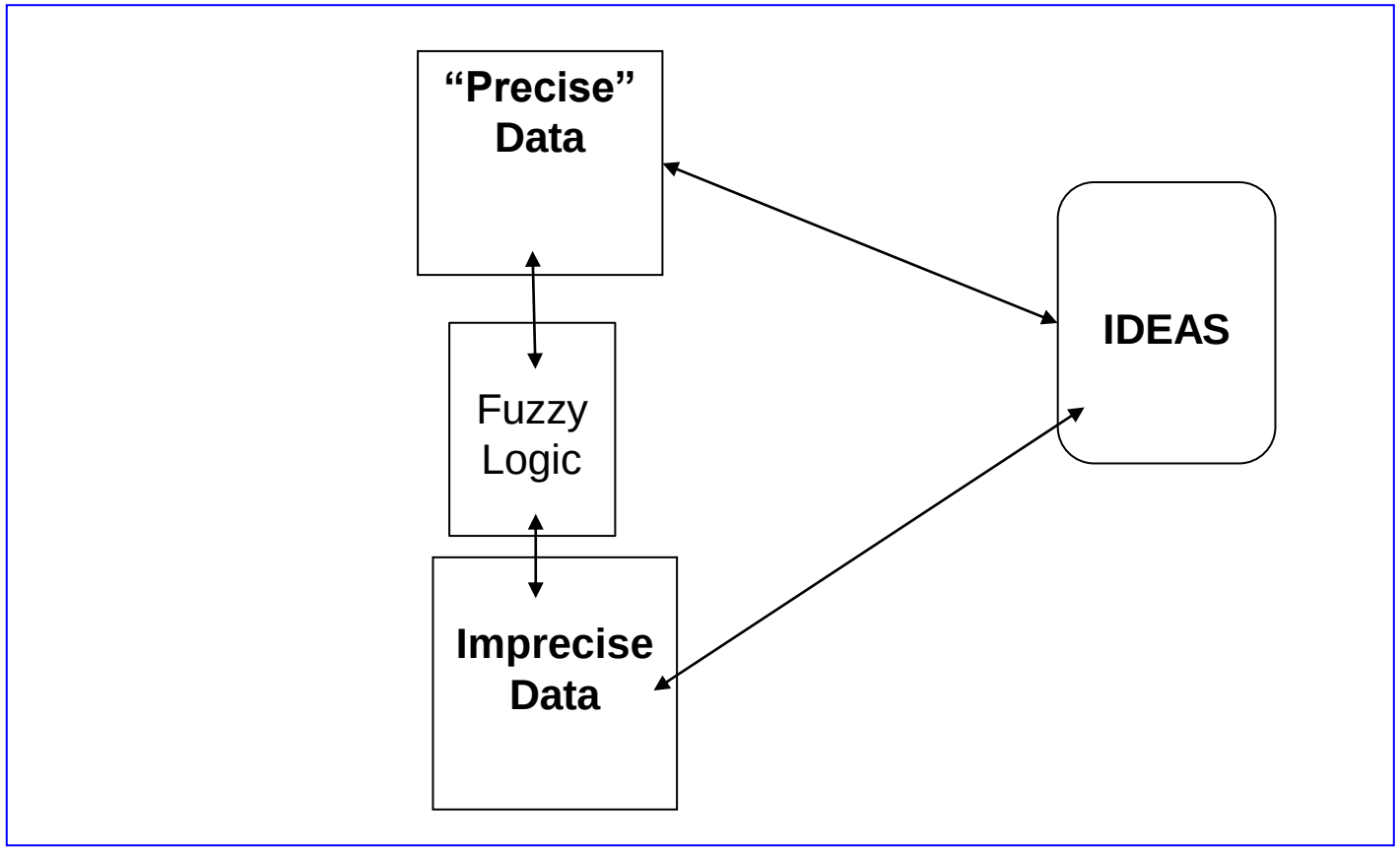
- Zadeh's alternative does not abandon the classical truth values—true and false—but allows for additional ones.



- “Fuzzy logic, like chaos theory, helps to handle situations that otherwise would be hard to deal *purely* in a rational way.”

[Source: Joseph Dauben, a historian of science, City University of New York].

Dialectical Strategies to Enhance Innovation & Creativity



Zadeh sought to build bridges between statistics/probability and fuzzy logic.

He sought to demonstrate the potential benefits of collaboration between both fields.

Source: D'Urs. P., Gil M.G. (2017). Fuzzy data analysis and classification. *Adv Data Anal Classific* Vol. 1: pages 645-657.

- Zadeh argued that probability theory by itself is not sufficient for dealing with uncertainty and imprecision in real-world settings, but allowing them to co-exist is much more effective.

Singpurwalla and Brooker (2004) Journal of the American Statistical Association

- "Probability theory has a sufficiently rich structure for incorporating fuzzy sets within its framework, and that probability and fuzzy set theories can work in concert."

Source: Singpurwalla, N.D., Brooker, J.M. (2004). Membership functions and probability measures of fuzzy sets. Journal of the American Statistical Association, 99 (467): 867-877.

SO WHAT ! ??

- Coexistence of fuzzy (qualitative oriented data) and probability / statistics (quantitative oriented data) and the development of hybrid models and methods have been thriving.

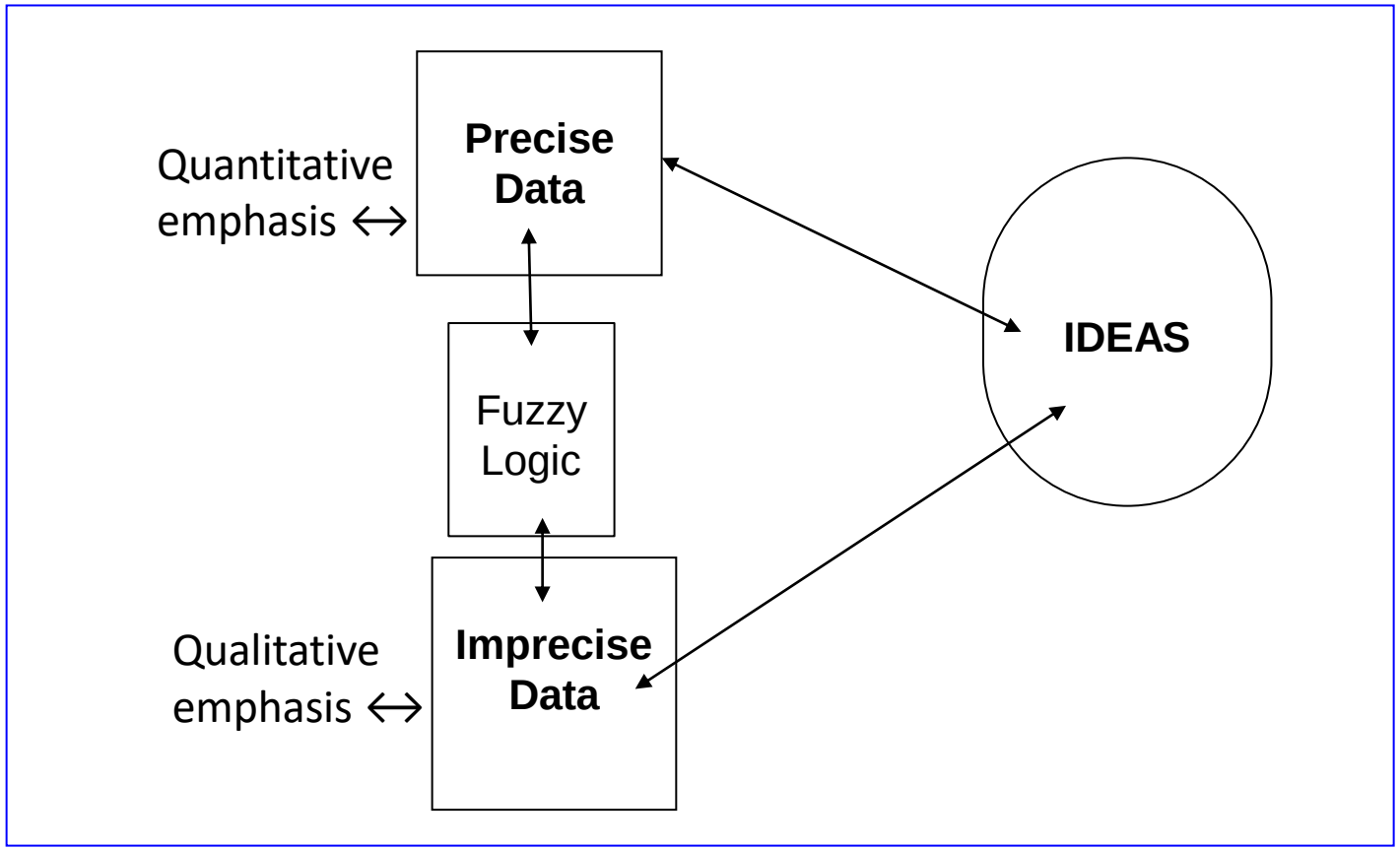
- Such links (via their integration / collaboration efforts) have perpetuated a rise in the creative development / use of machines, as well as the increase in more intelligent machines (e.g. via robotics / A.I.).

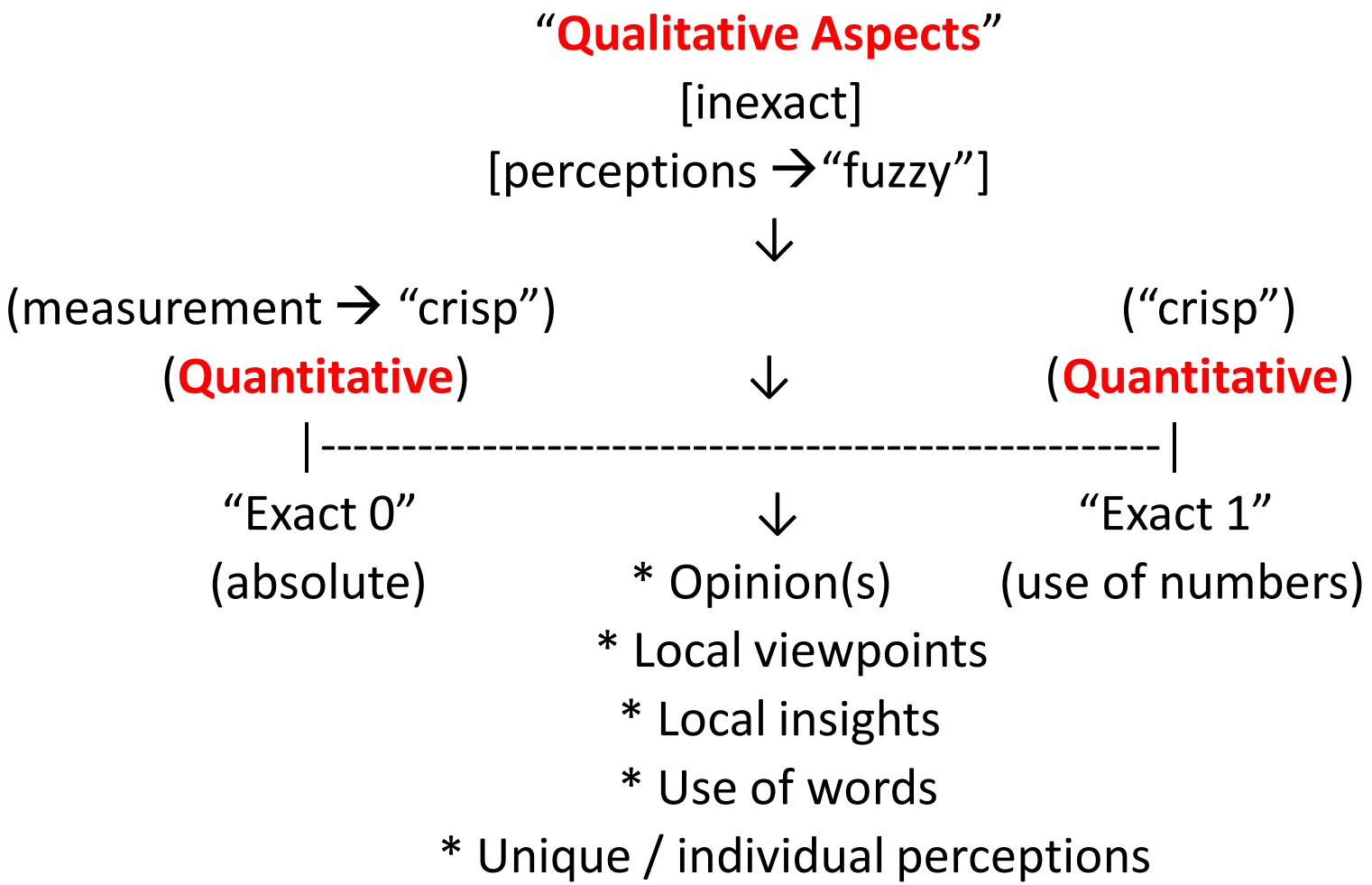
SO WHAT ! ??

- The Conference Board of Canada (2019) recently released: “The Future Ready Organization: the C-Suite Challenge.”

- Of N = 784 business and other leaders surveyed, 27 percent indicated that use of A.I. and other technologies will drive operational efficiency and most decision making.

Dialectical Strategies to Enhance Innovation & Creativity




"Qualitative Aspects"
[inexact]
[perceptions → "fuzzy"]
(measurement → "crisp")
(Quantitative)
("crisp")
(Quantitative)
"Exact 0"
(absolute)
"Exact 1"
(use of numbers)
* Opinion(s)
* Local viewpoints
* Local insights
* Use of words
* Unique / individual perceptions

Applications of Fuzzy Logic

Sample Applications of Fuzzy Logic / Soft Computing

Theoretical ↔ Practical Applications:

- Abstract mathematics
- Multi-media (image processing)
- Information retrieval
- Hybrid intelligent systems
- Robotics
- Manufacturing
- Actuarial Science
- Nuclear / Medical Engineering

Source: Jecintha, R.I., Teena, M.O. (2014). Fuzzy Logic, Soft Computing and Applications. International Journal of Computing Algorithm. May, page 890.

AI – Artificial Intelligence (aka soft computing)

- A.I. draws from many diverse fields.
- The theory of **fuzzy logic** has been constantly growing and, moreover, has been applied to very diverse fields, including artificial intelligence.

Source: Jecintha, R.I., Teena, M.O. (2014). Fuzzy Logic, Soft Computing and Applications. International Journal of Computing Algorithm. May, pages 889-893.

Growth in Artificial Intelligence

* **China** aspires to lead globally in AI and is supported by ambitious policies and rapid growth, especially in computer vision and fuzzy systems.

* **Europe** is the largest and most diverse region in terms of AI scholarly output, with high and rising levels of international collaborations outside of Europe. However, Europe appears to be losing AI talent in recent years, especially in academia.

Source: Elsevier (Report) – Artificial Intelligence: How knowledge is created, transferred, and used. Trends in China, Europe, and the United States. 2019. URL: https://www.elsevier.com/research-intelligence/resource-library/ai-report

Growth in Artificial Intelligence

- **In 2018, in Canada, academics, industry and government joined together to become a research and development powerhouse in artificial intelligence.**

  → with a 125 million dollar investment in AI.

Source: Smith, M. (2018). Canada Bets Big On AI. University Affairs – Building an AI Powerhouse. January edition. Pages 16-23.

Growth in Artificial Intelligence

- **Canada the iPhone [Siri] – as developed in Montreal.**

This came by way of the development of a computer program that turns the sound of one's voice into words. The system then undertakes actions based on such words to search for information (mimicking a human level of understanding).

Source: Smith, M. (2018). Canada Bets Big On AI. University Affairs – Building an AI Powerhouse. January edition. Pages 16-23.

A Further Link: Fuzzy Logic ↔ "Machines"

- In the 1980's, engineers in Sendai, Japan, incorporated fuzzy logic into the design of the city's new subway, using it to program the system's famously smooth starts and stops.

A Further Link: Fuzzy Logic ⟷ "Machines"

- A catalogue of fuzzy consumer electronics followed—cameras, washers and dryers, vehicle transmissions and anti-skid braking systems, air-conditioners and thermostats, rice cookers, vacuum cleaners, and unmanned helicopters.

The Future (?) ……..

Fuzzy logic (on one hand)

- Is constantly growing. Activities in soft computing, for example, have increased.

- Fuzzy logic continues to be applied to *diverse* fields.

Source: Jecintha, I.R., Teena, M.O. (**2014**). Fuzzy Logic, Soft Computing and Applications. *International Journal of Computing Algorithm*, Vol. 3, May, 889-893.

PONDER / REFLECT

"An important aspect is to understand the kind of disruption artificial intelligence (AI) will bring – on employment, privacy and our relationships with our devices – and finding ways to navigate it. This will require expertise from the humanities and social sciences, from ethicists to legal scholars."

- Dr. A. Berstein (2018)

Source: Smith, M. (2018). Canada Bets Big On AI. University Affairs – Building an AI Powerhouse. January edition. Page 22.

SUMMARY

Questions?

Acknowledgement:

This presentation draws in part from:

- Willison, K.D., Palos, T. (**2010**). **Enhancing Interprofessional Collaboration and Community-based Participatory Research through Technology**. *The International Journal of Technology, Knowledge and Society*. 6 (4):1-12. URL:http://ijt.cgpublisher.com/product/pub.42/prod.700

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