Shattering the Subject Silos: Learning about Big Questions, Working Scientifically and Epistemic Insight

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We live in an age of rapid change with pressures that are increasingly global alongside the everyday stresses and successes created by our individual lives. The rapid pace of change is driving opinion on what type of education can best prepare pupils for the challenges and opportunities that are ahead. In its perspective on this issue, the Organisation for Economic Co-operation and Development (OECD) emphasises the importance of equipping young people with the expertise, attitudes and values that they will need to contribute to and benefit from an inclusive and sustainable future. The OECD explains that future-ready students will need several different types of knowledge. One of these types is "Epistemic knowledge, or knowledge about the disciplines, such as knowing how to think like a mathematician, historian or scientist" (OECD 2018, p. 5). Citizens of the future will need to appreciate the natures of individual disciplines and how to conduct an enquiry within a discipline. They will also need a working knowledge of how disciplines can work together to address real world questions and big questions that bridge the sciences, religion and wider humanities. The new Ofsted education inspection framework (OFSTED 2019) is also calling for a change of focus from an education designed to get good test results to a more holistic view of the curriculum. As Chief Inspector Amanda Spielman (2018) comments, the curriculum should not be formed from isolated chunks of knowledge, identified as necessary for passing a test. Their new inspection methodology considers two main categories of knowledge-related objectives. *Substantive knowledge* (sometimes called content or conceptual knowledge) is the knowledge that has been gained through a discipline, such as knowing that rivers flow towards the sea and being able to identify the parts of plant. *Disciplinary knowledge* is knowledge about a discipline - or in other words, epistemic knowledge.

This article describe a large-scale research project that is taking place in multiple settings designed to help educators to overcome pressures and barriers that currently limit the teaching of epistemic knowledge. The article focuses on a central and topical aspect of the wider research which is a concern about how the nature of science is widely perceived and whether students have sufficient opportunity to explore ways that science and other disciplines can help us to address Big Questions and complex real world problems. We draw on current events and strategies being considered and introduced to respond to the corona virus to highlight some of the reasons for having an education system that enables our current and future generations to build a good understanding of the nature, power and limitations of science.

In particular our interest in epistemic knowledge is heightened by concerns about whether and how schools develop students' understanding of ways to address Big Questions about the nature of reality and human personhood. Examples of Big Questions include, 'How should individuals and society respond to a new virus?' 'Can a robot ever own its own ideas?' 'How can we best take care of the earth?' and 'To what extent are individuals responsible for how they behave?'. These types of questions are typically squeezed out of many subjects in secondary schools because they bridge science and other disciplines and can be morally and religiously sensitive (Billingsley, Brock, Taber, & Riga, 2016). When this tendency is combined with a focus on content knowledge over epistemic knowledge it means that young people miss out on opportunities to consider and compare how different disciplines address big questions.

Take for example, the idea that knowledge should be underpinned by a strong evidence base. Gathering and assessing data to form an evidence base applies in many disciplines and not only science. And yet scientific knowledge has a reputation for being more reliable than other types of knowledge, so why is that? In an interview study with 61 students, two thirds (41) described science using terms such as facts, certain and experimentally proven (Billingsley et al. 2016). Isobel in Year 9 said, "Science is there for you as a fact and you don't really question it." Students also widely said that they see science working for themselves in the classroom and that the science teacher talks with authority. Glenn (year 7) contrasted RE (religious education) lessons and science lessons on the origins of the universe, saying, "an RE teacher kind of lets you have more questions and stuff, I think. You know, they're like, 'What do you believe?' whereas a science teacher is more, 'This is what happened,' you know, 'These are the facts I've been told to teach you,'" Ferdinand (Year 11) felt that science is "stronger" than religion, and explained that this was apparent to him because "we generally have more science lessons than RE lessons" (Billingsley et al. 2016, pp. 472-474).

We are hearing science and scientists mentioned a lot at the moment so how does the way that science is presented in politics and the media compare with the picture that we are teaching in school? COVID-19 is a case in point because many of the questions that the politicians are discussing are complex and multidisciplinary. They include questions about the impacts of directing people towards social distancing and isolation on their mental and physical wellbeing, questions about how to protect businesses and the economy and questions that are seeking to model how different patterns of behaviour might influence how quickly the virus spreads. The science curriculum in school covers the natural sciences, however the phrase, ‘scientific advice’ is being used by politicians to refer to advice from specialists in a wide range of fields. Advice about handwashing is relatively straight forward and the link with science (if needed) can help to reinforce the message. Many other questions are more difficult to address and they call on multiple factors, many of which in turn are interdependent. Which experts and which fields of research, for example, can best advise about the impacts of different strategies to limit movement and social interactions on the mental and physical health of the elderly? Further this question is then one of many that informs and interacts with proposals for how to control more widely how the virus spreads. To investigate how different strategies to guide public behaviour might impact on the spread of the virus, researchers cannot create comparison groups and randomly allocate the groups to different sets of rules. Instead the picture and factors we know about are loaded into mathematical models. We see a news report with a series of graphics generated by a computer running different models. For a moment everything that was uncertain and complicated seems to be reduced to addressing a simple question with mathematical relationships that are orderly and knowable. But while this tool can also inform our understanding and help us to respond as wisely as possible, it hasn’t really replaced our shared responsibility and agency. We know we cannot expect people to behave exactly like the scenario in a model and that we do not know the significance of factors that may not currently be in the model. Big questions and complex real world problems can rarely if ever be addressed through science alone. Even so, mathematical tools and scientific knowledge and methods are rightly described as invaluable and can and do significantly inform our thinking.

There is a pervasive view among school students that science is always right which is initiated and/or supported by the types of activities that students do in schools. We have a bedrock of scientific knowledge and methods that are a wonderful resource for individuals and society to call on. The curriculum doesn’t say, however, that science is always right and in practice, the level of confidence we can have depends on the question and its amenability to science. The key phrase used by the curriculum is ‘working scientifically’. Working scientifically includes knowing how to frame a scientific question (which is much smaller than a big question or complex real world problem) and appreciating the power and limitations of the natural sciences and their methods. The teaching of epistemic insight is a gap in our current education system that we are proposing to address. Research in science education points to some of the causes of the problem and also to the some of the benefits we can expect if we change our approach. Practical sessions in science should be opportunities for students to think and work like a scientist. However in reality very little time if any is given to examining and discussing the questions and methods that scientists use (Abrahams 2017). Instead students follow a prescribed method using apparatus that the teacher provides. This pedagogical engineering is intended to help students to arrive at an established scientific concept and so reinforce their substantive knowledge. At the same time, by limiting the type of question to one that is particularly amenable to science and then directing students to a particular way to investigate, teaching can foster a misperception that science can answer any type of question given time and that science consists of a set of facts that are experimentally proven (Billingsley 2017). The risk associated with simplifying the process of science is that it fosters uncritical scientism (Billingsley and Nassaji 2019). Scientism is the view that science is the only valid way to construct knowledge and to understand the world (Stenmark 2013). Uncritical scientism is a label for a similar stance for use in education – to signify cases where this perception seems to have been assumed without insight into the arguments that scholars use to defend a range of views. Exploring the nature of science in real world contexts and in relation to Big Questions can build students' epistemic insight (Billingsley 2016) and also their interest in science (Byrne and Brodie 2013).

The Epistemic Insight Curriculum Framework

These concerns have motivated the Epistemic Insight Initiative which is a large-scale research and innovation project. The centrepiece of the initiative is a curriculum framework for epistemic insight which is designed to help tutors, teachers and student teachers link the epistemological dimension of the curriculum intent of individual subjects into a joined-up approach. The learning objectives in our current version are arranged into three categories designed to help schools to introduce them into existing timetables. These are: the nature of science in real-world contexts and multidisciplinary arenas, ways of knowing and how they interact, and the relationships between science and religion. The Framework can be freely viewed and downloaded from www.epistemicinsight.com

Resources to go with the framework encourage students' curiosity about Big Questions and also build their understanding of how to ask and investigate different types of questions. For example, the Discipline Wheel tool (Figure 1) provides a strategy to explore Big Questions through the lenses of multiple disciplines. Pupils place a Big Question or topic in the centre, such as "Is it true that you are what you eat?" or "what makes us human?", and then discuss how a selection of disciplines might help to investigate the question.

Another strategy is to give students a bridging question. This is a question posed by the teacher designed to prompt a comparative study of two disciplines. The Question Box tool (Figure 2) introduces a bridging question and contains objects and stimuli to prompt conversations about which disciplines we might call on to address it. By working in this way with a cross-disciplinary question, pupils learn about the nature of each discipline and also gain an insight into how much is lost if only one discipline is used to investigate and address the question.

The Bubble Tool [figure 3] helps students to recognise the distinctions between a big question and a smaller scientific question. It can be used to sort questions into those that are amenable, partly amenable or very amenable to science.

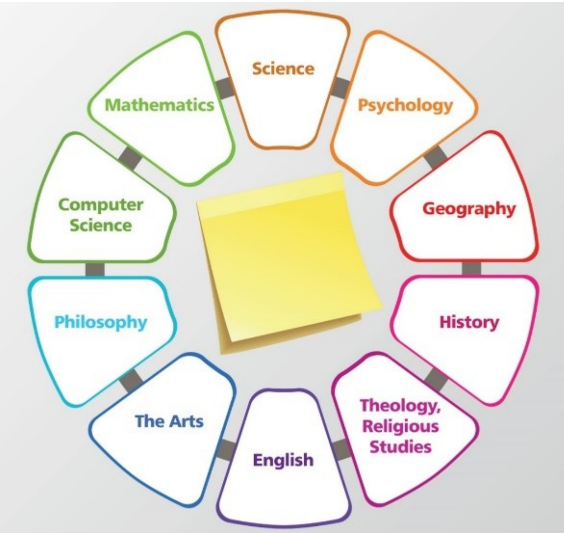

Figure 1

Figure 2

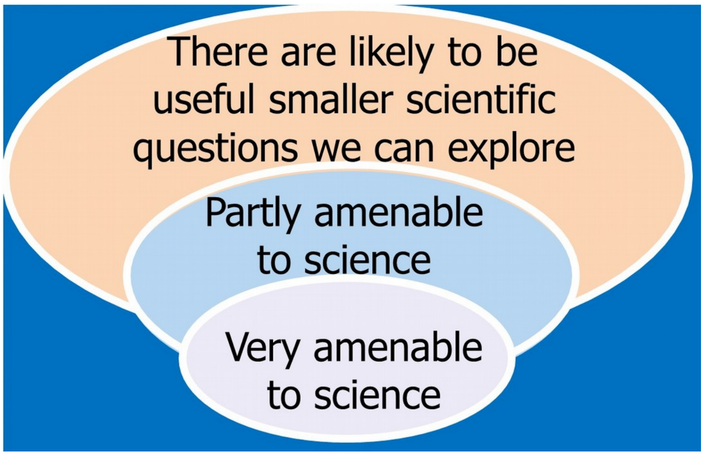

Figure 3 The Bubble tool can be used to sort questions

The Epistemic Insight Initiative

To test and refine the EI curriculum framework for a range of classrooms and settings, the research taking place as part of the initiative combines research-engaged teaching in teacher education institutions with a national research project in schools. Currently there are eight Higher Education institutions, led by Canterbury Christ Church University. By facilitating guided and independent research activities, tutors enable student teachers to experience a major research initiative while also becoming research-engaged and research informed in their academic studies and teaching practice; their research attends to a prescient issue within the curriculum and we anticipate will contribute to the trajectory and development of curriculum policy.

In secondary schools entrenched subject compartmentalisation is a barrier to setting up lessons to compare two or more disciplines. Several schools working with the Initiative are designing strategies that will mean students aged 11-14 experience more interaction between their subjects in a strand of the research called, *Permeable Walls*. Primary school teachers have opportunities already to work across subject and discipline boundaries but may want help with what to say about the nature of science and other disciplines. For this reason we provide professional development sessions in school along with workshops for students that teachers team-teach with researchers. Teachers and tutors are also co-creating the research methods and publications.

The work is supported by the Templeton World Charity Foundation, the Royal Academy of Engineering, The National Collaborative Outreach Programme and All Saints Education Trust. We are one year into a three year research plan and some early findings are beginning to emerge. We post news about the research and forthcoming events at www.epistemicinsight.com. To ask questions and/or explore ways to join the research please email the authors and others on the research team at LASAR@canterbury.ac.uk

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