

## It's in the wind: An opportunity for understanding epidemiological evidence

James Nicholson and Sean McCusker  
Northumbria University, UK  
[j.r.nicholson53@gmail.com](mailto:j.r.nicholson53@gmail.com)

*The government in England in 2024 initiated a wide-ranging review of curriculum and assessment across all subjects and ages. There is a broad consensus in the UK that data education should be across multiple subject areas. Ridgway (2022) sets out the rationale for Civic Statistics as an important element of the curriculum. We will review the literature on how epidemiology has been used recently in various innovative curricula. The drive for the introduction of Civic Statistics in curriculum reflects the public need to better understand information about the state of society. Epidemiology is inherently important in this context, as mis-information and dis-information about Covid-19, other diseases and vaccinations in general, has been increasingly problematic in an age where social media is the predominant source of information for many people, especially in the younger generations. Epidemiology offers a context in which the interplay between policy and evidence is immediate and transparent.*

### INTRODUCTION

The government in England in 2024 initiated a wide-ranging review of curriculum and assessment across all subjects from age 5 to 18. As education is one of nine policy areas for which responsibility has been devolved to the administrations in Scotland, Wales and Northern Ireland, each of them is currently undertaking a curriculum review as well. There is a broad consensus in the UK that data education should be across multiple subject areas. Smith (2004) noted the desirability that statistics and data handling be integrated with other subjects. The Royal Society (2023) proposed that Mathematics in the school curriculum be renamed *Mathematical and Data Education*. Concern about the quantitative skills in social science and humanities undergraduates led to the creation of seventeen Q-STEP centres across the UK in 2013-14. Initially funded by the Nuffield Foundation and one of the UK government funding agencies, the ESRC (Economic and Social Research Council), in 2022 they moved to being funded by the universities themselves. As part of the same concern over quantitative skills in social science, in 2010-11 Nuffield funded the *Reasoning from Evidence* project at the SMART Centre at Durham to produce data visualisation resources for three of the option areas of study in A-level Sociology: Education, Health and Crime & Deviance. While this has been a prevailing view for some time, the curriculum structure in the UK is extremely difficult to make changes to because of the national regulatory framework, particularly for the high stakes assessments at ages 16 and 18. Therefore the possibility to make substantive changes now represents a generational opportunity.

### CIVIC STATISTICS

Ridgway (2022) sets out the rationale for Civic Statistics as an important element of the curriculum. The drive for the introduction of Civic Statistics in curriculum reflects the public need to better understand information about the state of society. Current curricula largely ignore the large data repositories that offer open access data affecting the daily lives of almost everyone. Important contexts such as climate change, use of pattern recognition and automated decision-making, poverty, migration, epidemiology are all complex, nuanced, multi-faceted social problems. While formal analysis of data within these contexts is beyond the scope of school education, data visualisations and simulations offer opportunities for students to explore them in ways that were not available before. This paper will focus on just one of these areas. Epidemiology is inherently important in this context, as mis-information and dis-information about Covid-19, other diseases and vaccinations in general, have been increasingly problematic in an age where social media is the predominant source of information for many people, especially in the younger generations. Critical evaluation and reflection are habits of mind. Epidemiology offers a context in which the interplay between policy and evidence is immediate and transparent. Young people can be asked to compare models and theories as to which matches the empirical evidence more closely; can be asked to consider trade-offs, for example between individual rights and collective responsibilities; and can model the spread of disease, including the effect of parameters which could be modified by policy. Ridgway et al. (2018) summarises the 3 dimensions and

11 facets of Civic Statistics in the framework proposed by the ProCivicStat project (2015-18). While some of these facets have been part of traditional statistics courses for a long time, there are notable additions. Within the Knowledge dimension, *Facet 4: Statistics & Risk*; *Facet 5: Models, patterns, and representations*; *Facet 6: Methodology & enquiry processes* would all be largely familiar, but *Facet 7: Extensions in official statistics* and *Facet 8: Contextual civic knowledge* would not. Within the Engagement & Action dimension, *Facet 2: Critical evaluation & reflection* would be an aim of many current courses, but it takes on greater significance in conjunction with *Facet 1: Meaning for social policy*. Gal et al. (2022) provides a fuller articulation of the Civic Statistics Framework. There have been several projects over the years which have developed resources to teach epidemiology at school level. We will describe four projects, and summarise some work on modelling using Covid-19 as a context before discussing how this might be introduced in school curricula.

#### COVID-INSPIRED DATA SCIENCE EDUCATION THROUGH EPIDEMIOLOGY (CIDSEE)

Mokros et al. (2021) describes the genesis of this NSF funded project. Martin et al. (2022), Noyce et al. (2022), Noyce et al. (2023) provide a fuller description of the project and its rationale. When Covid-19 hit in early 2020 and quickly disrupted almost every aspect of life across the globe, they recognised that the pandemic offered an extraordinary example of the relevance of data science, and that there was an opportunity to teach children about data. Rich data resources were being updated by reputable sources daily; new ways to communicate that data were being developed in addition to the existing range of data tools and visualisations that already existed. The disruption to education and family life left many young people struggling with how to cope with a level of uncertainty they had not experienced previously in their lives, so the data mattered at a visceral level. The approach was for one of the team, Penny Noyce, who is a qualified physician, to write a science fiction novel, *The Case of the Covid Crisis* (Noyce, 2020), and for Jan Mokros and Jacob Sagrans and the Boston Museum of Science staff to come up with activities for each week for the new chapter written by Penny between April and June 2020. The CIDSEE project developed that initial initiative, and in 2021 it was funded by the National Science Foundation (NSF's) Innovative Technology Experiences for Students and Teachers (ITEST) program (grant no. DRL-2313212). It provides Data Detectives Clubs with data activities and challenges built around a science adventure novel now titled *Pandemics!* (Noyce, 2023). The novel follows the time travels of two young people, living through Covid-19 themselves, to different places and times to learn about past epidemics and pandemics, including outbreaks of measles, smallpox, the 1918 flu, Nipah, Ebola and polio. It was designed for use in afterschool clubs or summer camps, for middle-school ages, with 11 sessions each based on a chapter of the book. That use of historical narrative captures the development of medicine, and science more generally, in dealing with disease, complete with the uncertainties, mis-steps and controversies that accompanied it. The strength of the programme lies in the combination of data based activities and activities involving social and emotional learning (SEL), allied to brief virtual visits with epidemiologists and others working on infectious diseases. The science adventure framing allows 'science explanatory videos' to be used in a way which sits naturally in the sessions. NetLogo was used for simulations, and CODAP (Common Online Data Analysis Platform) used to work with data from the simulations, with time series data about COVID infections and vaccinations, and making comparisons between demographic groups, and between countries. This meant that there was balanced input between the epidemiology and the data science. Importantly, there is a four to six hour professional development programme introducing the leaders of the Data Detectives Clubs to the epidemiology and data concepts, and CODAP as well as the youth activities and career connections. The project had reached 1085 students in 72 clubs across 12 different US states by the end of 2024. The principal investigators of CIDSEE were aware of Ridgway (2022) as the project was underway and felt that the materials they had developed fell squarely within Civic Statistics, and that the framework could provide a useful evaluation tool for CIDSEE. Nicholson & Ridgway (2024) reported on that evaluation in more detail, but we want to focus here on the opportunities afforded to students in CIDSEE to engage meaningfully with facets 1 & 2 of the framework, namely *Meaning for Society and Policy* and *Critical Evaluation and Reflection*. During the programme, students are faced with many opportunities to explore effectiveness of enforcing a variety of mitigation policy mechanisms, from compulsory vaccinations to quarantine, and other approaches like herd immunity. The materials highlight the role of scientific investigation and modelling of very complex phenomena,

in order to inform action. Critical evaluation and reflection are stimulated by thought-provoking questions, by comparing theories and models, and by choosing what policies to implement in life & death scenarios, in time-limited circumstances, where imperfect information is all that is available.

#### THE INSTITUTE FOR RESEARCH IN SCHOOLS (IRIS) - BIG DATA: COVID-19

IRIS is a UK charity that was set up to provide opportunities for young people to participate in cutting edge research and to collaborate with leading universities and institutions while still at school. It particularly targets participation in schools serving communities in areas of deprivation, aiming to break down barriers that impact underrepresented young people entering STEM careers. When COVID-19 appeared, the standard IRIS model of expert support could not be followed, so they produced a suite of teaching materials, freely available online for teachers to download and use (IRIS, 2020). The resources give a broad insight into the variety of backgrounds of people working in epidemiology, and the cross-disciplinary nature of the work. There is also a powerpoint for whole class teaching and discussion that introduces communicable and non-communicable diseases, and the elements of public health emergencies. The ambition of the project is very much about the data, but emphasising that if you want to understand the data you need to understand the context, hence there is also a strong focus on the virology, transmission and clinical presentation of Covid-19. The substantive task in the first part is then based on a fictional disease ‘Exan-21’ and students are being asked to be part of ‘task force’ to advise the government. The task is structured so that students work independently in small groups on 7 different questions and then reconvene to each present their conclusions & advice to the government. They have 2 documents – information about Exan-21 and its transmission, and an additional information booklet which has statistical information about the demographics in the UK, so responding to the questions is fairly data intensive. Once the pandemic restrictions were lifted, IRIS returned to their normal model with *Big Data: Covid-19* (IRIS, 2022) which expanded the previous materials to include seminars and training packages on the virology of COVID-19 and epidemiology analysis using Excel and ‘R’ – the mathematical statistics programming language. The unique aspect of IRIS projects is that students propose a research question of their own – they are provided with guidance notes and suggested themes to explore, and support is available. In this project the support for R is particularly demanding of IRIS resources. Students, individually or in groups, submit a poster presentation of their research and have the opportunity to present it at one of the student conferences IRIS hold in June. These are in the style of professional academic conferences, with a keynote speaker, two sessions of student research presentations plus two poster sessions. So most students will present through their poster, but a few will present to the full conference of several hundred students, academics, teachers and scientific researchers. Research investigations on Covid-19 included Derby College (2023) which compared different government approaches to lockdown in the UK and in New Zealand, and investigated the effect on the number of Covid deaths. Dartford Grammar School for Boys (2024) compared the effect on recreational behaviour in India and the USA in relation to the numbers of new Covid-19 cases being reported. In both investigations the students had identified and accessed relevant information from open source data repositories, and analysed it to answer their chosen research question. This seems to be the most comprehensive attempt to engage students with both data science and the science of epidemiology. However, the level of specialist resources and support available to students from IRIS exceeds what would be feasible for large scale implementation if epidemiology were to be introduced into the curriculum.

#### CONTAGIOUS MATHS – NRICH

NRICH is a mathematics education organisation which is part of Cambridge University Mathematics Department, and part of MMP – the Mathematics Millenium Project, focused on providing open access rich problem-solving activities. Julia Gog is the new Academic Director of MMP, and Professor of Mathematical Biology in the Department of Applied Mathematics and Theoretical Physics at Cambridge University. Julia contributed to the scientific advice to the UK government during the COVID-19 emergency, as a member of the modelling group SPI-M (Scientific Pandemic Infections Group on Modelling), and as a participant of SAGE (Scientific Advisory Group for Emergencies). The Royal Society awarded her the Rosalind Franklin Award and Lecture for her achievements in the field of mathematics, and she chose to use the project component of her award to produce resources for Key

Stage 3 (ages 11-14) maths pupils and teachers exploring the curriculum in the context of modelling epidemics and infectious diseases and showing how maths can change the world for the better. Figure 1 shows an excerpt from an interview with The Royal Society (2024) about the award:

The 11-14 age we are targeting is a real crunch point for retaining girls in maths, and future female mathematicians. What exactly happens is complex and multifaceted, but this is a period when people form their views on how they fit with maths and science. Many disengage as it can seem that “maths” at school is utterly disconnected from the real world. It can also be a time when maths appears very starkly right or wrong, whereas any research mathematician can tell you it’s always so much more subtle than that, and therefore so much more interesting!

Figure 1. Quote from Julia Gog about Contagious Maths resources.

The materials (NRICH, 2021) are presented in four parts, and each has teachers’ resources to support delivery in the classroom and activities to develop and explore key ideas. In each part there are several short videos of Julia Gog discussing the next stage of developing a model, or an aspect of the virology or transmission of an infectious disease. Desmos is used to introduce what exponential growth is, and the effect of changing the value of  $R_0$  on the way the disease spreads. Modelling the spread of disease is initially done by a physical ‘lucky dip’ simulating the process, and once that is established in students’ minds it is speeded up by making it electronic. Over the different sessions, the model is made more sophisticated as it begins to take account of more of the factors that account for the randomness of human behaviour and interactions, and of variations in physiology and susceptibility to infection, including whether individuals have been vaccinated. The simulations are bespoke artefacts for this project, and allow users to vary different parameters to explore how they affect the spread of the disease, and to consider how they match observed behaviour. Some of the visual representations are not easy to relate to the parameters in the model, to follow the spread of the disease, but the simulations introduce a very impressive array of factors. There are a variety of settings in which the disease can be introduced, where the population behaviour is quite different – including ‘party’, ‘visitors’ and ‘commute’ which is a really nice feature of the materials, illustrating how introducing restrictions on social behaviour can affect the spread of the disease. There are also discussions exploring the practical decisions about who should be vaccinated if there is a limited supply, and the ethical issues that arise. A second version of the materials has been developed for use with older students, where MMP have produced a number of accessible articles on different aspects of contagious diseases, and on the mathematics involved.

#### AFRICAN MATHS CAMPS

IDEMS (Innovations in Development, Education and the Mathematical Sciences) is an International Community Interest Company. Supporting African Maths Initiatives (SAMI) is a UK charity established by mathematics educators in UK to support initiatives in mathematics education in Africa, and they have taken over responsibility from IDEMS for overseeing and supporting these camps – which operate in Kenya, Ghana, Ethiopia mainly, but have also been done in other countries. Typically the camps would cover several different activities over the course of the week that the students were in attendance. The activities would vary depending on the expertise and experience of the volunteer staff - the camps are staffed by local and international volunteers, who gather for two weeks – the first week of planning, and the second week is running the camp with students. There has often been someone with some background in epidemiology, and it proved to be a very engaging context for the students. While detailed content varied, the epidemiology activities typically had a physical simulation initially, followed by electronic simulations. The physical activity sometimes involved throwing a die to decide if a contact got infected. Alternatively, students each got an ID number and then mingled, recording ID numbers of those they met, in several stages. Then one ID was selected at random, and contact tracing was performed to see how the disease had spread in the several stages before any symptoms would have appeared. Again, dice could be used to simulate whether infection occurred in a contact. Activities such as these lay the foundation for the students’ understanding of the processes at work when the electronic simulations are introduced. Two particular vehicles for simulating spread of disease were employed. Brockman (2025) has a website which hosts collections of interactive models (Complexity Explorables) for complex systems including epidemiology. The suite of epidemiology simulations allow exploration of herd immunity, and how changing transmission rates, vaccination rates, recovery rates etc. affect the

behaviour of the disease, and offer the opportunity to explore how different population structures affect the behaviour. GLEAMviz (2022) offers a much more sophisticated modelling environment. It uses real-world data on population and mobility networks to generate data driven simulations of the spread of infectious diseases. The physical activities in the maths camps used parameters typical of measles, and of Ebola, and the camp instructors then constructed GLEAMviz simulations of a measles outbreak in Accra (for use in a camp in Ghana), and of an Ebola outbreak in Monrovia (for use in a camp in Liberia). While it can be used at school age level, the GLEAMviz environment offers almost unlimited scope for exploring more complex models and the interaction with real-time population movement data as an integral part of the process offers the opportunity for it to be used in research.

#### MATHEMATICAL MODELLING USING COVID AS CONTEXT

Modelling has been an explicit component of the prescribed mathematics curriculum in UK schools for a long time. However, modelling is difficult to assess reliably, and consequently the taught curriculum often does not reflect its importance in developing mathematical thinking. McCusker et al. (2010) discussed some of the longstanding issues in statistics assessment shaping the taught curriculum, including the use of inappropriate contexts, and questions where the context was irrelevant. When COVID-19 appeared, there were a number of papers published describing opportunities for using it as a context to teach modelling, both at school and college levels, and others describing challenges and opportunities for integrating data with other subject disciplines. The following describes only a small sample of these papers. Ridgway (2021) presents a powerful argument for using epidemiology as a vehicle for teaching data science. Life and death decisions had to be made while uncertainty reigned about key aspects of the disease – how dangerous it was, how it was spread, how quickly it would spread, what changes in population behaviour might mitigate the speed of spreading or the seriousness of the health outcomes. With the experience of COVID-19 still vivid, there is no doubt this is a real-world problem to engage young people with. While some of the unknowns when COVID-19 first appeared are better understood now, it is likely that the next pandemic will face similar challenges. Meyer and Lima (2023) identify some difficult challenges in modelling a social situation like COVID-19: that there are no ‘correct answers’, only adequate approximations, and many mathematics teachers are not experienced in, or comfortable with, mediating the cycling process of developing a better model. See the International Data Science in Schools Project (IDSSP), (2019) for more details of this process. Berg and Hawila (2021) argue that the software R provides the best vehicle for teaching a data science curriculum developed using the IDSSP framework, and discuss how it can be used to explore COVID-19 death rates and how they vary with other risk factors such as age, diabetes, cardiovascular disease and hypertension. Gal and Geiger (2022) analyse the statistical and mathematical demands of media items related to COVID-19 in what they characterise as *the era of vague news*, which they describe as where uncertainty and margins of error form a critical element of the information being reported. Maass et al. (2023) and Weber-Stein and Engel (2022) look at the opportunities presented by COVID-19 to integrate mathematical modelling with citizenship education. The World Health Organisation (2020) identifies particular health challenges in a world where misinformation and disinformation is becoming ubiquitous. Cazorla et al. (2023) offer some reflections on how statistics education can engage in projects that involve cross-cutting contemporary themes on important social issues.

#### DISCUSSION

Identifying ‘Ratio, proportion and rates of change’ as a high level domain was arguably the most significant change in secondary school mathematics education in the past fifty years. This was a recognition that moving from additive to multiplicative reasoning is fundamental in the development of mathematical thinking. We believe that embracing real world complexity in data should be the next major change: very few real world contexts are adequately described by one or two variables and yet the mathematics curriculum does almost nothing with more complex data, and two variables are usually constrained further by restricting them to contexts where a linear model + random variation is assumed (often with little justification). Relationships are often non-linear and variables interact with one another. We are definitely not advocating the introduction of multivariate analysis into the school curriculum, but describing stories in data with 3 or 4 variables in meaningful contexts is well within the capability of most learners aged 11 up (see for example Nicholson et al. 2009, 2010, 2011, Ridgway & Nicholson,

2010, Ridgway et al., 2008). ‘Playing with data’ in complex contexts seems to free students from some of the inhibitions which constrain them in mathematics – because there are obviously no ‘correct answers’ when describing the data. It would greatly enhance the teaching of other curriculum subjects, as well as increasing learners’ appreciation of the relevance and usefulness of mathematics. This is in line with the recommendations Smith (2004) made in 2004, as well as The Royal Society’s Mathematical Futures proposals (2023). Finzer (2013) argues that in the US also, data science has no natural home and that mathematics, physical and biological sciences, and the social sciences each have different reasons for resisting the inclusion of multivariate data within their curricula. He posits that the challenge is to figure out how to change educational systems so that students leave school equipped with data science skills and the conceptual understanding needed to function fully in society. The Institute of Mathematics and Its Applications (IMA) published a five year strategy plan (IMA, 2023) which has three broad strategic priority areas, including *Showcase and Develop Mathematics for Societal Challenges*. It specifically identifies three such challenges as examples: Climate Change, Artificial Intelligence and Disease Modelling. There is a great deal of work going on in the UK and elsewhere (see for example Department for Education, 2023, UNESCO, 2024 and The Royal Meteorological Society, 2025) to include climate literacy across multiple subject areas at school. We believe there is a strong case to be made to develop a framework for teaching epidemiology across multiple subject areas at school: pandemics, like climate change, present an existential threat, with the prevalence in both of misinformation and disinformation reinforcing the need for better educated citizens. Core ideas such as exponential growth, estimation, measurement, sampling, interpreting graphs, evaluating the quality and strength of evidence available at any given time, weighing the consequences of alternative policy choices have been shown to be accessible to school age students in the projects described above. Making predictions in the light of uncertainty, and understanding that such predictions will necessarily involve a range of likely outcomes rather than point estimates, are important in developing resilience. The availability of data to support students in exploring the validity of different models of disease spread for themselves is important, as is the existence of multiple interactive simulation interfaces which encourage exploration of the effects of changing parameters in models to better understand how effective interventions might be if they were able to change parameters such as transmissibility. A challenge in the projects described above is that students meet open-ended questions, placing a high demand on instructors to have the confidence to encourage students to follow independent lines of enquiry. Aggregated data can offer an overview of what is happening, and disaggregation by characteristics such as age, sex, ethnicity, occupation and health conditions like diabetes can be used to explore hypothesis of risk factors. Large sets of case level data are now available, and accessible to those with the capability to use more sophisticated software. Again, this will present challenges for the teaching workforce to be able to support its use in the classroom. There is perhaps an opportunity now for work to be done collaboratively by key innovators and experts in epidemiology, data science and education policy to provide guidance about how data-centred epidemiology might be taught at school level.

## REFERENCES

- Berg, A., & Hawila, N. (2021). Some teaching resources using R with illustrative examples exploring COVID-19 data. *Teaching Statistics*, 43(S1), S98–S109. <https://doi.org/10.1111/test.12258>
- Brockmann, D. (2025). *Complexity Explorables (Epidemiology)*. Complexity Explorables. <https://www.complexity-explorables.org/fields/epidemiology/>
- Cazorla, I. M., Monteiro, C. E. F., Carvalho, L. M. T. L. d., Carvalho, R. N., & Carvalho, C. F. d. (2023). Possibilities of the COVID-19 pandemic context for statistics education: Some reflections. *Em Teia Revista de Educação Matemática e Tecnológica Iberoamericana*, 14(3), 201–223. <https://doi.org/10.51359/2177-9309.2023.256603>
- Dartford Grammar School for Boys. (2024). Big data: COVID—The effect of new daily COVID cases on recreational mobility.
- Department for Education. (2023, December 20). Sustainability and climate change: A strategy for the education and children’s services systems. GOV.UK. <https://www.gov.uk/government/publications/sustainability-and-climate-change-strategy/sustainability-and-climate-change-a-strategy-for-the-education-and-childrens-services-systems>

- Derby College. (2023). How UK and New Zealand approaches to lockdown affected the number of COVID deaths. [https://researchinschools.org/wp-content/uploads/2023/09/L041\\_BDC\\_DerbyCollege\\_different-government-approaches-for-lockdown-in-the-UK-and-New-Zealand\\_NS.pdf](https://researchinschools.org/wp-content/uploads/2023/09/L041_BDC_DerbyCollege_different-government-approaches-for-lockdown-in-the-UK-and-New-Zealand_NS.pdf)
- Finzer, W. (2013). The data science education dilemma. *Technology Innovations in Statistics Education*, 7(2). <https://escholarship.org/uc/item/7gv0q9dc>
- Gal, I., & Geiger, V. (2022). Welcome to the era of vague news: A study of the demands of statistical and mathematical products in the COVID-19 pandemic media. *Educational Studies in Mathematics*, 111, 5–28. <https://doi.org/10.1007/s10649-022-10151-7>
- Gal, I., Nicholson, J., Ridgway, J. (2022). A conceptual framework for civic statistics and its educational applications. In J. Ridgway (Ed.) *Statistics for empowerment and social engagement: Teaching civic statistics to develop informed citizens* (pp. 37–66). Springer. [https://doi.org/10.1007/978-3-031-20748-8\\_3](https://doi.org/10.1007/978-3-031-20748-8_3)
- GLEAMviz (2022). *GLEAMviz*. <https://www.gleamviz.org/>
- Institute of Mathematics and Its Applications (2023). *IMA strategy 2023–2028*. <https://cdn.ima.org.uk/wp/wp-content/uploads/2023/12/IMA-Strategy-2023-2028-FINAL.pdf>
- International Data Science in Schools Project (IDSSP) (2019). *IDSSP data science curriculum frameworks for schools* (Edition 1.0). [http://www.idssp.org/files/IDSSP\\_Data\\_Science\\_Curriculum\\_Frameworks\\_for\\_Schools\\_Edition\\_1.0.pdf](http://www.idssp.org/files/IDSSP_Data_Science_Curriculum_Frameworks_for_Schools_Edition_1.0.pdf)
- IRIS (2020). *It takes a community*. <https://researchinschools.org/projects/it-takes-a-community/>
- IRIS (2022). *Big data: Covid-19*. <https://resourcecentre.researchinschools.org/?projects=bigdata-covid19>
- Maass, K., Zehetmeier, S., Weihberger, A., & Flosser, K. (2023). Analysing mathematical modelling tasks in light of citizenship education using the COVID-19 pandemic as a case study. *ZDM – Mathematics Education*, 55(1), 133–145. <https://doi.org/10.1007/s11858-022-01440-9>
- Martin, L., Mokros, J., Deol-Johnson, N., Noyce, P., & Sagrans, J. (2022). Data detectives clubs: A collaborative approach to data science through epidemiology. Connected Science Learning. <https://www.nsta.org/connected-science-learning/connected-science-learningnovember-december-2022/data-detectives-clubs>
- McCusker, S., Nicholson, J., & Ridgway, J. (2010). Statistics assessment: The good, the bad and the ugly. In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the 8th International Conference on Teaching Statistics (ICOTS8, July, 2010)*. International Statistical Institute.
- Meyer, J., & Lima, M. (2023). Relevant mathematical modelling efforts for understanding COVID-19 dynamics: an educational challenge. *ZDM – Mathematics Education*, 55(1), 49–63. <https://doi.org/10.1007/s11858-022-01447-2>
- Mokros, J., Sagrans, J., & Noyce, P. (2021). Data Science for Youth in the Time of Covid. *Proceedings of the IASE 2021 Satellite*. <https://doi.org/10.52041/iase.hmtse>
- Nicholson, J. & Ridgway, J. (2024), New viruses are inevitable; pandemics are optional: lessons for and from statistics. *Teaching Statistics*, 46(3), 132–140. <https://doi.org/10.1111/test.12379>
- Nicholson, J., Ridgway, J. & McCusker, S. (2013) Health, wealth and lifestyle choices – Provoking discussion on public spending. *Teaching Citizenship* 36, 23–27.
- Nicholson, J., Ridgway, J., & McCusker, S. (2009). One small step for a pupil – one giant leap for citizens. In P. Murphy (Ed.), *Proceedings of the International Association for Statistics Education Satellite Conference, Next Steps in Statistics Education*. Durban SA: International Association for Statistical Education. <https://doi.org/10.52041/SRAP.091001>
- Nicholson, J., Ridgway, J., & McCusker, S. (2010). Luring non-quantitative majors into advanced statistical reasoning (and luring statistics educators into real statistics). In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the 8th International Conference on Teaching Statistics*. International Statistical Institute.
- Nicholson, J.R., Ridgway, J. and McCusker, S. (2011). Visualise then conceptualise. *Social Science Teacher*, 40(3), 8–13.
- Noyce, P. (2020). *The Case of the Covid Crisis*.

- Noyce, P. (2023). *Pandemics!*
- Noyce, P., Mokros, J., Finzer, W. (2023). Data Detectives Clubs: Narrative, data, and sound. (Concord Consortium Newsletter). <https://concord.org/newsletter/2023-spring/data-detectivesclubs-combine-narrative-data-and-sound/>
- Noyce, P., Mokros, J., Martin, L. & Sagrans, J. (2022). Integrating Technology and Narrative to Engage Young Adolescents with Covid Data. In S. Peters (Ed.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11)*. [https://iase-web.org/icots/11/proceedings/pdfs/ICOTS11\\_112\\_NOYCE.pdf](https://iase-web.org/icots/11/proceedings/pdfs/ICOTS11_112_NOYCE.pdf)
- NRICH (2021). *Contagious maths: understanding the spread of infectious diseases*. <https://nrich.maths.org/contagious-maths-understanding-spread-infectious-diseases-0>
- ProCivicStat (2015–2018). Promoting civic engagement via explorations of evidence. <http://iase-web.org/islp/pcs/>
- Ridgway, J. (2021) Covid and data science: Understanding  $R_0$  could change your life. *Teaching Statistics*, 43(S1), S84–S92. <https://doi.org/10.1111/test.12273>
- Ridgway, J. (Ed.) (2022). *Statistics for Empowerment and Social Engagement: Teaching Civic Statistics to Develop Informed Citizens*. Springer. <https://doi.org/10.1007/978-3-031-20748-8>
- Ridgway, J., Nicholson, J., & McCusker, S. (2008). Alcohol and a Mash-up: Assessing Student Understanding. *Proceedings of the ENAC biannual conference*.
- Ridgway, J., Nicholson, J. & McCusker, S. (2007). Reasoning with multivariate evidence. *International Electronic Journal of Mathematics Education*, 2(3), 245–269. <http://dx.doi.org/10.29333/iejme/212>
- Ridgway, J., Nicholson, J.R., and McCusker, S. (2010). Pupils reasoning with information and misinformation. In C. Reading (Ed.), *Data and context in statistics education: Towards an evidence-based society. Proceedings of the 8th International Conference on Teaching Statistics (ICOTS8, July, 2010), Ljubljana, Slovenia. Voorburg, The Netherlands: International Statistical Institute*
- Ridgway, J., & Ridgway, R. (2022). Covid-19 shows why we need civic statistics: Illustrations and classroom activities. In: J. Ridgway (Ed.), *Statistics for empowerment and social engagement: Teaching civic Statistics to develop informed citizens* (pp. 297–319) Springer. [https://doi.org/10.1007/978-3-031-20748-8\\_12](https://doi.org/10.1007/978-3-031-20748-8_12)
- Ridgway, R., Nicholson, J. & Gal, I. (2018). Understanding Statistics about Society: A Framework of Knowledge and Skills Needed to Engage with Civic Statistics. In M. A. Sorto (Ed.), *Looking back, looking forward. Proceedings of the Tenth International Conference on Teaching Statistics (ICOTS10)*.
- Royal Meteorological Society (2025). *A curriculum for climate literacy*. <https://www.metlink.org/wp-content/uploads/2025/05/A-Curriculum-for-Climate-Literacy.pdf>
- Royal Society (2023). *A New Approach to Mathematical and Data Education*. <https://royalsociety.org/-/media/policy/projects/maths-futures/new-approach-to-mathematics-and-data-education.pdf>
- Royal Society (2024). *Bringing infectious diseases into the maths classroom*. <https://royalsociety.org/blog/2024/02/bringing-infectious-diseases-into-the-maths-classroom/>
- Smith, A. (2004). *Making mathematics count: The report of Professor Adrian Smith's inquiry into post-14 mathematics education*.
- UNESCO (2024) *Greening curriculum guidance: Teaching and learning for climate action*. <https://www.unesco.org/en/articles/greening-curriculum-guidance-teaching-and-learning-climate-action>
- Weber-Stein, F., & Engel, J. (2022). *The COVID-19 Crisis as a Challenge for the Integration of Statistical and Citizenship Education*. In S. Peters (Ed.), *Bridging the Gap: Empowering & Educating Today's Learners in Statistics. Proceedings of the 11th International Conference on Teaching Statistics (ICOTS11)*. <https://doi.org/10.52041/iase.icots11.T1E1>
- World Health Organisation (2020). *Managing the COVID-19 infodemic: Promoting healthy behaviours and mitigating the harm from misinformation and disinformation*. <https://www.who.int/news/item/23-09-2020-managing-the-covid-19-infodemic-promoting-healthy-behaviours-and-mitigating-the-harm-from-misinformation-and-disinformation>