

Engineering Education for Responsible Innovation: A Data-Driven Approach to Understanding the Socio-Economic Impacts of Technology

Gita Ghiasi, Tim Aitken



uOttawa

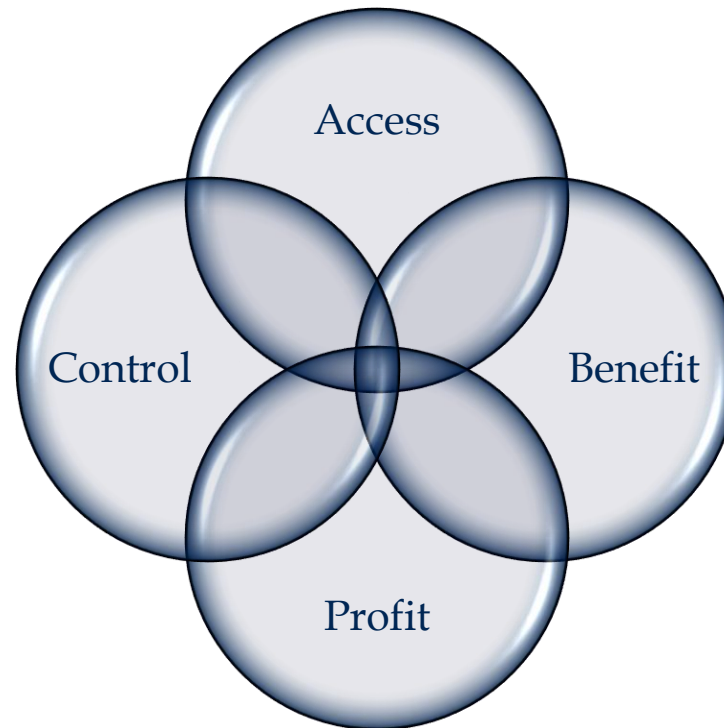


The Institution of
Engineering and Technology



Introduction

- The advent of digital technologies has driven the development, diffusion, and adoption of some technologies over others.
- Technologies actively shape society but can also deepen divides between individuals, communities, and groups.
- Divides:



Sparrow, Rob. "Negotiating the nanodivides." *New global frontiers in regulation: The age of nanotechnology* (2007): 87-107.

Role of engineering education

**Gina Cody School of
Engineering and
Computer Science**



- Today's engineering students are the future developers of these technologies.
- Critically assess the societal implications of technology
- Be prepared to guide its development in alignment with societal values.
- This presentation provides a case study with a focus on undergraduate engineering students at Concordia University
 - Relate a technology with Canadian so

Framework



Innovation as a system: “a dynamic network of agents interacting in a specific economic/industrial area under a particular institutional infrastructure and involved in the generation, diffusion, and utilization of technology.”



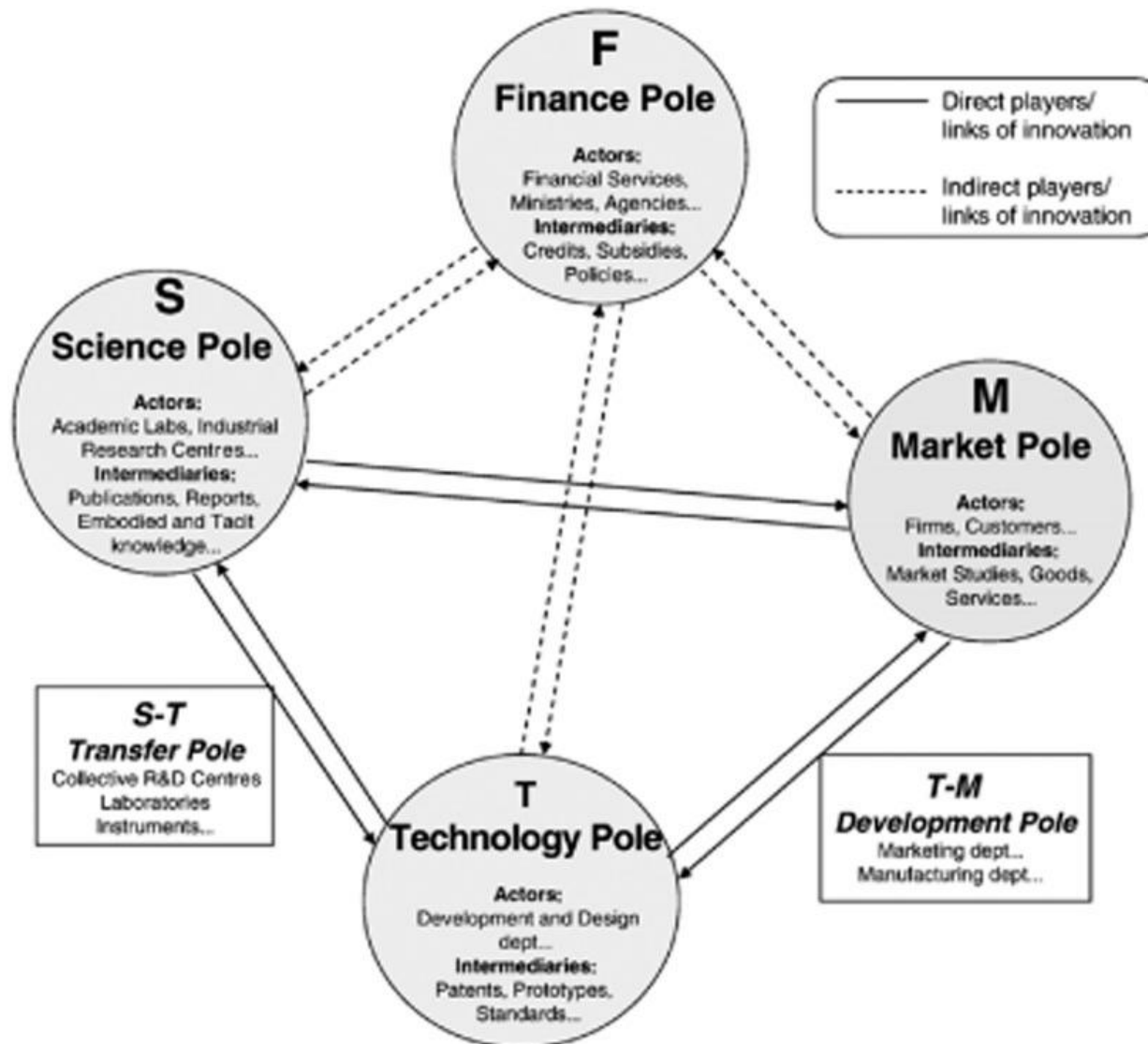
Systems of innovation:

“all important economic, social, political, organizational, and other factors that influence the development, diffusion, and use of innovations.” (Edquist, 2001)



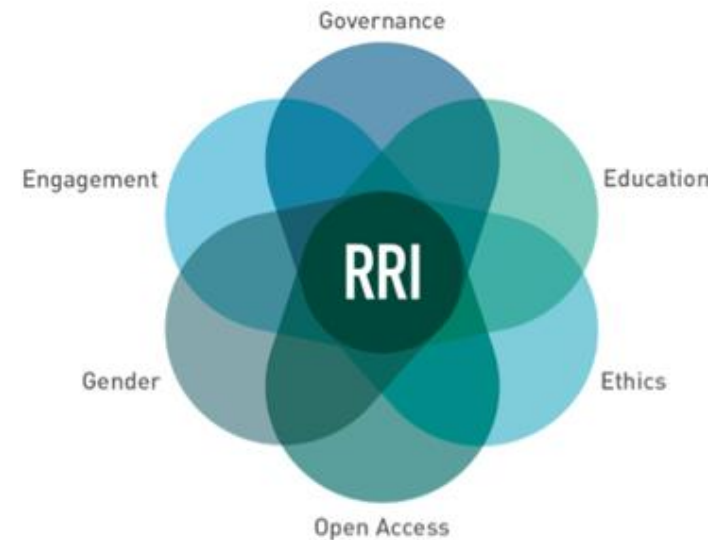
The techno-economic network (TEN) framework (Bell & Callon, 1994) was used as an analytical tool to map this relationship.

TEN framework



Responsible research and innovation

- Concept that brings together society and science for a better future that anticipates and assesses potential implications and societal expectations with regard to research and innovation (R&I). Six key elements:
 - **Gender equality**, which highlights the need to integrate the gender dimension in the research and innovation context.
 - **Science education** as a means to drive change by raising awareness and embedding RRI into educational curricula.
 - **Open access** as a means to boost innovation and increase the use of scientific results.
 - **Public engagement** to involve society in R&I processes.
 - **Ethics**, aimed at increasing the societal relevance and acceptability of research and innovation outcomes.
 - **Governance**, aimed at developing a framework that integrates the above five elements.



About the course

- Social and societal problems stemming from the unintended consequences of technology
 - Definition and politics of technology
 - Technology assessment and policy
 - Technology mapping techniques
 - Science decolonization and responsibility
 - Technology and gender
 - Open science and open innovation
 - Sustainable Development Goals (SDGs)



Case study: Concordia University

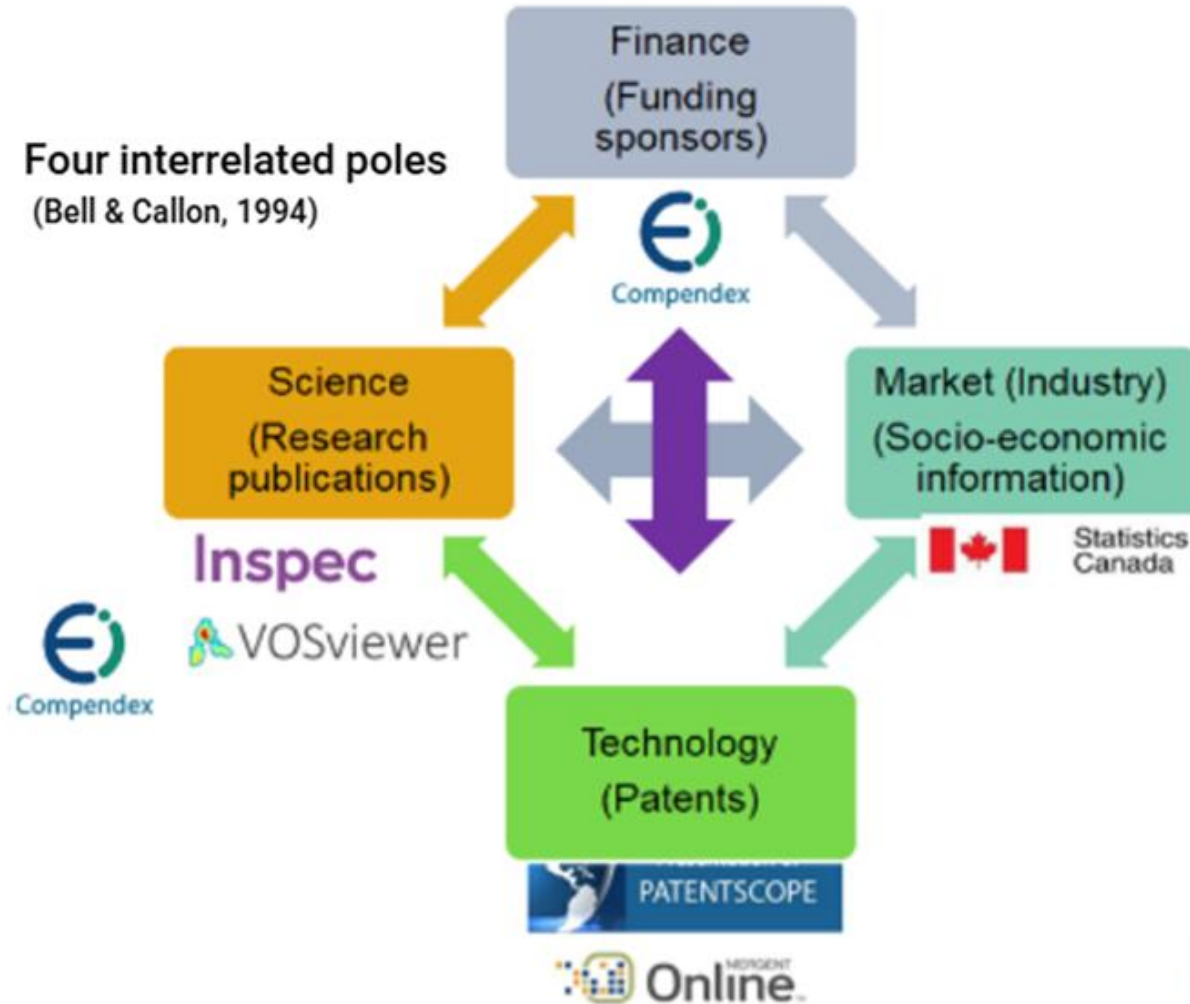
- Mechanisms and tools to characterize technological developments and define their relationship with Canadian society.
 - Use of various databases – namely Inspec, PatentScope, Mergent Online, and Statistics Canada.
 - They presented their results using visualization tools such as VOSviewer (for keyword analysis and network visualization) and Prezi (for interactive maps).
- Students provided recommendations to mitigate or eliminate the unintended social harms of a given technology
 - by aligning their findings with responsible research and development practices.
- As a result, they connected the social impacts of widely used technologies with their future roles as engineers.
- A better understanding of how their designs may have unintended consequences.
- Speculation and hype around these relationships often diverge from reality.

How?

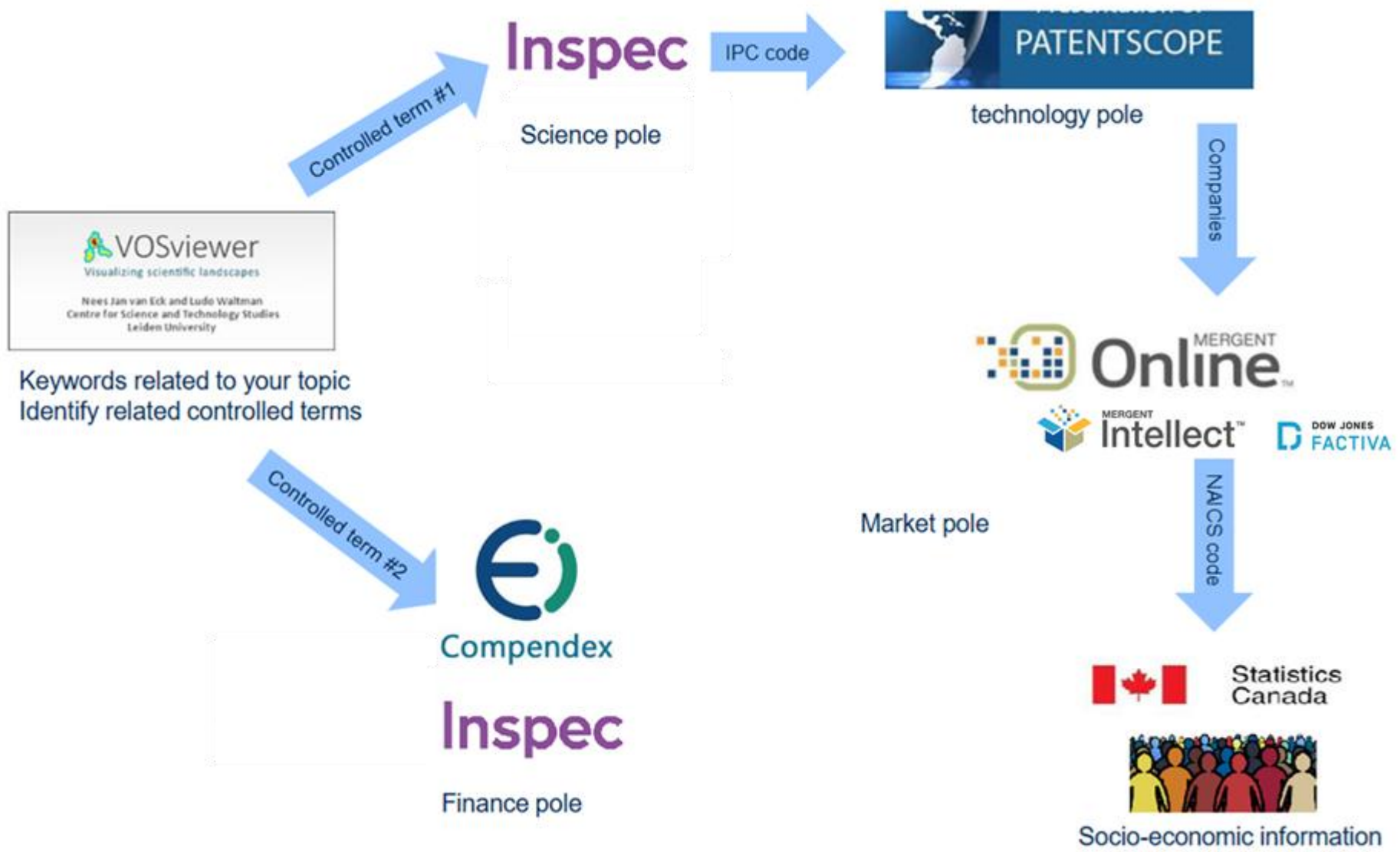
Mapping R&D

Techno-economic network framework:
a coordinated set of actors which participate collectively in the R&D process.

Four interrelated poles
(Bell & Callon, 1994)



In a nutshell



Inspec

- Indexing for subject-specific and interdisciplinary research in the fields of engineering, physics, and computer science.
- Thesaurus and controlled vocabulary: an organized arrangement of words that facilitates the search and the retrieval of data
- The option of narrowing down the results by selecting records to specific controlled vocabulary, as there is an abundance of information for a single term.
- Easy to identify the IPC/CPC code related to a specific technology
- Subject classifications (an alphanumeric code): hierarchical
 - five main sections: A - Physics; B - Electrical Engineering & Electronics; C - Computers & Control; D - Information Technology; E - Manufacturing & Production Engineering;

Inspec thesaurus

Thesaurus search:

Vocabulary search



for

electronic voting

Database:



Compendex



Inspec



GEOBASE

2 matching terms ^

electronic voting

1 of 1

Term

electronic voting (politics)

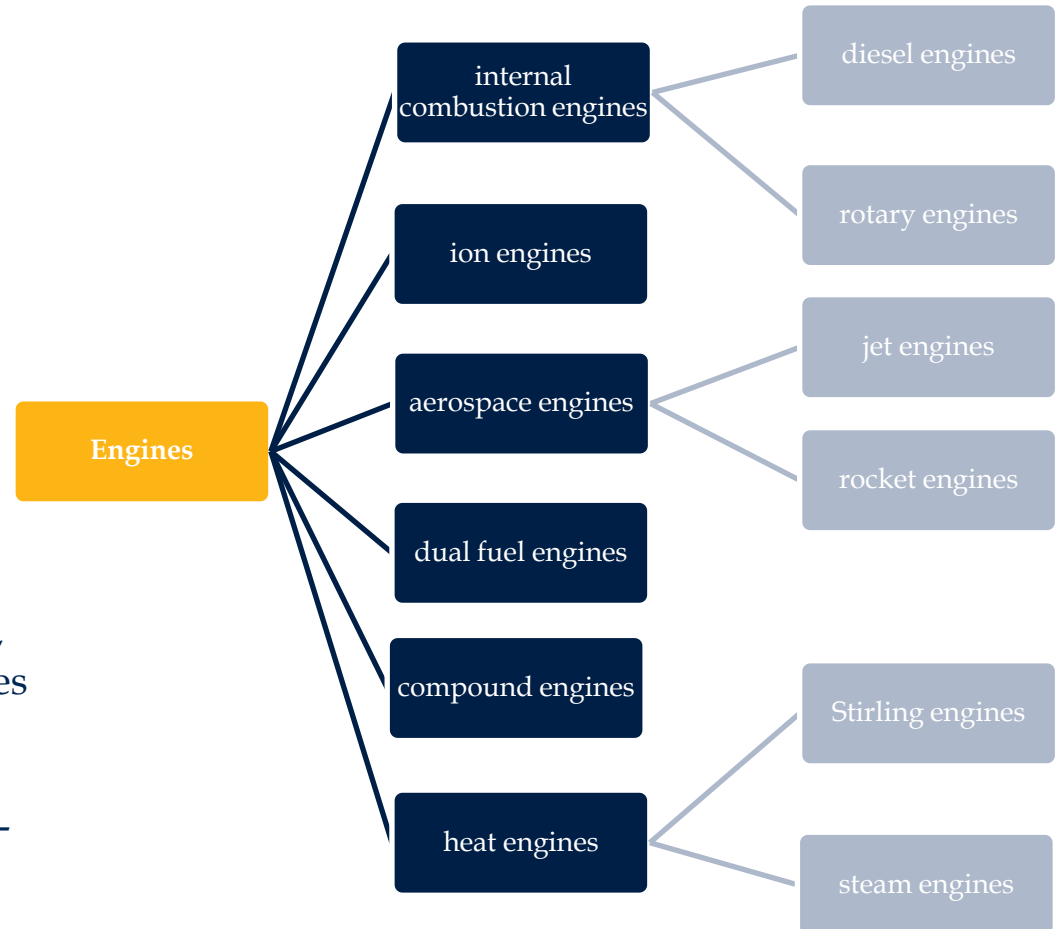
government data processing

Selected term(s) >

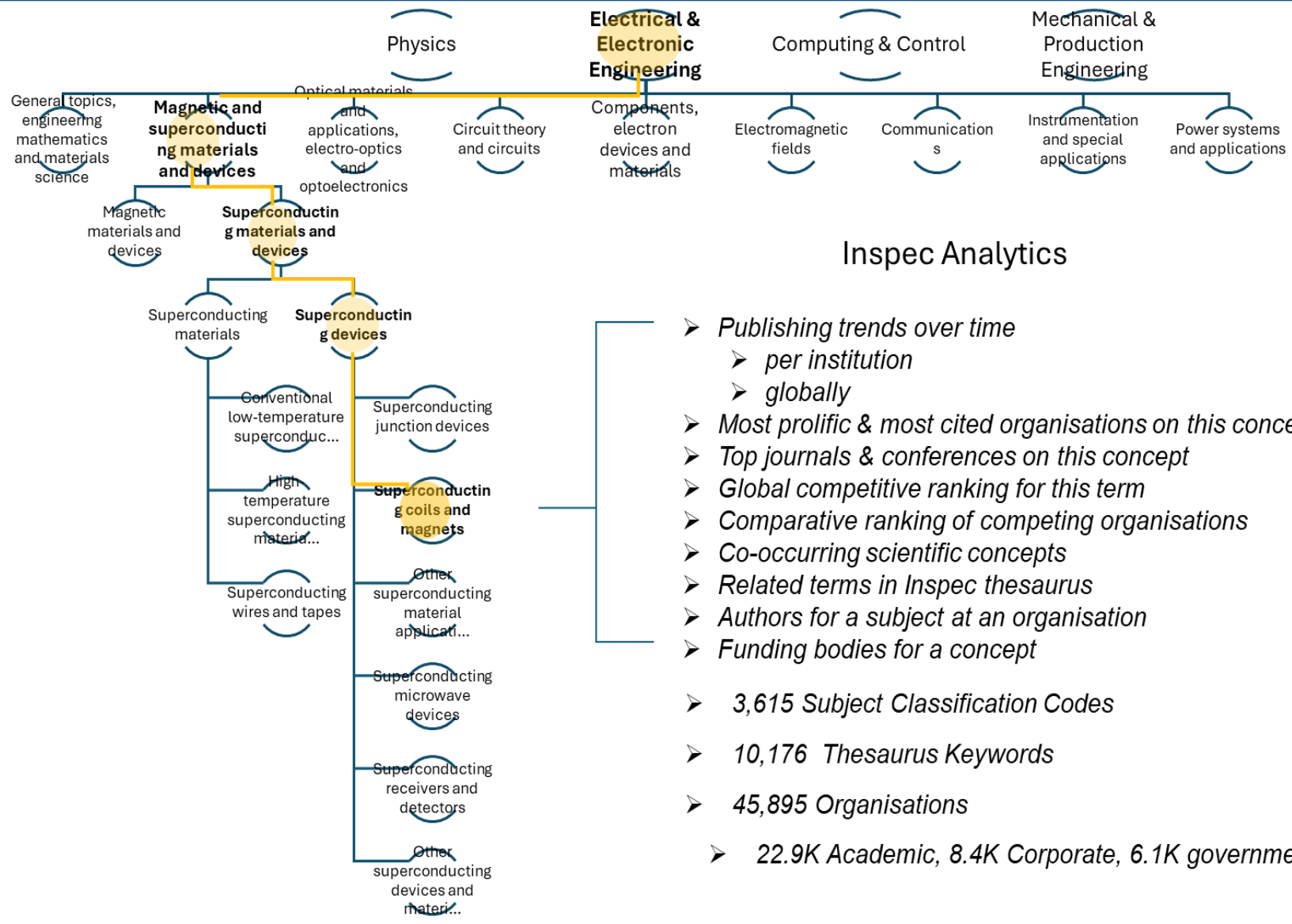
Select term by using terms by clicking on

Inspec Thesaurus – Narrower Terms & Related Terms

- A&I database with 25M records, focusing on Engineering, Physics & Computing
- 10,125 terms in Controlled vocabulary updated & curated annually
- Renowned for quality & legacy
- Broader Terms, Narrower Terms, Related Terms & Lead-ins
- Mapped to author-affiliations, authors, dates, publishers, source titles, countries etc
- Inspec Analytics enables intuitive data-mining to solve research-related problems



5 level deep Subject Classification Hierarchy



Inspec Analytics

- Publishing trends over time
 - per institution
 - globally
- Most prolific & most cited organisations on this concept
- Top journals & conferences on this concept
- Global competitive ranking for this term
- Comparative ranking of competing organisations
- Co-occurring scientific concepts
- Related terms in Inspec thesaurus
- Authors for a subject at an organisation
- Funding bodies for a concept

- 3,615 Subject Classification Codes
- 10,176 Thesaurus Keywords
- 45,895 Organisations

- 22.9K Academic, 8.4K Corporate, 6.1K government

Inspec Analytics

45,895

Organisations

Monitor the research output for your organisation and compare trends with collaborators and competitors.

3,615

Subject classifications

Explore our subject classifications to identify global trends for high-level research areas or niche fields.

10,176

Controlled terms

Discover emerging topics related to your field, find collaboration opportunities and identify relevant publications.

Organization search by location and type

Update graph 0

Search for an organisation

Location matching

AND matching

academic
corporate
government
health & hospital
other

Apply Cancel Remove All

Organisation

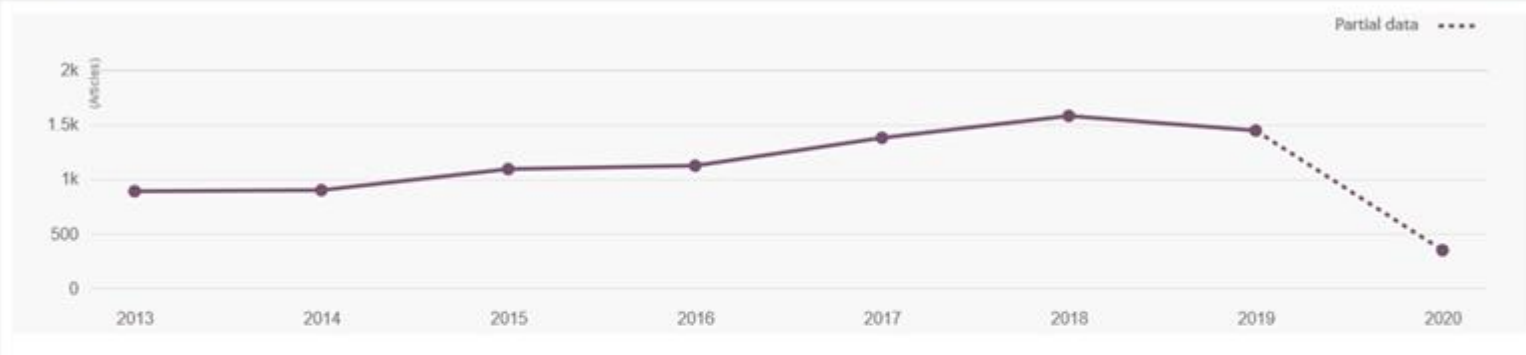
Concept Pages for every Controlled Term & Subject

Home > Controlled terms > fibre reinforced composites

fibre reinforced composites

Export -

Controlled term over time



Articles

Articles published

8,754

articles published with this Controlled term
between
2013 - 2020

Articles published % change

Between

2013 - 2019

article output increased

62.54% ▲

Times cited



Articles published with this Controlled term
between 2013 - 2020 have been cited

30,816

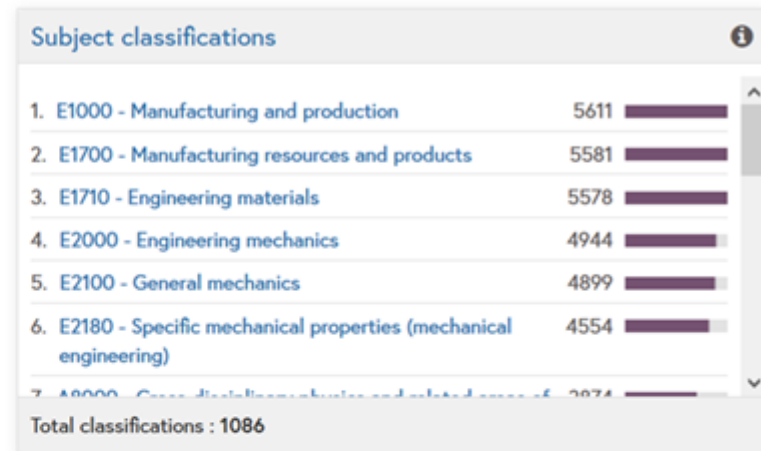
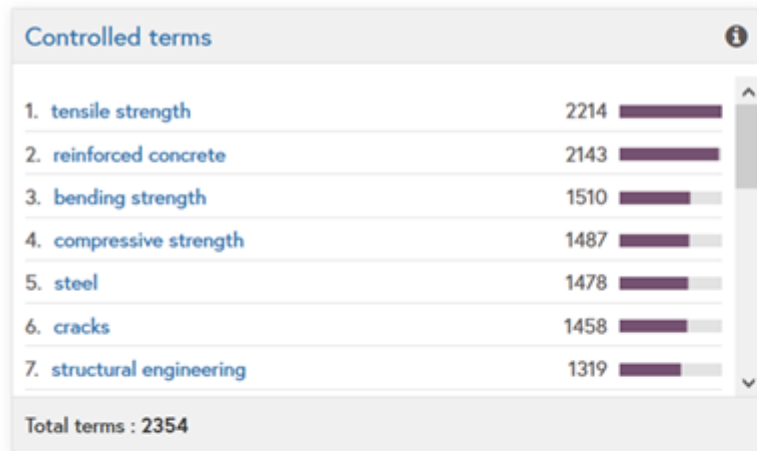
times, with an average of

3.52

citations per article

Co-occurring Concepts

Co-occurring concepts



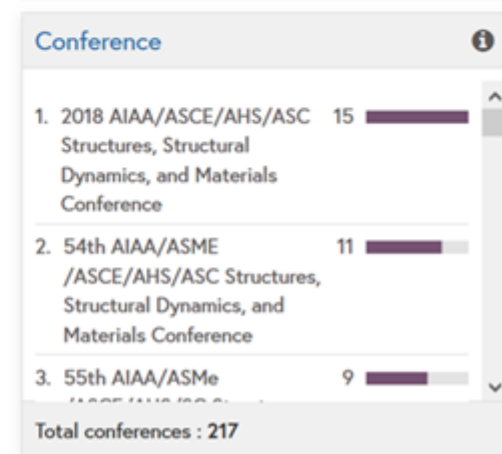
Top organisations



Journals

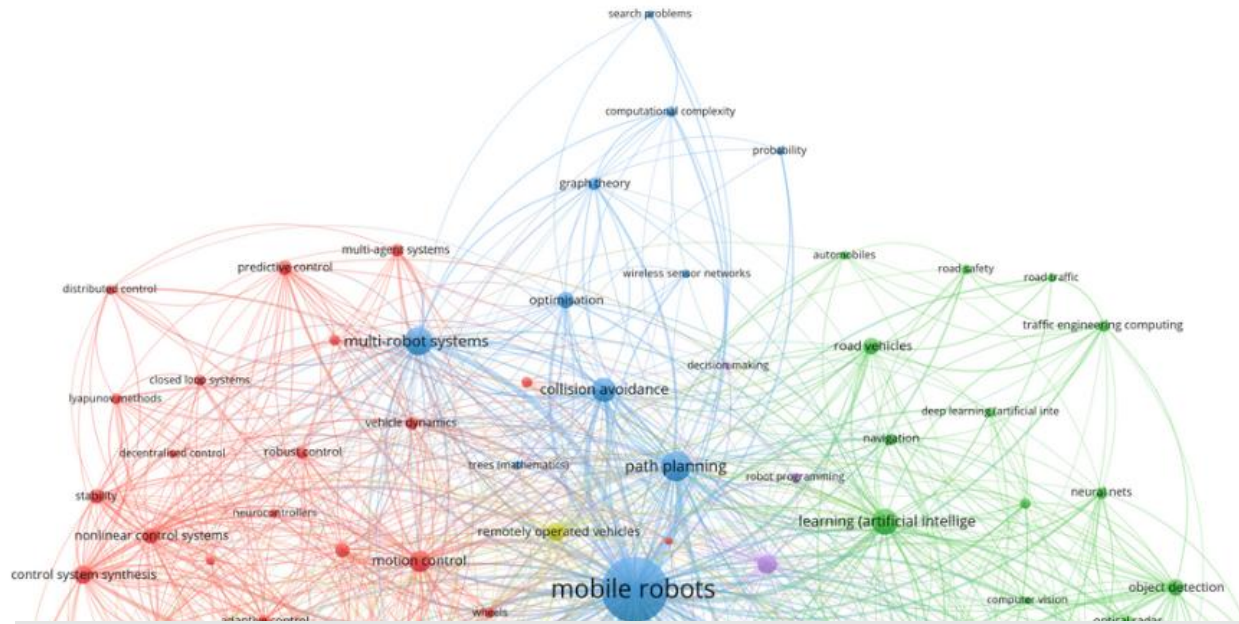
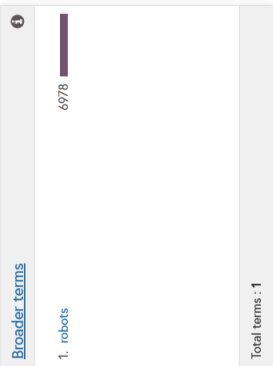
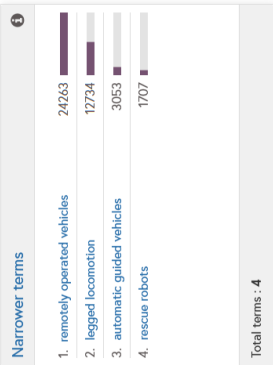
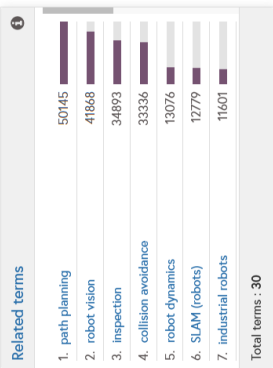


Conferences



Related controlled terms

Related controlled terms



Example: what are the main clusters and interrelated topics? **1**

2 Example: what are the most recent keywords used around your topic? why?

Example: How your network reflects keywords that could be beneficial or detrimental to social development of Canadian society? **3**

Finance Pole (auxiliary pole)



Funding sponsor



<input type="checkbox"/>	Natural Sciences and Engineering Research Council of Canada	160
<input type="checkbox"/>	Natural Sciences and Engineering Research Council of Canada	30
<input type="checkbox"/>	Nserc	14
<input type="checkbox"/>	Mitacs	12
<input type="checkbox"/>	Canada Research Chairs	11

[View more >](#)

Technology pole

Mobile robots

Identify IPC or CPC:

CPC code	
<input type="checkbox"/> G05D1/00	37,535
<input type="checkbox"/> G05D3/00	22,520
<input type="checkbox"/> G06T	11,042
<input type="checkbox"/> G05B15/00	10,177
<input type="checkbox"/> B60W30/095	9,331

[View more >](#)

IPC code	
<input type="checkbox"/> G05D1/00	202,776
<input type="checkbox"/> G05D3/00	102,364
<input type="checkbox"/> G06T	57,281
<input type="checkbox"/> B60W30/095	49,083
<input type="checkbox"/> G05B15/00	42,205

D **A** **-** **G05D 1/00** **Control of position, course, altitude or attitude of land, water, air or space vehicles, e.g. using automatic pilots**
(drive control systems specially adapted for autonomous road vehicles B60W 60/00) [2024.01]

D **-** **G05D 3/00** **Control of position or direction**
(G05D 1/00 takes precedence; numerical control to execute positioning G05B 19/18) [2006.01]

Patent Scope

https://patentscope.wipo.int/search



PATENTSCOPE

IC:(G05D1) and DP:[2015 TO 2025]



871 results Offices CA Languages en Stemming true Single Family Member false Include NPL false



Analysis

Close

Filters Charts

Countries		Applicants		Inventors		IPC code		Publication Dates	
PCT	559	KOMATSU LTD	62	HIGH, DONALD R.	14	G05D	871	2016	92
Canada	312	WALMART APOLLO LLC	54	MELCHIOR, NICHOLAS ALAN	6	G08G	114	2017	100
		CROWN EQUIPMENT CO	28	ATCHLEY, MICHAEL D.	4	G01C	112	2018	131
		WAYMO LLC	20	CLARK, ROBERT PARKER	4	B64C	110	2019	93
		GUANGZHOU XAIRCRAFT TECH CO LTD	18	MATTINGLY, TODD D.	4	G06Q	79	2020	111
		SANDVIK MINING AND CONSTRUCTION OY	13	NISHIJIMA, AKIHARU	4	B60W	77	2021	86
		LOCUS ROBOTICS CO	12	PENG, BIN	4	G01S	76	2022	96
		EPIROC ROCK DRILLS AKTIEBOLAG	11	DOOLEY, MICHAEL J.	3	B64D	47	2023	80
		HITACHI CONSTRUCTION MACHINERY CO LTD	11	MINAGAWA, MASANORI	3	G05B	38	2024	19
		CATERPILLAR INC	10	OGIHARA, MASANORI	3	B25J	36	2025	4

Market pole



69-054-1560. KOMATSU LTD.

Company Details

Financial Details

Industry Details

Executive Details

Family Tree

Aa Aa Aa



NAICS Codes

Primary NAICCODE

Construction Machinery Manufacturing 333120

Secondary NAICCODE

Construction Machinery Manufacturing 333120

All Other Transportation Equipment Manufacturing 336999

Other Miscellaneous Durable Goods Merchant Wholesalers 423990

US SIC Codes

Primary SICCODE

Construction machinery 35310000

Secondary SICCODE

Construction machinery 3531

Transportation equipment, nec 3799

Durable goods, nec 5099


Socio-economic information

Employee wages by industry, annual^{1, 2}

Frequency: Annual

 [Help](#)

Table: 14-10-0064-01 (formerly CANSIM 282-0072)

 Save my customizations

Release date: 2025-01-24

Geography: Canada, Province or territory

▼ Customize table

Geography : ³

Canada

Wages : ⁴

Average hourly wage rate

Reference period

From:

2001

To:

2024

Type of work :

Both full- and part-time emp...

Gender : ^{5, 6}

Total - Gender

Age group :

15 years and over

Apply

Archived - Employment by Indigenous group and industry, inactive (x 1,000)^{1, 2}

Frequency: Annual

[Help](#)

Table: 14-10-0366-01 (formerly CANSIM 282-0229)

[Save my customizations](#)

Release date: 2025-01-10

Geography: Canada

▼ Customize table

Sex :

Both sexes

Apply

Age group :

15 years and over

15 years and over

25 years and over

25 to 54 years

Reference period

From:

2006

To:

2024

[Add/Remove data](#)

[Download options](#)

Percentage of workforce teleworking or working remotely, and percentage of workforce able to carry out a majority of duties during the COVID-19 pandemic, by business characteristics¹

Frequency: Occasional Monthly

[Help](#)

Table: 33-10-0228-01

[Save my customizations](#)

Release date: 2020-04-29

Geography: Canada

▼ Customize table

Indicator :

Workforce teleworking or working rem... ▲

Workforce teleworking or working remotely prior to February 1st, 2020

Workforce teleworking or working remotely on March 31st, 2020

Workforce still able to carry out a majority of their duties

[Add/Remove data](#) ⓘ

[Download options](#)

[Filter](#) [Reset](#)

Indicator	Workforce teleworking or working remotely prior to February 1st, 2020													
Percentage range	Percentage range, 0% to less than 1%	Percentage range, 1% to less than 10%	Percentage range, 10% to less than 20%	Percentage range, 20% to less than 30%	Percentage range, 30% to less than 40%	Percentage range, 40% to less than 50%	Percentage range, 50% to less than 60%	Percentage range, 60% to less than 70%	Percentage range, 70% to less than 80%	Percentage range, 80% to less than 90%	Percentage range, 90% to less than 100%	Percentage range, 100%	Percentage range, unknown	
Business characteristics														

Course portfolio (ENGR 392)



Course portfolio (ENGR 393)



Computer Games: Socioeconomic Analysis of R&D in Canada

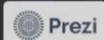
Dominique Cartier, Laila Chamma'a, Smit Desai, Zafir Khalid, Deokyeong Kim

Abstract

This study consists of an analysis of the recent trends in research and development in the field of computer games within Canada, with a particular focus on age and gender. It also identifies the most prominent organizations and institutions involved in developing and disseminating technology within the computer games industry. We dissect employment and wages in the industry and how it relates to Canada's socioeconomic makeup. We adopt the TEN framework as a major component of our methodology, and proceed with data collection through the analysis of keywords, companies, and socioeconomic data collected based on publications found in recognized databases such as Inspec, Compendex, and PATENTSCOPE. In addition, this report discusses the impact of academia, government agencies, and companies on the Canadian gaming industry and highlights the main actors driving the industry. Notably, our results demonstrate that the computer game industry is male-dominated and features a significant gender-gap with respect to income. Furthermore, our publication analysis hints at the potential for the use of computer games within the field of geriatrics. We expect that the results of this study will be helpful to R&D strategists and policymakers, prompting consideration of Responsible Research and Innovation in terms of age equality, gender equality, and ethics in the computer game industry.

Keywords

Employment Wage
Gender Gap Computer Games Social issues
Age Gap



Want to learn more? Please see our...

Dashboard Presentation

The screenshot shows a Prezi presentation dashboard with the following content:

- Title:** ENCS 393- Group M Dashboard - Computer Games
- Subtitle:** The relationship between science, technology and society: the case of computer games R&D in Canada
- Text:** "Computer games" refers to games that are presented and interacted with through electronic means, such as a computer or game console. Aside from entertainment purposes, computer games hold a lot of potential for positive developments in health and education. Examples include teaching basic numeracy and improving depressive symptoms. This study examines the link between computer game R&D and Canadian society in terms of employment and salary disparities in gender and age.
- Methods:** Mapping R&D. Techno-economic network framework: a coordinated set of actors which participate collectively in the R&D process.
- Diagram:** Four interrelated poles (S&I & Cohen, 1994) showing Science (Research publications), Finance (Funding sponsors), Market (industry) (Socio-economic information), and Technology (Patents) interconnected by arrows.
- Network Graph:** A complex network graph with nodes and edges, centered around "computer games".
- Callouts:**
 - 1:** This network features five main clusters: computer games' effects on health and behaviour, technologies used to enhance computer games, AI research in computer games, improving user experience in computer games, educational applications of computer games.
 - 2:** The most recent keywords used are: "healthcare", "geriatrics", "psychology", "teaching", "computer science education" and "user experience". These keywords seem to imply a general trend towards applications of computer games in health and education.
 - 3:** Gender and age issues aren't present in our networks, while accessibility issues and social aspects of automation are, showing that while there is still work to be done, the research community is making strides to be more inclusive and socially aware.



Questions?

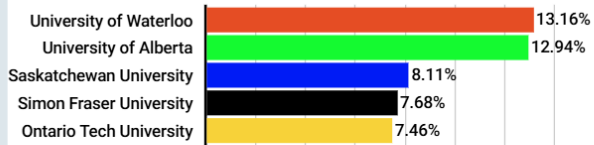
Contact gita[dot]ghiasihafezi[at]concordia[dot]ca to get more information about the project.

Science Pole

Inspec Computer Games Canada 2017-2021

Publications (%)

Publications (#)



Download data

Type something



Compendex Computer Games Canada 2017-2021

Open access (%)

Open access (#)

Total Publications (#)



Download data

Finance Pole

Compendex Computer Games Canada 2017-2021

Natural Sciences and Engineering Research Council of Canada



% of total Canadian publications

Download data



Technology Pole

Related IPC: A63F13

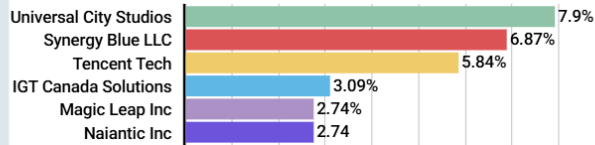
A HUMAN NECESSITIES
63 SPORTS; GAMES; AMUSEMENTS
F CARD, BOARD, OR ROULETTE GAMES; VIDEO GAMES
13 VIDEO GAMES



PatentScope IPC:A63F13 Canada 2017-2021

Patents (%)

Patents (#)



Download data

Market Pole

Related Industries (NAICS):

[54] Professional, scientific and technical services
[52-53] Finance, insurance, real estate, rental and leasing
[51, 71] Information, culture and recreation
[31-33] Manufacturing



Statistics Canada Canada 2017-2021

Professional, scientific and technical services [54]



Download data

3 / 4

Gender analysis

Statistics Canada Canada 2017-2021

Employment by gender

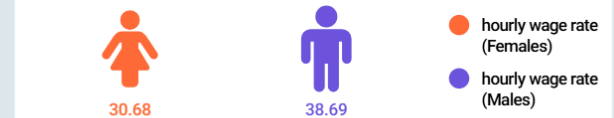
Professional, scientific and technical services [54]



Download data

Hourly wage by gender

Professional, scientific and technical services [54]



Download data

Gender gap in employment and wage

Professional, scientific and technical services [54]



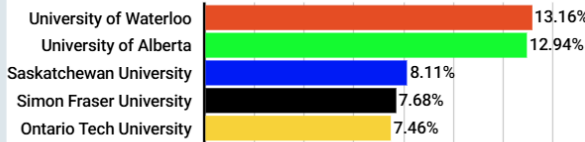
Download data

Science Pole

Inspec Computer Games Canada 2017-2021

Publications (%)

Publications (#)



Download data

Type something



Compendex Computer Games Canada 2017-2021

Open access (%)

Open access (#)

Total Publications (#)



Download data

Finance Pole

Compendex Computer Games Canada 2017-2021

Natural Sciences and Engineering Research Council of Canada



% of total Canadian publications

Download data



Technology Pole

Related IPC: A63F13

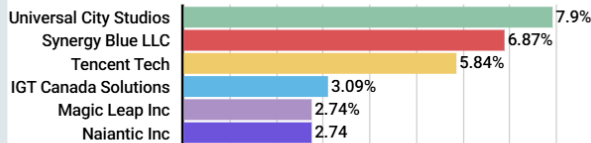
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63 SPORTS; GAMES; AMUSEMENTS
F CARD, BOARD, OR ROULETTE GAMES; VIDEO GAMES
13 VIDEO GAMES



PatentScope IPC:A63F13 Canada 2017-2021

Patents (%)

Patents (#)



Download data

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Statistics Canada Canada 2017-2021

Professional, scientific and technical services [54]



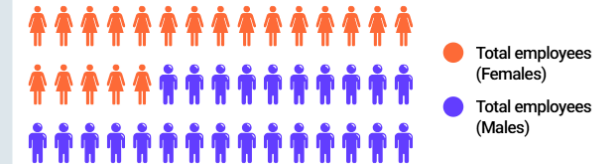
Download data

Gender analysis

Statistics Canada Canada 2017-2021

Employment by gender

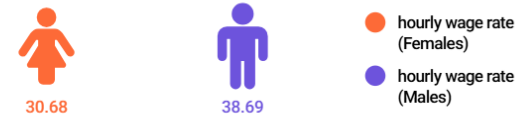
Professional, scientific and technical services [54]



Download data

Hourly wage by gender

Professional, scientific and technical services [54]



Download data

Gender gap in employment and wage

Professional, scientific and technical services [54]

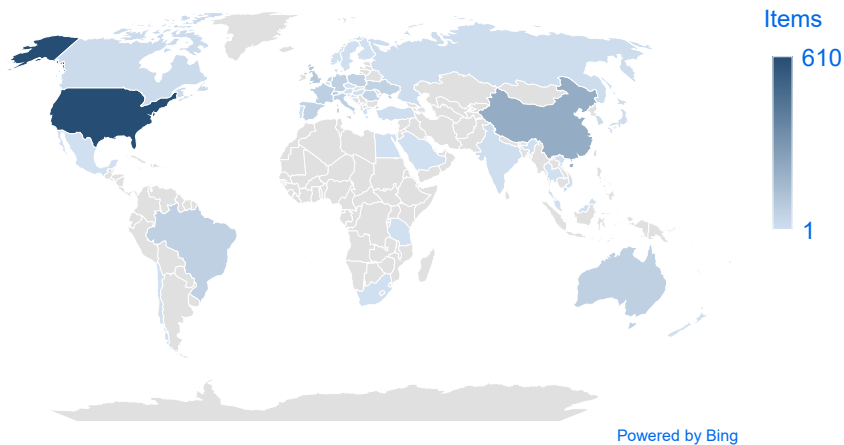


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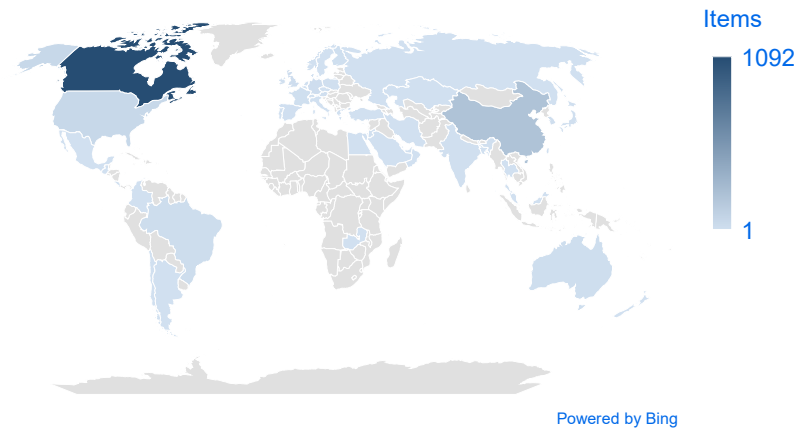
Future steps

- Duplicate course with additional Inspec data
 - Funding bodies for Thesaurus terms
 - Citation counts for Thesaurus terms
 - Explore citation/reference networks
 - Funders for Canadian institutions publishing on selected topics

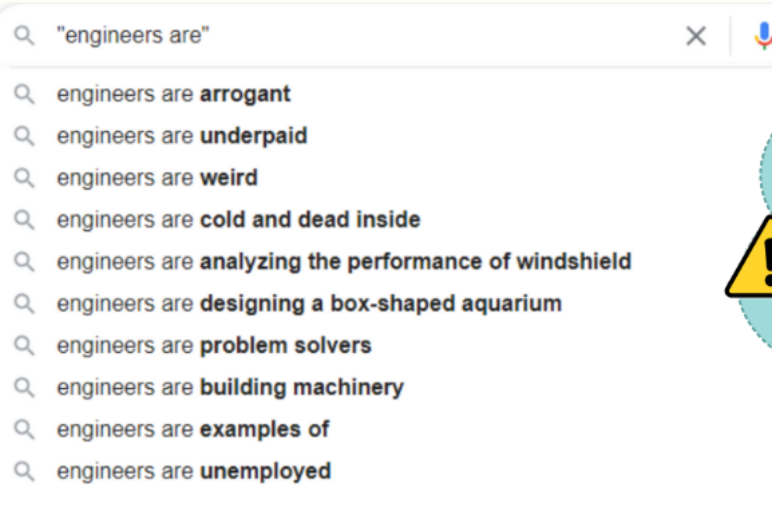
Funders of (US) University X by country



Funders of Canadian University Y by country



Importance



Engineers are the ones having a large and essential impact on society and are able to revolutionize industries and the larger people lives and societies.

Engineers who have learned to think **critically about technoscience and society** embody the societal capacity that we need to help steer technologies toward **just and sustainable outcomes.**

Thank you!
Questions?

gghiasi@uottawa.ca
TAitken@theiet.org