Strengthening Teachers' Capabilities with Big Data

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Project Team

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- Project funded by Australian Universities-German DAAD Joint Cooperative Research Scheme
- Australian Catholic University and University of Würzburg
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Strengthening Teachers' Capabilities

- We live in a time of disruption (e.g., Geiger, in press; Geiger, Gal & Graven, 2023; UN General Assembly, 2015).

- This includes COVID-19 pandemic, climate change, food security and poverty (Maass et al., 2019) – provoking an international focus on sustainability.

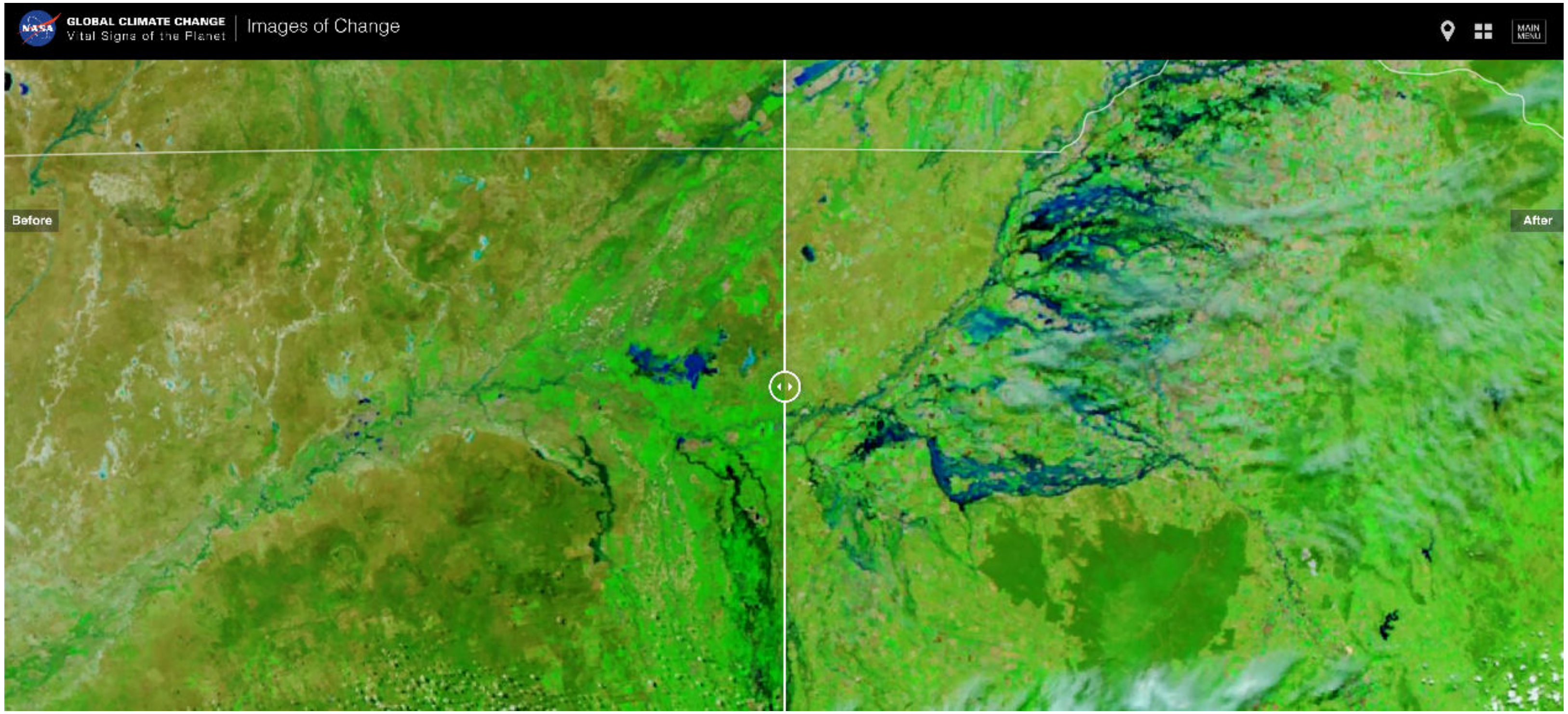
India Gate in Delhi

April 2020

October 2019

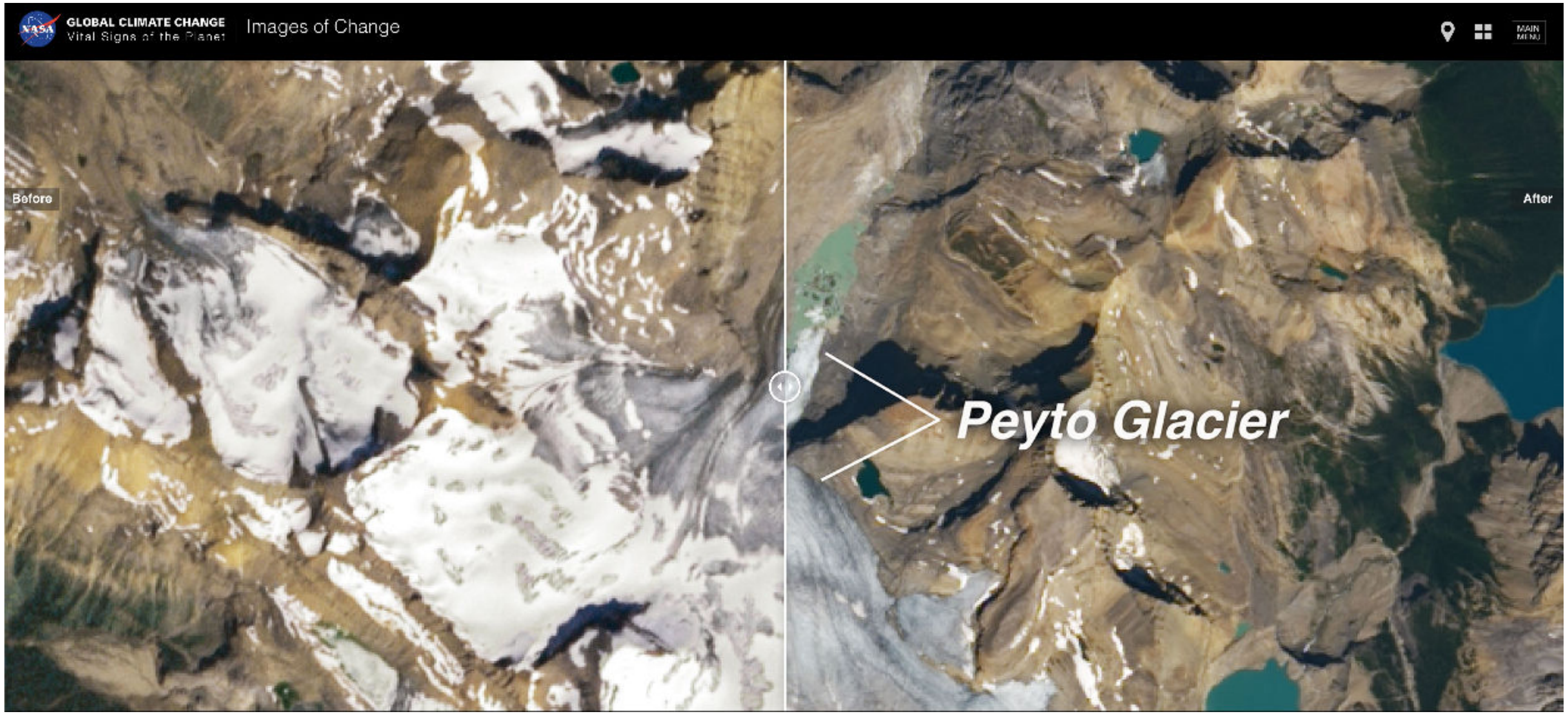
Storm Nalgae Floods, Philippines

Flooding in NSW



Rainfall totals in the basin Murry-Darling (500 k from Sydney) reached almost 5.9 inches (150 millimeters), which is four times the historical average for the month of October.

Declining Peyto Glacier, Canada



Peyto Glacier has lost about 70% of its mass over the past 50 years.

Parched Poyang Lake, China

An extended heat wave (**July 10, 2022 - August 27, 2022**) and drought have caused China's largest freshwater lake to reach low-water levels not seen in decades.

Californian Wildfire

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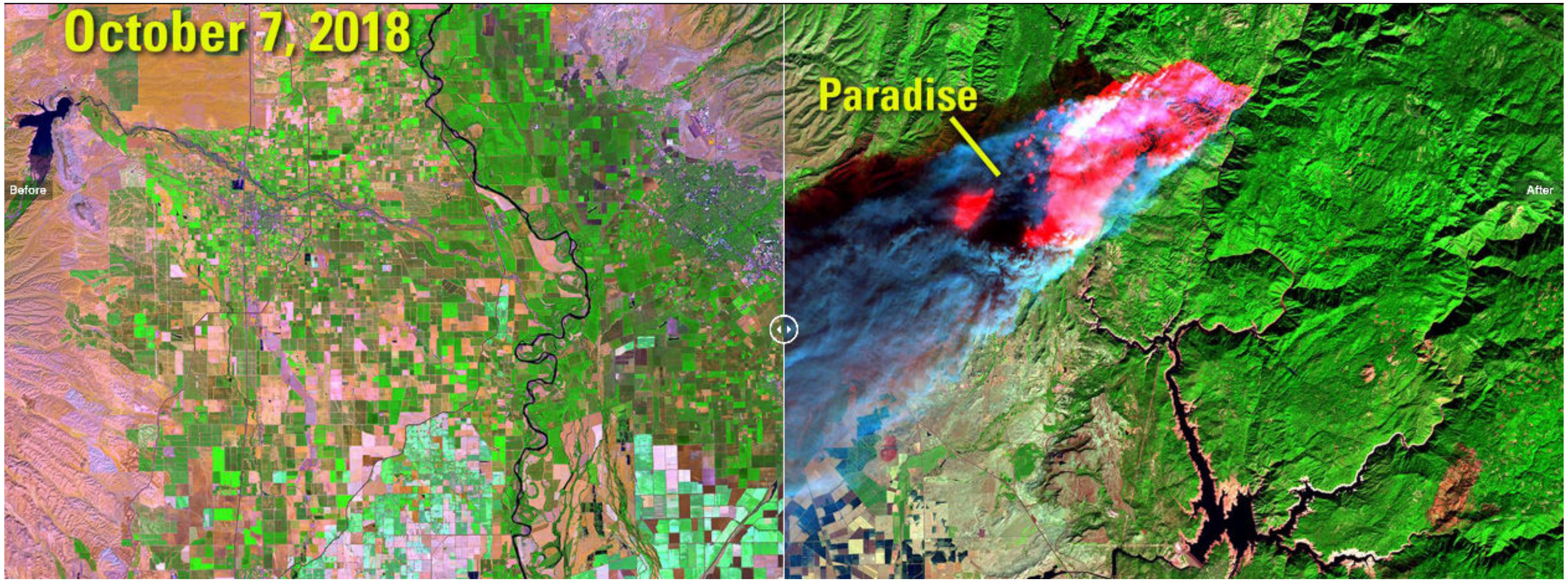

153,000 acres burned, 85 deaths, 14 000 residences destroyed

Deforestation in Bolivia

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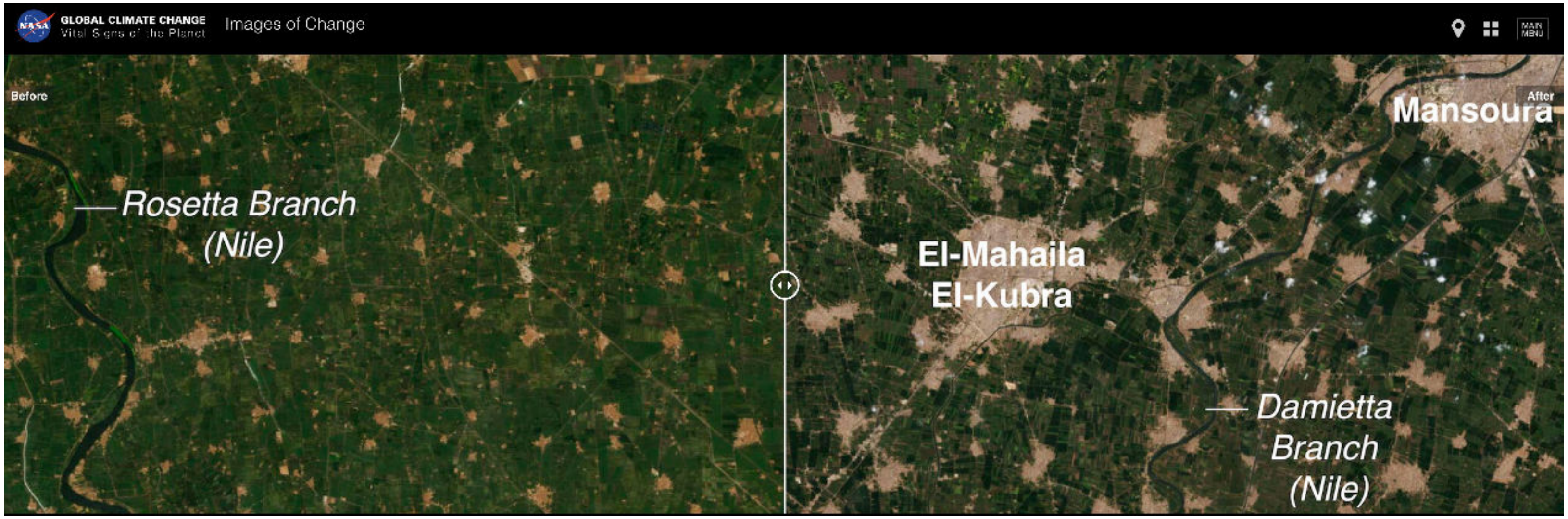
Data from the World Resources Institute show that forest loss in the country has roughly doubled over the past two decades, with 16.6 million acres (6.7 million hectares) of total loss between 2001 and 2021

Nile Delta's Disappearing Farmland



Just 4% of Egypt's land is suitable for agriculture. Urbanisation is depleting what is available. Further, 15% of agricultural land has been dmaged by sea level rise and saltwater intrusion.

Dubai builds a chain of artificial islands

The rapidly developing use of Artificial Intelligence (AI) to generate media content, including dis-information, is increasing the complexity of making well-founded judgements and prudent decisions about the veracity of claims and arguments. (e.g., World Economic Forum, 2024)

Several major tech companies agree to AI safeguards set by White House (ABC News 23-7-2023)

ChatGPT is blocked in China but techies are creating ways to get around the great firewall (ABC News 20-7-2023)

Rise of artificial intelligence among issues dominating Hollywood strike (ABC News 15-7-2023)

Can you tell if these artworks were created by artificial intelligence or a human? (ABC News 17-12-2023)

Google's hidden search algorithms are being investigated by researchers (ABC News 16-8-21)

Calls for transparency surrounding social media algorithms and hate speech (ABC News 11-1-2021)

UN Sustainable Development Goals

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Sustainability

Sustainability addresses the ongoing capacity of Earth to maintain all life. Sustainable patterns of living seek to meet the needs of the present generation without compromising the needs of future generations.

The Sustainability cross-curriculum priority explores the knowledge, skills, values and world views necessary for people to act in ways that contribute to a sustainable future. Designing solutions and actions for a sustainable future requires an understanding of the ways environmental, social and economic systems interact, and an ability to make balanced judgements based on present and future impacts.

Response to Disruption

- Responses to disruptive phenomena invariably rely on the use of mathematics and statistics (M&S), often involving mathematical modelling and statistical modelling of very large data sets (Kazak et al., 2018).
- Citizens must be able to understand, interpret and evaluate M&S information (Gal & Geiger 2022) to:
  - remain informed and empowered; and
  - contribute to a prosperous, just and equitable society (Maass et al., 2019).

Statisitcal and Mathematical Products (StaMPs)

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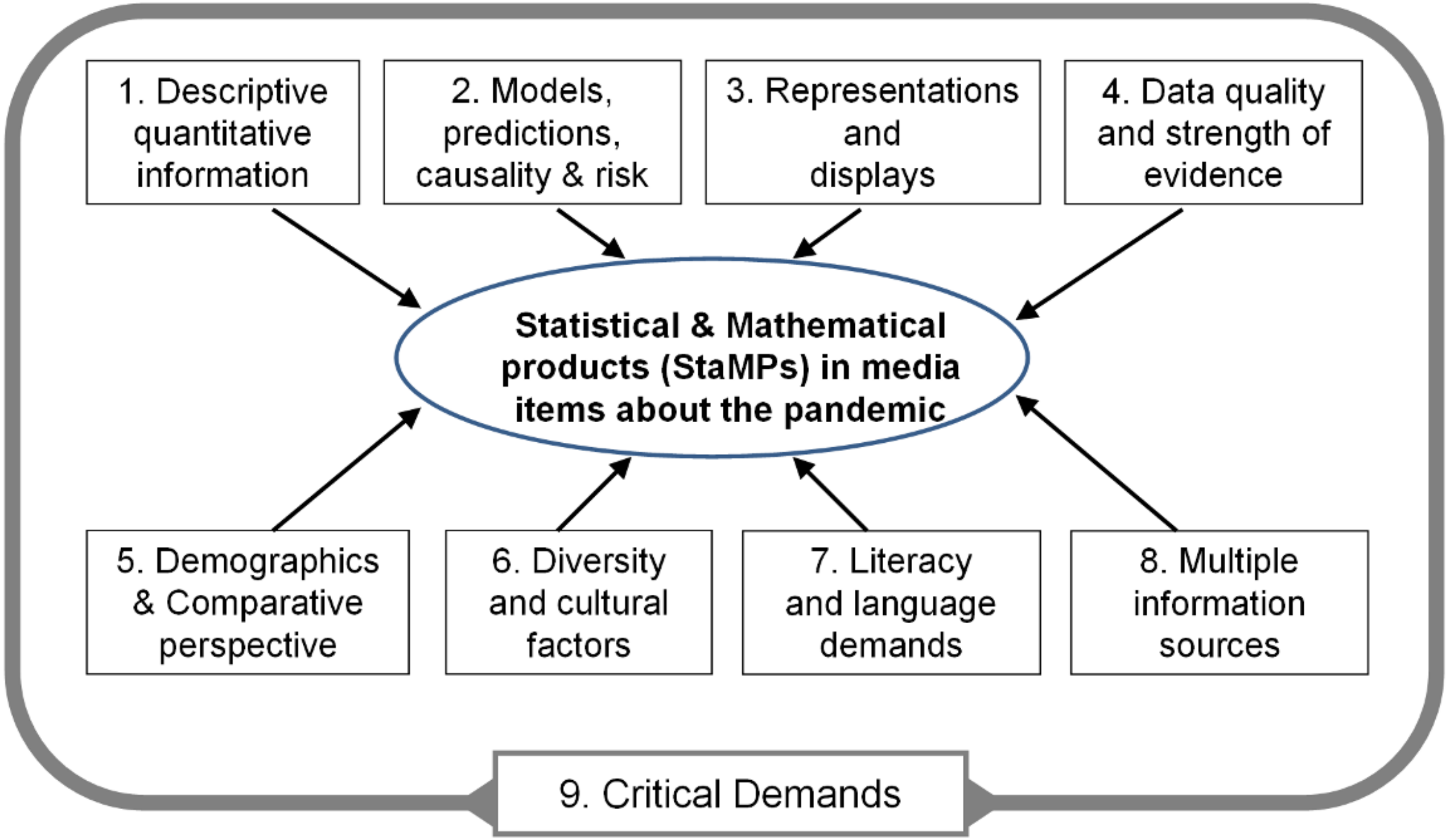

(Gal and Geiger, 2022)

Information, the media, and policy advice

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- Central findings of the German Bertelsmann Foundation's study — "Disinformation: A Challenge for Democracy" — How can school and teaching, especially in mathematics, help future generations to reflect critically on news that affect current issues, such as sustainability?

- European Commission, Directorate-General for Education, Youth, Sport and Culture, *Key competences for lifelong learning*, Publications Office (2019) — "This also involves the ability to access, have a critical understanding of, and interact with both traditional and new forms of media and understand the role and fucntions of media in democratic societies." [Citizenship Competence]

The Role of Mathematics and Statistics (M&S)

- M&S can be used as *evidence* to support arguments about how to respond to disruptive events.
- Citizens must possess the capability to critically evaluate M&S evidence (Gal & Geiger, 2022), including the capacity to pose questions, select relevant data-sets, evaluate the quality of data and analyse and critically evaluate findings – evidentiary practices (Duncan et al., 2018)
- COVID-19 pandemic highlighted how:
    - government agencies, politicians, commercial entities, experts, and non-experts can use M&S; and
    - M&S were embedded in claims that were technical and hard to understand, incomplete, fuzzy, or even contradictory. In the most undesirable cases, information can be misleading or even "fake", by mistake (misinformation), or intentionally (disinformation).

Evidentiary practices

Evidentiary practices – as used in science education – are processes that provide a foundation for prudent decision-making (e.g., Duncan et al., 2018). Evidence is complex and context based.

Dimension	Reliable epistemic processes (examples)
Evidence analysis	• Discerning and aligning evidence components(goals, methods, data analyses, patterns of data, conclusions) using strategies such asself-explanation • Identifying measurements that should be used • Selecting appropriate representations of data • Drawing conclusions from data • Comparing and contrasting studies to identify similarities and differences
Evidence evaluation	• Evaluating the appropriateness of study design(e.g., appropriate samples and comparisons) • Developing valid and reliable measures • Developing proper data analytic methods • Providing evidence of relevant source expertise and lack of bias • Identifying and eliminating sources of error • Looking for alternative explanations for each step in the model of data

Evidence interpretation	• Generating study setups that meet the ideals of diagnostic evidence • Developing arguments that systematically connect evidence to models in ways that meet the ideals • Evaluating evidence strength when interpreting evidence • Evaluating model–evidence fit (i.e., carefully analyzing which parts of models are supported)Systematic coordination of alternative models with evidence • Model perspective taking (i.e., inferring what results different models predict and how different models explain the same evidence)
Evidence integration	• Reliable evidence selection methods are used to select all relevant evidence • Quality checks ensure that only evidence of adequate quality is integrated • Systematic integration methods such as meta-analyses, tallying methods, and so on, enable consistent and impartial weighting of evidence • Develop algorithms to weight evidence by quality and strength • Cluster related studies into lines of evidence • Seek out and evaluate relevant methodological studies and constraining studies • Identifying and coordinating lines of evidence • Using constraining bodies of evidence to constrain interpretation
Laypersons' use of evidence	• Identify who the experts are, including level and relevance of expertise • Identify sources of bias • Examine if publication platforms and dissemination channels include mechanisms of evaluation, vetting, or filtering • Determine whether there is consensus in the scientific community; identify areas of agreement and disagreement among experts • Critically read popular science reports (e.g., being aware of possible simplifications and missing qualifications)

Disruptive Events and Mathematical Modelling Research

- There is a need to link mathematical modelling and critical thinking to evaluate information disseminated in public forums about disruptive phenomena.
- Current research, however, focuses on modeling competencies and instructional effectiveness – not on the nature of evidence or the role of modelling in generating evidence.
- There is a paucity of research that connects modelling with large data sets (big data).
- Such capabilities are key for addressing disruptive phenomena and critical societal issues like sustainability?

Disruptive Events and Mathematical Modelling Research

Table 1 Topics in Mathematical Modelling Publications (ICTMA, ESM, ZDM)

Category	**n**	**%**
Wildlife/Nature	5	4.50%
Public Health/Pollution/Population	9	8.20%
Sport/Athletics/Body Mechanics	11	10.00%
Industrial Commercial	85	77.30%
Total	110	100.00%

Source: Geiger (in press)

Table 2 Perspectives in Mathematical Modelling Publications (ICTMA, ESM, ZDM)

Theoretical / Conceptual Framework	**n**	**%**
Cycle/Cognition/Competency/Instruction	81	75.70%
CHAT/Socio-Cultural/Socio-Epistemological/Structuralism	26	24.30%
Total	107	100.00%

Source: Geiger (in press)

Research Study Overview

- The study aims to develop students' capabilities to evaluate claims and arguments in the media through the modelling of large data sets related to sustainability issues.

- The study will:
  - utilise a mixed method research design
  - requires 24-36 students (Grade 9/10) and 2 teachers (mathematics and/or science)

- The project will generate, trial, and refine student tasks and pedagogies that develop students' evidentiary practices.

Approach

- The study is based on two rounds of intervention over a two-year period, including student activity and teacher professional learning.
- There was no explicit intervention or preparation before the first session. The only input was regular mathematics lessons.
- Interventions are conducted in computer rooms off-site from their school at the researchers' universities and are approximately three to four hours in duration.
- During these interventions, students are expected to make selections from a set of four datasets and carry out mathematical modelling processes to determine the validity of claims in provided media items.
- Teachers are present during these sessions. Professional learning opportunities for teachers, targeting insight into student activity, are provided after the intervention sessions.

Data Collection and analysis

- Data collection instrumentation include computer screen casting (including audio recordings of student commentary during tasked based activity), pre-/post-surveys, and student post-session interviews.

- Both deductive and indictive approaches will be adopted to identify emergent themes from qualitative data using the Grasp of Evidence Framework as a starting point.

- Analysis will focus on students' handling of large data sets, approach to the modelling of data, criteria for selecting appropriate data sets, processes for identification of misleading and contradictory information in media articles.

Task design

- The approach to designing tasks is a foundational element of the study.
- Each task is based on two media items that include contradictory information about specific issues related to sustainability and several large data sets from trusted sources.
- Media items and related data sets are made available to students and teachers via a website developed specifically for this purpose — https://we-stem.it.
- The design of tasks was initiated through searches across publicly available, online media sources for article that made contradictory statements about an issue related to sustainability, for example, rates of atmospheric CO_2 emissions.
- Relevant data sets were then identified from publicly available repositories that contained numerical data. These are made available to students in their original form, that is, without corrections.
- We have not explicitly defined the notion of large data set, although there is an expectation that a large number of columns and rows is available (e.g., 32 columns and 195 rows in one of the used data sets).

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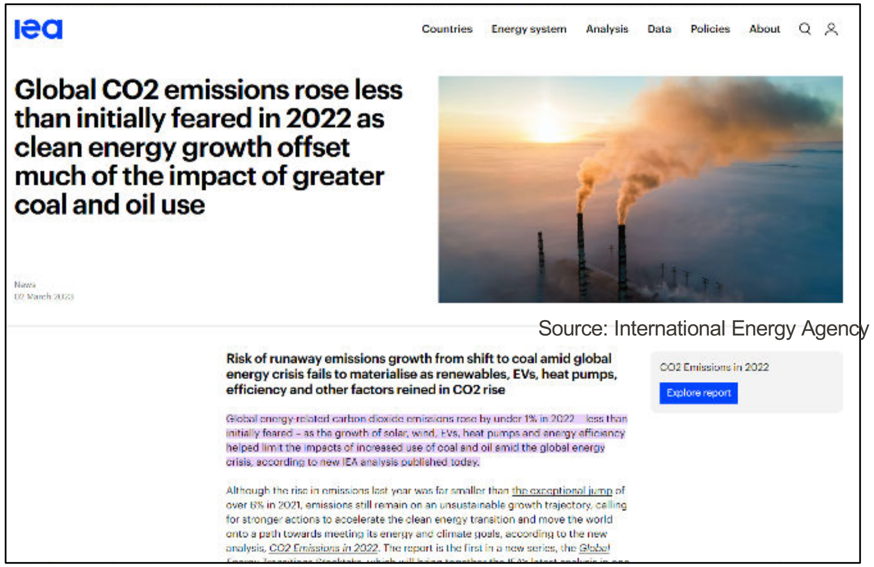
Student Task: What are the levels of CO_2?

Global CO_2 emissions rose less than initially feared in 2022 as clean energy growth offset much of the impact of greater coal and oil use

- Global energy-related CO_2 emissions grew in 2022 by 0.9%, or 321 million tonnes, reaching a new high of more than 36.8 billion tonnes, according to the report.



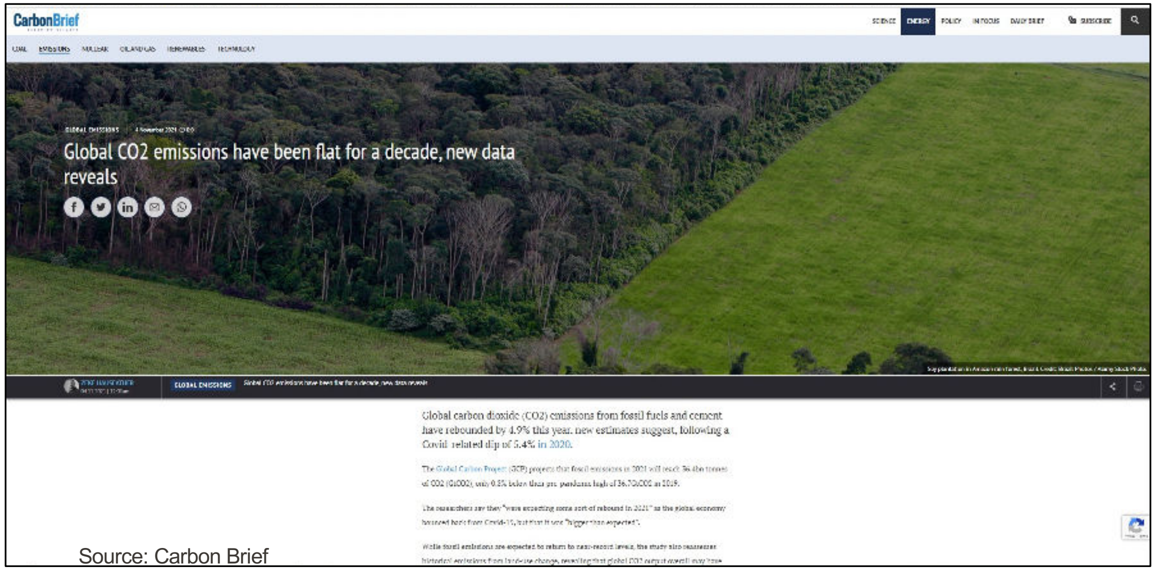
Source: International Energy Agency

Source: International Energy Agency

Student Task: What are the levels of CO_2?

Global CO_2 emissions have been flat for a decade, new data reveals

- The Global Carbon Project (GCP) projects that fossil emissions in 2021 will reach 36.4bn tonnes of CO_2 ($GtCO_2$), only 0.8% below their pre-pandemic high of 36.7$GtCO_2$ in 2019.



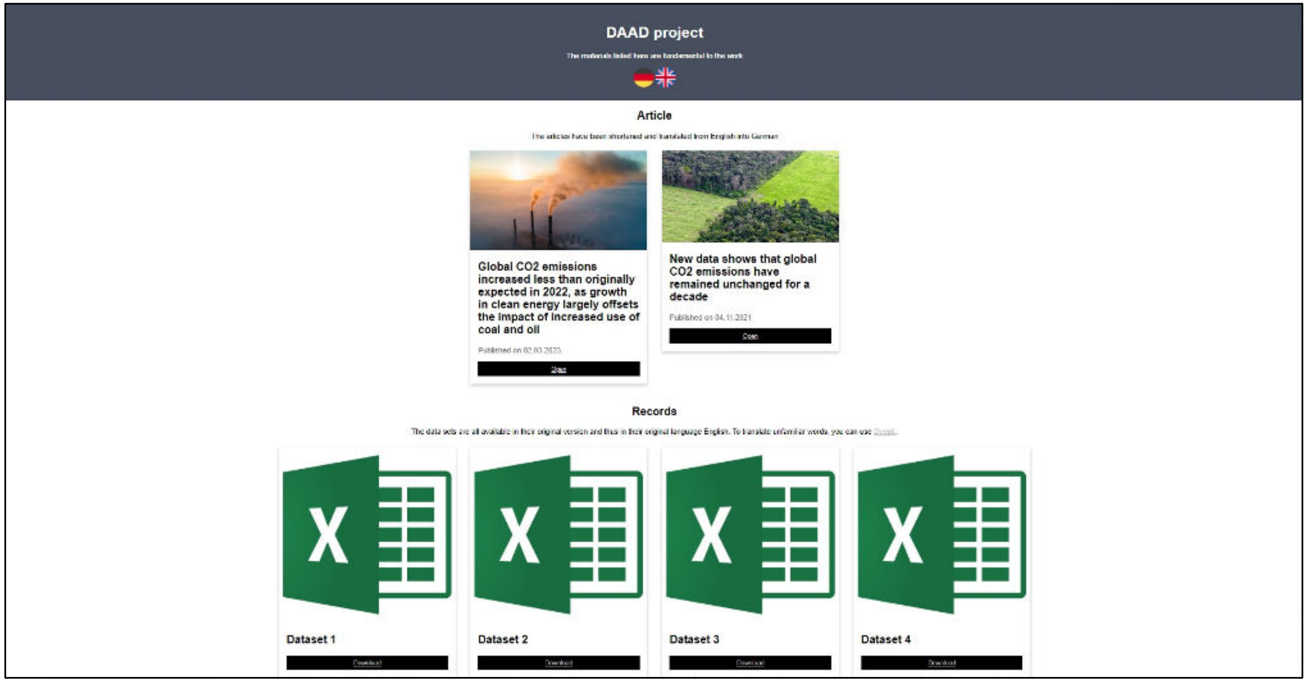
Source: Carbon Brief

Student Task: What are the levels of CO_2?

- Students have access to multiple CO_2 emission data sets

- The data sets are from reliable sources such as:
  - Climate Watch
  - International Energy Agency
  - Global Carbon Budget 2022

Student Task: What are the levels of CO_2?



https://we-stem.it

Source: Overview of the DAAD - https://we-stem.it/de/index.html

Student Task: What are the levels of CO_2?

Country/Region	unit	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000	2001
China	MtCO2e	2173.36	2302.18	2418.18	2645.41	2767.67	3088.62	3070.51	3134.11	3236.28	3153.66	3346.53	3529.08
United States	MtCO2e	4844.52	4807.5	4879.63	4995.21	5066.81	5117.04	5273.49	5543.35	5590.54	5609.02	5775.81	5748.26
India	MtCO2e	563.58	607.23	626.29	651.35	685.9	737.86	774.07	819.27	836.27	901.33	937.86	953.54
Russia	MtCO2e	2163.53	2136.44	2030.81	1880.25	1685.05	1635.49	1601.18	1489.51	1487.97	1523.72	1563.85	1567.17
Japan	MtCO2e	1090.53	1103.98	1115.06	1107.61	1160.78	1171.01	1184.67	1172.63	1130.31	1165.32	1182.61	1170.38
Germany	MtCO2e	955.31	932.55	892.82	887.06	875.9	874.66	904.34	872.65	865.25	833.59	830.28	847.68
Iran	MtCO2e	198.47	219.1	233.65	236.73	266.69	271.52	279.81	292.4	290.99	323.36	340.45	354.07
Indonesia	MtCO2e	148.53	162.4	171.51	185.09	199.18	223.68	236.72	261.16	262.7	279.48	280.65	302.06
South Korea	MtCO2e	247.68	274.79	297.05	327.6	354.28	385.41	409.99	431.64	366.57	401.88	456.66	471.53
Canada	MtCO2e	419.49	413.3	426.37	422.05	436.76	448.05	461.7	476.82	484.79	494.28	514.22	506.62
Saudi Arabia	MtCO2e	171.41	187.93	202.04	203.26	206.36	204.83	217.65	220.07	233.9	239.52	249.66	254.09
Mexico	MtCO2e	269.58	288	291.68	300.67	326.5	306.84	322.7	342.48	365.14	355.18	379.18	378.83
South Africa	MtCO2e	247.66	242.33	238.82	246.49	252.14	264.31	274.11	289.03	296.49	278.41	284.66	320.54
Brazil	MtCO2e	197.9	205.48	207.87	215.26	222.5	241.28	262.41	281.33	290.59	300.96	313.67	319.38
Turkey	MtCO2e	139.2	143.8	149.8	155.58	153.82	168.15	185.34	193.43	193.69	192.65	216.4	197.77
Australia	MtCO2e	263.63	264.76	268.4	273.05	280.18	290.18	300.81	307.85	328.62	333.71	339.45	345.64
United Kingdom	MtCO2e	561.77	570.68	557.89	541.38	535.18	526.81	545.48	524.19	526	522.75	530.89	545.26
Vietnam	MtCO2e	19.33	19.8	20.81	24.24	26.68	31.4	35.03	40.84	45.47	46.41	51.21	56.72
Italy	MtCO2e	405.26	404.07	402.27	396.93	392.29	416.42	412.15	415.52	426.37	433.01	436.3	436.57
France	MtCO2e	356.24	380.65	368.59	349.42	344.4	352.24	367.9	359.07	381.11	374.9	373.12	376.73
Poland	MtCO2e	350.21	351.62	343.37	344.02	339.75	340	355.32	344.63	318.41	308.98	295.77	293.63
Thailand	MtCO2e	89.22	98.07	107.95	122.72	137.06	155.78	174.71	177.94	156.79	163.79	164.49	173.16
Malaysia	MtCO2e	54.62	65.1	67.17	73.04	79.74	86.31	98.64	106.02	105.69	114.45	124.36	129.46
Egypt	MtCO2e	87.75	89.37	90.9	92.66	87.9	93.72	98.94	106.06	110.98	116.54	114.61	126.7
Spain	MtCO2e	214.95	222.1	232.37	218.08	228.45	240.57	230.11	248.6	256.22	278.3	293.31	294.79
Kazakhstan	MtCO2e	237.25	246.37	253.84	219.24	199.17	175.24	153.39	132.24	135.84	122.65	120.15	117.44
Pakistan	MtCO2e	59.03	60.31	66.98	73.75	76.25	82.74	85.82	89.36	90.19	98.77	98.37	99.84
United Arab Emirates	MtCO2e	55.21	61.56	59.7	63.62	70.78	75.17	78.53	81.44	83.45	85.68	84.73	97.2
Ukraine	MtCO2e	688.62	651.93	574.64	499.31	415.67	399.25	346.11	328.24	309.29	305.73	297.38	300.55
Iraq	MtCO2e	64.21	45.55	67.34	89.56	102.12	100.07	98.88	118.91	91.78	72.71	87.63	97.55
Algeria	MtCO2e	62.94	66.43	66.84	72.22	73.61	76.44	76.12	74.43	74.65	77.51	80.05	78.65
Argentina	MtCO2e	100.32	105.92	107.93	110.26	111.91	112.89	122.55	126.12	132.67	134.51	132.27	125.26
Netherlands	MtCO2e	148.38	154.51	153.25	158.15	157.26	164.11	173.62	166.31	166.73	161.45	162.1	167.12
Philippines	MtCO2e	41.08	40.65	44.02	47.8	51.51	61.75	67.22	74.79	74.22	71.58	72.1	70.48
Uzbekistan	MtCO2e	117.77	118.58	113.08	114.59	108.88	98.15	99.6	100.73	116.26	116.49	123.81	125.7
Nigeria	MtCO2e	72.77	81.93	91.81	86.24	78.33	86.17	100.23	98.65	88.7	87.02	97.22	101.95
Venezuela	MtCO2e	101.63	100.99	103.11	107.39	106.53	114.04	121.84	127.59	129.3	125.46	131.52	135.8
Czech Republic	MtCO2e	150.2	136.9	134.14	130.98	124.71	125.18	126.74	124.79	118.92	111.95	123.17	122.72
Belgium	MtCO2e	109.31	113.96	112.33	110.11	114.9	114.57	119.45	116.63	119.41	115.51	117.27	118.34
Kuwait	MtCO2e	29.13	7.82	23.05	30.74	36.67	36.25	35.63	37.3	42.13	45.74	49.84	53.19
Qatar	MtCO2e	12.54	14.98	14.68	16.61	18.49	19.05	20.94	25.39	26.5	29	28.66	28.65

Country/Region	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016	
China	3810.06	4415.91	5124.82	5824.63	6437.47	6993.18	7199.6	7719.07	8474.92	9282.55	9541.87	9984.57	10006.67	9861.1	9874.66	10
United States	5593.03	5658.99	5738.29	5753.49	5653.08	5736.32	5558.38	5156.43	5392.11	5173.6	4956.06	5092.1	5107.21	4990.71	4894.5	48
India	985.45	1011.77	1085.67	1136.47	1215.21	1336.74	1424.38	1564.88	1659.98	1756.74	1909.44	1972.43	2147.11	2158.02	2195.25	23
Russia	1565.34	1610	1600.98	1611.98	1654.85	1658.15	1655.19	1546.67	1617.83	1699.09	1675.76	1632.68	1611.96	1592.56	1571.52	15
Japan	1206.6	1214.95	1209.85	1212.82	1189.52	1225.07	1158.22	1100.98	1156.48	1213.52	1253.61	1262.78	1217.12	1179.44	1167.79	11
Germany	833.38	836.79	821.07	802.38	814.41	783.8	789.69	734.81	773.07	746.48	760.13	776.15	736.01	742.31	747.15	73
Iran	369.87	389.77	417.66	450.79	484.18	514.14	523.05	542.29	541.17	552.05	559.12	583.7	605.35	599.18	607.21	62
Indonesia	305.64	333.89	341.24	342.15	364.47	379.96	376.14	391.08	415.52	475.31	481.51	447.94	483.91	488.55	482.51	51
South Korea	463	465.7	485.91	481	487.85	503.69	514.92	526.64	575.22	598.48	600.32	599.6	588.09	607.83	615.88	62
Canada	524.35	544.54	536.42	549.03	540.53	571.63	550.47	521.32	537.01	549.29	546.21	555.66	561.68	558.7	556.83	56
Saudi Arabia	272.25	284.83	299.89	315.29	335.44	354.62	389.72	406.53	446.13	463.77	492.47	503.21	540.52	565.19	561.23	54
Mexico	386	404.69	414.1	432.19	448.3	457.12	459.55	448.37	462.87	478.4	486.45	475.74	462.24	471.63	473.31	47
South Africa	331.32	353.09	379.99	377.65	379.79	397.06	426.74	404.2	425.31	409.26	426.78	436.92	447.93	424.81	425.14	43
Brazil	317.76	310.81	328.52	331.69	335.62	352.56	373.63	350	397.93	418.31	454.23	486.84	511.62	485.34	447.08	45
Turkey	208.11	219.16	224.6	235	261.08	288.97	287.19	287.83	297.11	317.72	328.88	318.17	340.64	351.59	374.59	41
Australia	353.37	352.58	365.81	370.09	375.49	385.75	388.94	395.29	387.54	386.38	386.97	380.28	371.63	377.8	384.99	38
United Kingdom	530.79	543.04	543.08	540.92	542.06	530.5	515.34	466.49	482.44	445.59	467.78	453.76	415.6	401.08	380.81	
Vietnam	66.5	70.9	85.05	92.37	94.87	105.14	117.59	132.29	151.41	155.97	155.52	164.3	180.87	220.65	223.72	23
Italy	443.47	462.2	472.4	473.83	466.65	459.37	444.98	397.06	405.27	396.69	376.75	346.46	327.5	337.86	333.34	32
France	371.02	376.71	377.79	380.66	371.55	362.83	357.99	343.73	347.78	335.14	338.42	338.56	306.1	311.3	313.92	31
Poland	287.32	297.73	301.85	301.35	314.09	313.38	308.33	297.26	313.74	310.59	303.35	298.3	285.73	289.08	299.8	31
Thailand	184.24	191.93	210.19	217.77	219.88	224.59	227.58	220.26	234.38	233.6	250.68	260.7	256.8	264	261.6	25
Malaysia	136.38	144.49	158.27	167.42	174.1	189.94	202.91	181.93	200.22	202.74	205.81	223.66	236.65	236.54	235.96	22
Egypt	129.44	133.02	144.5	162.22	170.75	183.4	189.94	197.66	200.31	205.77	215	213.86	219.12	226.28	231.23	24
Spain	312.75	318.66	335.56	350.5	341.78	354.68	324.27	287.49	273.25	274.4	269.27	242.81	240.96	256.28	247.03	26
Kazakhstan	131.06	146.14	158.03	169.21	185.3	198.39	242.03	213.61	229.7	245.45	244.6	260.01	209.23	190.73	202.15	21
Pakistan	102.33	105.66	118.65	121.67	132.48	146.26	142.16	145.14	140.62	141.7	143.81	146.06	154.24	164.13	181.11	19
United Arab Emirates	99.15	103.82	110.01	116.46	121.56	131.83	156.05	157.02	162.79	165.6	175.59	184.47	184.76	195.24	201.08	19
Ukraine	303.94	330.23	307.14	295.41	303.99	312.14	301.2	251.62	268.92	283.34	277.11	270.27	237.73	191.07	201.66	17
Iraq	91.16	81.28	88.11	85.13	82.96	76.65	88.14	94.2	108.55	113.04	129	139.1	134.04	133.17	142.23	15
Algeria	82.4	88.19	89.49	94.19	99.81	102.75	107.75	112.17	114.18	120.79	134.93	139.02	147.74	156.27	154.91	15
Argentina	117.47	127.66	141.38	145.99	154.9	162.81	167.23	156.57	167.22	176.64	177.96	183.25	179.6	185.55	183.16	17
Netherlands	167.43	170.36	172.12	167.93	163.7	164.55	165.22	160.49	171.11	158.77	157.47	157.09	149.79	157.41	158.54	15
Philippines	71.57	73.63	75.14	76.67	69.47	73.22	75.15	76.3	81.93	82.63	86.18	95.5	101.82	111.01	121.96	13
Uzbekistan	129.89	121.91	124.84	119.19	127.36	122.58	128.88	116.53	126.24	128.63	113.14	111.86	104.87	99.17	105.23	10
Nigeria	92.24	101	98.73	98.72	88.77	81.12	86.93	76.95	90.06	95	95.34	108.13	114.83	107.76	110.83	10
Venezuela	140.75	135.77	139.61	147.38	147.53	142.39	151.11	152.59	164.1	160.04	181.13	180.43	179.24	163.13	151.07	14
Czech Republic	118.53	122.77	123.44	119.99	120.6	123.62	118.31	111.17	112.25	109.17	106.07	101.15	97.51	99.14	101.73	10
Belgium	110.85	115.5	114.02	110.61	108.65	104.59	106.93	99.67	106.72	96.48	95.27	96.59	90.14	95.13	94.22	92
Kuwait	55.59	58.12	61.91	69.91	72.43	70.6	75.84	77.65	80.72	83.29	85.31	87.36	85.57	89.02	91.55	90
Qatar	32.5	34.74	37.07	38.54	43.77	49.83	53.04	54.07	60.58	68.19	75.08	76.17	81.66	84.78	86.92	87

Climatewatch_ghg-emissions-excl

Source: Climate Watch - Annual CO_2 Data by Country (1990-2019)

Student Task: What are the levels of CO_2?

GHG emissions from energ

Source: IEA (2022), GHG Emissions from Energy
Documentation: Accessible here

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million tonnes of CO_2 eq	1971	1972	1973	1974	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984
World	16144	16865	17800	17747	17773	18771	19367	19873	20460	20173	19779	19615	19692	20361
Annex I Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex II Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..
North America	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Europe	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Asia Oceania	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex I EIT	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Non-Annex I Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex B Kyoto Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..
OECD Total	9835	10263	10800	10580	10248	10818	11059	11204	11478	11146	10887	10548	10460	10808
Non-OECD Total	5781	6047	6416	6617	7006	7422	7762	8114	8409	8464	8354	8555	8737	9046
Region/Country/Economy	**1971**	**1972**	**1973**	**1974**	**1975**	**1976**	**1977**	**1978**	**1979**	**1980**	**1981**	**1982**	**1983**	**1984**
Canada	366	385	404	413	404	415	428	429	446	452	431	414	407	426
Chile	22	22	21	21	18	19	20	20	22	23	23	20	20	22
Colombia	32	33	34	36	34	36	37	38	39	40	40	41	44	44
Costa Rica	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mexico	118	131	143	156	164	175	183	212	219	248	275	289	276	281
United States	4604	4848	5011	4846	4652	4919	5088	5080	5127	4920	4853	4628	4587	4800
OECD Americas	5143	5421	5615	5473	5273	5566	5757	5782	5854	5685	5624	5393	5335	5574
Australia	153	159	169	184	192	194	209	204	212	221	223	230	220	227
Israel	14	15	16	16	17	17	18	19	19	19	20	21	22	23
Japan	762	799	909	896	859	886	911	906	928	881	857	830	836	897
Korea	56	58	72	75	82	90	103	112	126	130	136	136	144	157
New Zealand	14	16	17	18	17	19	20	19	17	17	17	19	19	20
OECD Asia Oceania	998	1047	1182	1189	1166	1207	1261	1260	1302	1268	1253	1236	1241	1324
Austria	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Belgium	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Denmark	56	58	57	51	53	59	61	60	64	64	54	56	53	55
Estonia	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Finland	..	..	..	..	..	..	..	..	..	..	..	..	..	..
France	433	449	485	466	433	473	459	478	485	465	417	399	384	371

million tonnes of CO_2 eq	1985	1986	1987	1988	1989	1990	1991	1992	1993	1994	1995	1996	1997	1998	1999	2000
World	20669	21050	21716	22449	22899	23281	23430	23312	23448	23549	24207	24727	25147	25312	25443	26262
Annex I Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex II Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
North America	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Europe	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Asia Oceania	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex I EIT	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Non-Annex I Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Annex B Kyoto Parties	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
OECD Total	10913	10904	11173	11494	11657	11663	11713	11738	11826	12018	12177	12566	12838	12850	12899	13216
Non-OECD Total	9220	9568	9955	10335	10610	10983	11074	10894	10949	10832	11306	11417	11539	11667	11708	12185
Region/Country/Economy	**1985**	**1986**	**1987**	**1988**	**1989**	**1990**	**1991**	**1992**	**1993**	**1994**	**1995**	**1996**	**1997**	**1998**	**1999**	**2000**
Canada	427	419	431	463	478	445	441	456	453	469	481	496	512	521	531	552
Chile	22	22	22	27	32	31	30	31	33	36	40	46	52	53	56	52
Colombia	46	47	50	51	53	55	56	58	61	62	66	66	72	73	65	67
Costa Rica	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Mexico	289	283	295	291	305	300	320	322	331	356	339	356	379	401	390	414
United States	4823	4782	4948	5168	5234	5135	5097	5170	5279	5358	5411	5570	5842	5888	5901	6070
OECD Americas	5609	5555	5748	6002	6104	5969	5947	6042	6162	6287	6342	6539	6860	6940	6946	7159
Australia	241	243	255	263	278	284	287	292	297	304	316	326	336	357	363	372
Israel	25	27	29	31	32	33	34	36	39	42	45	48	50	50	51	55
Japan	877	877	882	948	976	1063	1075	1085	1078	1131	1142	1155	1146	1108	1147	1163
Korea	162	168	175	199	209	238	261	281	307	332	361	386	407	348	382	427
New Zealand	20	19	20	22	22	23	24	25	25	25	25	27	29	28	30	31
OECD Asia Oceania	1324	1335	1362	1462	1517	1642	1681	1719	1747	1834	1889	1941	1967	1891	1974	2048
Austria	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Belgium	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Czech Republic	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
Denmark	63	63	62	58	52	53	64	58	60	64	61	74	65	61	58	54
Estonia	..	..	..	..	..	35	32	23	18	19	16	17	18	16	15	15
Finland	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..	..
France	362	351	345	343	359	355	380	369	351	345	353	369	360	382	376	374

Source: International Energy Agency – Annual Greenhouse Gas Emissions from Energy by Country (1971-2021)

First impressions

- Task development is challenging
  - Finding media items that are accessible to students with obvious contradictions
  - Finding relevant data basis that match the media items
- Students were initially surprised by the size of the data sets provided. They became more comfortable after work began (both Australia and Germany)
- There were instances of students who attempted to respond to questions without using mathematics
- Those that used mathematics favoured the use of measures of central tendency, used percentage differences year-by-year, or attempted graphic displays looking for trends in the data.
- Students were highly engaged throughout. Conversations were on topic and directed towards finding a response to the problem.
- Post session interviews indicated students found the activity important for their development mathematically and for their roles as future citizens. They questioned why they had not been exposed this this type of problem in regular mathematics lessons.
- A professional learning session was held in Australia post intervention (planned for Germany). Teachers indicated that this was valuable professional learning and that more activities of this type needed to be incorporated in mathematics teaching/learning.

Links to related work

There are other projects, internationally, that are working on the connection between mathematics education/curriculum and the challenges associated with disruption. For example:

- Geiger and colleagues (Merrilyn Goos, Kim Beswick, Gabriele Kaiser, Thorsten Scheiner, Jill Fielding) are conducting an Australian Research Council funded project into Critical Mathematical Thinking — investigation the use of mathematics to make decisions about real problems while also taking into account issues of inclusiveness, equity and social justice (e.g., making decisions about moving where people live in flood prone areas),
- Alf Coles (2023) from the University of Bristol has been working on the idea of *socio-ecological issues* and how these should be represented in the curriculum.
- Armando Solares-Rojas from Mexico (Solares-Rojas et al., 2022) is conducting a school curriculum innovation project about the revitalisation of the Atoyac River which was used for waste disposal for many years.
- Sean Chorney reports from Canada reports on a project involving teachers' and students' exploration of the reasons for flooding on an area that was once a lake within lands where the Sumas Nation live. The outcome of the investigation suggested that the redirection of rivers by government, and the Chilliwack River, in particular, had disrupted traditional flows (Amico et al., 2023).

Each of these projects have the potential to inform curriculum development by pointing to ways that the underpinning ideas and ideals can be embedded in curriculum and practice.

ICMI Study 27

ICMI Study 27 "Mathematics Education and the Socio-Ecological"

The study has been launched by the ICMI Executive Committee during its meeting on April 28, 2023.

The International Program Committee (IPC) has been designated:

- **Alf Cole** (University of Bristol - UK) Co-chair
- **Kate Leroux** (University of Cape Town, South Africa) Co-chair
- Marcelo Borba (Brazil)
- Arindam Bose (India)
- Vince Geiger (Australia)
- Rochelle Gutiérrez (USA)
- Mariam Makramalla (Egypt)
- Natalie Sinclair (Canada)
- Armando Solares-Rojas (Mexico)
- Paola Valero (Sweden)
- Catherine Vistro-Yu (Philippines)
- Frederick Leung (Honk-Kong) ex-officio President of ICMI
- Jean-Luc Dorier (Switzerland) ex-officio Secretary-General of ICMI

Its first role will be to produce a Discussion Document will be made public early in 2024.

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- The scheme fosters research collaboration between Australian and German researchers.

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