Epistemic Insight

THE EPISTEMIC INSIGHT DIGEST

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FACULTY OF
ARTS, HUMANITIES & EDUCATION

Canterbury Christ Church University

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EDITOR'S WELCOME

Dr Dani Shalet

I am so happy to bring you the latest issue of the EI digest once again. With support from the Epistemic Insight Initiative and the FAHE (Faculty of Humanities and Education at CCCU) and collaborators we happily bring you issue 5, and I hope there will be many more to come. What makes this journal so important is that it gives a voice to not only academics, but students, teachers and collaborators. It enables those who may not feel that they have an opportunity to publish to do so, and to share their experiences and love of knowledge, EI, and education with a large and friendly community.

This issue is a very exciting edition as it enables us to share some thrilling news with you. An EI event will be held at the RSC (Royal Society of Chemistry) on Wednesday the 28th of September. This event will highlight a few projects we have in the pipeline fir the next phase of our research: The Future of Knowledge. This is an initiative that hopes to bring together a global community of educators, researchers, students, stakeholders, and other epistemophiles:

Please see the message below from Renato Opertti, Senior Expert, IBE-UNESCO:

The Epistemic Insight Initiative on the Future of Knowledge offers a superlative reworking of the nature, purpose, contents and strategies of education. The 'EI' strategy for transforming the curriculum, pedagogy, teaching and learning helps us to see what is needed to achieve the UNESCO vision of educating new generations for sustainable, fair, inclusive and peaceful futures. We need to explore, test, expand and share renewed ways of collaboration and integration among knowledge areas and disciplines to equip all learners to competently face disruptive challenges at present and in the future. Epistemological rearrangement of knowledge is crucial for strengthening the relevance of education, and for connecting the curriculum and pedagogy to societal opportunities and challenges. This is a pathway that brings together experts and practitioners from many different areas and fields, to realise the aspiration of better futures for our own and future generations.

RENATO OPERTTI
Senior Expert at the International Bureau of Education, IBE-UNESCO


Epistemic Insight
PROJECT VISION
WHAT IS THE FUTURE OF KNOWLEDGE?


Epistemic Insight
PROJECT VISION
in 2030
In a few decades society has been transformed by digital technologies like artificial intelligence, machine learning and algorithmic organization which can store, share, search and increasingly reformulate knowledge at a pace and scale unimaginable by those who created our systems and institutions for science and education.
WHAT WILL KNOWLEDGE LOOK LIKE?


Epistemic Insight
At the
ROYAL SOCIETY OF CHEMISTRY
in London
28TH SEPTEMBER 2022


Epistemic Insight
The Future of Knowledge
At The Royal Society of Chemistry
28th September 2022
Entry is free and by invitation.
Please contact:
LASAR@canterbury.ac.uk
for more information
The Royal Society of Chemistry at Burlington House is in London's Piccadilly, a five-minute walk from Green Park Underground Station.
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Burlington House,
Piccadilly, London,
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Venue telephone number:
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INTERDISCIPLINARY ENGINEERING EDUCATION - A NEED FOR THE 21ST CENTURY. HOW TEACHING EPISTEMIC INSIGHT CAN MOTIVATE AND EMPOWER ENGINEERING STUDENTS TO MAKE WISE AND COMPASSIONATE DECISIONS IN REAL-WORLD CONTEXTS

Dr Agnieszka J. Gordon, Sherry Simpson and Dr Hany Hassanin

Abstract.
This article describes a Higher Education (HE) Engineering workshop which aimed to develop foundation students' understanding of how to investigate a question through a multi-disciplinary lens; seeking responses from different disciplines including science, religion and the wider humanities. These activities are equally appropriate for KS4-KS5 students and have also previously been adapted for younger students. Two Big Questions were explored by student engineers, inviting them to think how different disciplines could answer the emotive question, 'How can we generate sustainable power using a wind turbine?', providing a rationale to justify their choices. Adopting an Epistemic Insight approach, they considered if engineering or STEM disciplines were sufficient to answer the question or whether the context needed to widen to examine other perspectives, for instance the sociological impacts for those living near a wind farm. Secondly, exploring 'Why did the "Titanic" sink?', initially from an engineering perspective, examining how historical knowledge of design and materials used can inform the present. The question was then investigated using a multidisciplinary approach to help students to better appreciate the power and limitations of distinct disciplines, particularly how they are shaped by the questions they ask, their methods and what they value in an answer (norms of thought). The workshop encouraged students to consider how Epistemic Insight can be a pathway to critically think about a Big Question or problem, and how different disciplinary perspectives provide a deeper, richer response. The results of the intervention, although in the preliminary stages, have been encouraging, working towards the learning outcomes of the Epistemic Insight Curriculum Framework.

Introduction.
Undoubtedly the world is rapidly changing, with unprecedented technological development and increasing challenges to society. In accord with OECD (Organisation for Economic Cooperation and Development, 2021), Billingsley and Hazeldine (2020) argue this acceleration is driving how education must adapt to prepare future citizens for the challenges and opportunities ahead. However, entrenched subject boundaries present within our education system can limit available disciplinary dialogue and a wider context in which to explore problems or questions, potentially leading to student knowledge gaps, confusions, and misperceptions (Billingsley and Ramos Arias, 2017), which are then taken forward into professional life. Amidst the global socio-economic forum, which aims to prepare humanity for a sustainable future, the OECD recognizes a need for students to *"think across the boundaries of disciplines…to connect the dots"* (OECD, 2018, p. 5), developing capability to apply a range of knowledge and skills to diverse or evolving situations. Teaching and learning that facilitates learning within and across domains of knowledge, engages in an interdisciplinary approach that aims to address real-world problems in a practical and compassionate way. By framing these multi-faceted problems as Big Questions, students have opportunity to develop epistemic insight - 'knowledge about knowledge' (Billingsley, 2017b), encouraging reflection of the distinct nature of different disciplines, nurturing intellectual curiosity, critical thinking skills and attitudes toward t learning (OECD, 2021).

It is evident from the OECD narrative that creativity and innovation are not the sole constructs of individual thinking but is borne out of the cooperation between experts drawing from their unique field knowledge, working collaboratively to create new knowledge and ideas. These notions are in accord with Epistemic Insight, which aims to help navigate different disciplinary perspectives and thus underpins an interdisciplinary alliance for development of transferable competencies such as creativity, critical thinking and curiosity. Therefore, Epistemic insight seems particularly pertinent to education of future engineers. The engineering profession is widely recognised to be interdisciplinary due to the professional demands on engineering practice [MEYERS, C. W. & ERNST, E. W., 1995; Mahmud, M.N, 2018]. Designing complex engineering, such as wind turbines, necessitates combining skills and knowledge from disparate disciplines: mechanical, civil, electrical and aeronautical engineering, environmental and sustainability engineering—to mention a few.

It has been recognised that in order to be successful in the 21st century's—fast paced global world--engineers not only need strong analytical skills, but also creativity, agility, compassion, high ethical standards and understanding of complex global societal and professional contexts [Lattuca, 2017]. However, despite this recognition of interdisciplinarity as being a key aspect of the profession, it is not always reflected in engineering education, particularly when drawing on knowledge outside the STEM disciplines. In addition, not much research has been performed on interdisciplinary education, particularly on development of interdisciplinary competencies [Lattuca, 2017]. Interdisciplinary teaching is similarly challenging for engineering education, as it is for secondary schools, as academic staff mostly consists of disciplinary specialists. Disciplinary specialisms start early at schools and therefore students can often perceive interdisciplinary learning as disjointed chunks of separate disciplines [Foley, 2016]. So, at undergraduate level students already see themselves through the lens of their chosen discipline, moreover this perception starts to be shaped as early as KS4. They continue to learn in a compartmentalised way through engineering curriculum, concentrating primarily on developing scientific enquiry and skills—mathematical and physical concepts, with relevant ethical considerations, particularly in teaching of biomedical engineering.

Consequently, young people are unable to develop skills to link knowledge across disciplines and understand specific questions, methods and relationships between them. This creates gaps in knowledges and results in inability to answer Big Questions fully and that is where epistemic insight can help.

To test how epistemic Insight could help engineering students develop a diverse set of interdisciplinary skills and knowledge, we worked with foundation engineering students at Canterbury Christ Church University, to develop their epistemic insight and demonstrate how epistemic insight and accompanying tools can help them solve complex problems in 21st century. We believe that for this purpose a synthesis of knowledge from a variety of disciplines is required, not only STEM disciplines, but including humanities and social science is also necessary. Our approach embraces the unique contribution of various disciplinary perspectives, integrating their insights into a more holistic approach.

We designed an evidence-based, interdisciplinary problem-solving set of teaching activities to help students to learn and understand what epistemic insight is and how it relates to their area of study. Students learned about interdisciplinary thinking, particularly how knowledge is acquired and how distinct disciplines ask and approach question and what methods they use. Secondly, in three practical activities students explored Big Questions related to engineering, adopting a wider approach by thinking through a variety of disciplinary lenses. Initially students investigated mainly STEM disciplines, asking relevant questions before applying other relevant disciplines from humanities and/or social sciences. In groups, we encouraged them to explore and challenge their existing perspectives and biases.

Workshops - Interactive introduction to epistemic insight

The session began with exploration of what it means to be interdisciplinary. For the students interested in STEM, the focus is typically around hard scientific, technological and mathematical skills to develop ideas, models, or create new concepts. As anticipated, engineering students perceived those skills to be essential in pursuing their chosen path and inclusion of other disciplines seemed irrelevant to their area of study and chosen career. The facilitator's background in STEM interdisciplinary working assisted explanations to students' expressed doubts, considerations and questions about the relevance of humanities and social science perspectives within engineering.

Epistemic Insight Initiative (www.epistemicinsight.com) was introduced, briefly explaining the work across all school levels and within initial teacher education. Notably how entrenched compartmentalisation [Billingsley, B, Nassaji, M. and Abedin, M., 2017a] impedes students' abilities to link areas of knowledge, drawing on interdisciplinary thinking to solve complex problems. It was shown how learning in silos [Billingsley, Hazeldine,2020] limits appreciation of social, economic, and political aspects, pertinent to engineering. It was demonstrated how the engineering profession is interdisciplinary by nature and at least requires collaboration within a team of various disciplinary specialists. Although this is not always possible, an appreciation of how a range of skills and knowledge fit together would give them a competitive advantage in their future career.

Subsequently introducing a concept of a nature of discipline, explaining how knowledge about specific questions, methods and norms of thought helps to link disciplinary knowledge making connections and enhancing the ability for problem solving. We have shown, how epistemic insight can increase capacities for critical thinking about the nature, application and communication of knowledge. We stressed that epistemic insight goes beyond mere cross-curricular link enabling students to 'think like a scholar' (Billingsley & Lawson, 2020) and thus helps to address complex problems, whilst considering cultural, societal and emotional aspects.

The students had not heard about the project before, hence the concept of 'epistemic insight' seemed new and daunting at the start and completely alien to their area of study. By explaining that by epistemic insight we mean knowledge about knowledge (Billingsley, Simpson & Lawson, 2021) and how separate areas of knowledge interact and complement one another through their unique way of approaching the problem, they have begun to understand how epistemic insight can enrich their learning within engineering and beyond.

In this part of the activity, we explored questions, methods and norms of thought specific to science and engineering, contrasting and comparing a science enquiry with that in engineering. This was implemented through stressing a need for gathering observations and data, developing and testing models, and reproducibility of the data. We also stressed the importance of strengths and limitations of science and its nature as an ever-evolving knowledge rather than absolute and unchangeable truth.

Having introduced the epistemic insight approach, Big Questions were introduced, defined as questions about the nature of reality and human personhood, and whether such questions can be addressed through only one discipline. Group discussion were carried out to consider Big Questions such as: 'Can a robot be a good companion'? 'Can and should genetic engineering be used to make better people?'.

Finally, introducing the bubble tool and discipline wheel (LASAR, 2019a, b), epistemic insight pedagogical tools. The former can help break down a Big Question into smaller questions; identifying how some questions can be amenable to science and others require other disciplines to provide a richer answer. The discipline wheel helps investigate a question (placed in the centre), through appropriate disciplinary lenses (petals on the outside). The tool can be adapted to the Big Question of interest, and students can remove or add disciplines as appropriate to the question or problem they are exploring, using a wide range of disciplinary perspectives.

Students were encouraged to discuss and challenge the newly learned concepts by asking questions and exploring the disciplinary relevance with their peers and the facilitator. The students were very engaged and were clearly making connections between presented concepts and solving problems in new and exciting ways.

Activity 1. Wind turbines – identifying disciplines

To consolidate students' learning and test their understanding of key concepts, the first author designed and led a hands-on activity, closely related to current engineering topics. The aim was to strengthen the newly acquired epistemic insight and apply it to a Big Question, in this instance 'How to produce sustainable energy?' This was further focused to the specific and emotive challenges surrounding wind turbines. It was also interesting to explore whether students' perception of interdisciplinarity changed after learning about epistemic insight; and whether by actively exploring a problem closely related to their area of interest, would provide them with appreciation for the interdisciplinary nature of engineering and the relevance of epistemic insight to the challenges of modern engineering.

Initially, students were given their own unpopulated discipline wheel and were asked to explore the question 'How can we produce sustainable energy using a wind turbine?' And were encouraged to explore the Big Question, by asking themselves:

1. What discipline can answer this question? Please provide a rational for your answers.
2. Can this/these disciplines answer this question alone?

To ensure the students understood the term 'discipline', the term was explored with students, who showed a correct understanding of discipline as a scholarly branch of knowledge. The students worked in two groups of four, others chose to work with the questions and discipline wheel individually, and in pairs. They were encouraged to exchange their thoughts with their peers. The session was facilitated throughout, with the facilitator helping to shape discussions, prompting questions where necessary.

Applying their newly acquired knowledge, the students spent 10 minutes thinking which disciplines they might need to construct a wind turbine. To analyse all the aspects of creating a wind turbine, students used an unpopulated discipline wheel and wrote in the question' How can we produce sustainable energy using a wind turbine?' and collaborated to identify a range of relevant disciplines to answer it. Providing an unpopulated discipline wheel avoided leading them in their investigation, and enabled engagement with a creative activity, prompting critical thinking. It was also interesting to see whether they would identify disciplines outside STEM, which could help with the question.

The students were naturally drawn to STEM related disciplines, unsurprisingly they thought like 'engineers'. The facilitator's aim was to develop them into thinking like 'scholar' and a 'disciplinary specialist'. Initial analysis of the discipline wheel brought disciplines such as mechanical, aerodynamical, structural, civil and electrical engineering, computer science, physics, mathematics, environmental science, turbine engineering, marine biology, product design, they also mentioned business and logistics (Figure 1). The facilitator reminded them how current issues relate to STEM and a wider society, requiring input from other disciplines including humanities, social sciences, and the arts. This prompted consideration about surface and terrain, bringing geology into play and discussion related to weather and meteorology. They asked what discipline was related to the weather, which evidenced they were beginning to think about wider scholarly disciplines, rather than school subjects. Further facilitation initiated discussions about people's feeling regarding turbines which brought psychology and sociology into the picture. The English discipline was brought as needed for communication, descriptions, and report. The students shared their discipline wheels with their peers and briefly discussed them. Finally, the facilitator summarised students' work and presented their view on the disciplines involved. These are presented in Table 1:

Engineering/STEM	Humanities, social sciences and arts
Mechanical engineering – designing, prototyping and testing	Geography – space, weather (wind), location
Electrical engineering – planning, designing and manufacturing electrical parts	Sociology – would you like to live near the wind farm? Turbine noise?
Aeronautical engineering – aerodynamics, aeroelasticity	Politics – prevailing sustainability policies, different points of view
Civil engineering- structural strength, terrain	Economics – value for money; financial benefits
Chemistry/chemical engineering (materials and their properties– carbon fibres, glass fibres, natural fibres, composites)	Meteorology – weather consideration – observing and forecasting
Material design – shape of cylinder/turbine for efficiency and fit for purpose, beauty	History – is it good to build in historical places? How designing and building wind turbines changed overtime?
Computer engineering - programming and software; condition monitoring system	Business – value for money, quality versus efficiency
Physics and maths – fundamental knowledge underpinning all engineering	Aesthetics - Is it ok to build in beautiful places? Visual design of a wind turbine
Computer science – design, process control, maintenance	Law – meeting current regulations and legal requirements
Marine biology, ecology, environmental science – sea life; ecosystems; environment	Languages – creating documentation and conversations relevant to the context
Geology – seabed, terrain	

Table 1. How can we produce sustainable energy using a wind turbine – examples of relevant disciplines co-created by authors and students. This list is not exhaustive. The disciplines can be simplified for use at school, depending on the students' level of knowledge/interest.

Activity 2. An engineer's perspective

An examination of the Titanic design provided the topic for this example from the past, which can inform the present. Facilitated by author three, the students considered the design issues, of the Titanic, and tested a range of materials to explore why it sank. The engineering students engaged with this activity through a 3-D printed model demonstration [Figure 2] and material properties data. 3D printing or additive manufacturing is a technology that transforms a designer's idea to life by building 3D objects layer by layer according to a computer-aided design (CAD) file. Flexibility and customizability are key strengths. These advantages have enabled the technology to continue to disrupt the way people work in many sectors, including healthcare, aerospace, defence, and others. In education, 3D printing can be used to facilitate learning, improve technical skills and increase students' engagement. In preparation for the workshop, students worked with the third author on using 3D printers, and they went through all stages, from preparing the computer-aided design models to 3D printing using desktop printers. At the start of this activity, students were given 3D printed physical models of the Titanic to identify visible defects such as incomplete geometries, poor surface quality, and failed features. Students were first asked to work in groups to identify these defects and propose technical solutions. Students were actively engaged in these discussions with each other and with the third author, and the use of 3D printed models promoted critical thinking and greater student collaboration in identifying defects of 3D printed models. Students subsequently explored a question; 'Why the Titanic sank' from an engineering perspective. Group discussions were encouraged and those explored engineering ideas about the ship design, quality of the materials used to manufacture the ship and operational problems involved. The fracture toughness—material property—was explained and explored in relation to the ship design. Exploration involved a question: 'Why is fracture toughness of the material essential?', and 'How this property is measured?' The students linked this property to the poor quality of the rivets and ship hull materials found in the sunk Titanic. Students also explored the effect of temperature on the fracture toughness of the material and how temperature can degrade the material properties, and how this could be one of the reasons to aid the answer of the big question posed. This explanation provided the background topic for further exploration of this interdisciplinary question in activity 3.

Activity 3. Asking interdisciplinary questions

To consolidate students' newly acquired learning and to enable them to apply epistemic insight to a real problem, the second author designed and led a practical activity, which took advantage of their study of design and materials to learn from the past, as described previously by author three. To maximise understanding, students were invited to engage with Epistemic Insight, based on the hypothesis that typically, they will have experienced a fragmented subject specific curriculum in school which dictated pedagogical practice and student expectations of their learning (Billingsley, Nassaji and Abedin, 2017). It is argued that by missing out on Epistemic insight development in school, they will have experienced limited opportunity to move between knowledge domains and to ask questions outside the immediate subject area – thereby stifling student curiosity and critical thinking, whilst instilling gaps, confusions, and misperceptions in learning. This part of the workshop was therefore positioned as a starter activity within the Epistemic Insight Framework (Billingsley et al., 2018), encouraging students to appreciate how school and university are multidisciplinary arenas, by engaging with different disciplines, identifying preferred questions, methods, and norms of thought.

Big Questions were initially discussed, to provide the foundation HE students with opportunity to consider what these questions looked like, recognising that they are questions about being human and the nature of reality. In addition, how Big Questions often concern real-world problems i.e., sustainable energy, which is viewed as particularly pertinent to future engineers. The Epistemic Insight Initiative (Billingsley and Nassaji, 2019) has established that these questions benefit from an interdisciplinary response that goes beyond the boundaries of engineering knowledge to consider science, religion, and wider humanities perspectives. Furthermore, the workshop highlighted how Epistemic insight can be a pathway to achieving transferable competencies such as creativity, critical thinking and curiosity, described by OECD as the *"…mobilisation of knowledge, skills, attitudes and values…"* (OECD, 2018. p.5, 2021), which are demanded in response to the complex issues within today's global society.

The Epistemic Insight framework [Figure 3] offers an approach that recognises how disciplinary boundaries are shaped by their strengths and limitations, whilst appreciating how distinct disciplines frame and understand questions within the boundary of their methodology by focusing, on what is valued from an answer, through relative norms of thought. For example, a historian would ask questions about people or events from the past, answered through examination of a range of sources, checking for bias and motive, being open to interpretation.

If school curriculum has little space for questions unrelated to the subject classroom, then arguably there will be missed opportunities for students to develop epistemic humility, which is reasoned to be an intellectual virtue (Billingsley *& Lawson, 2020). The notion of epistemic humility is established through the limits of our individual knowledge construction, which is subjectively filtered and interpreted, highlighting how knowledge can be conditional, transient, and incomplete and may need revision when subject to new information (Matthews, 2006; Angner, 2020). Therefore, such humility seeks answers to Big Questions from other disciplinary viewpoints, which can be a powerful skill for engineering students to hone, unlocking diverse possibilities and perspectives over and above their own limited 'disciplinary solutions' shaped by a unique disciplinary position and understanding of reality.

Encountering the question 'Why did the Titanic sink?', which is set within a fascinating historical event, is a clear example of how to engage with different lenses. It is pedagogically engineered to develop Epistemic Insight and has been successfully utilised as a transition workshop in schools (Billingsley, Simpson and Abedin, 2020). This question could remain limited to a science classroom experiment, by observing through a model how and what caused it to sink or relegated to a historical event, investigating various past sources, to assess whether an individual was to blame. However, a much deeper explanation can be found by interrogating a range of disciplinary perspectives. To facilitate clear comprehension of how different disciplines have preferred questions and to establish what is valued in an answer, the foundation students were invited to think critically about what other questions they could ask through the examination of, how the ship came to sink, stepping outside the comfort of engineering to a wider context. Asking these smaller questions helped to inform and answer the Big Question, which by its very nature opens the discussion and excites student curiosity, thus providing opportunity to grapple with a question and 'deep dive' into a variety of disciplinary viewpoints and accepted curriculum content (Monreal, 2015).

To support this approach the cohort were split into two groups and provided with a pre-populated 'discipline wheel,' a helpful visual which presents pre-named 'subject' or 'discipline petals' to support students when asking different questions, through an appreciation of how to:

- Interpret the question?
- Investigate the question?
- Know they have arrived at a good answer?

Thus, allowing students to place questions into one or several relevant disciplinary boundaries (petals on the discipline wheel) and then to justify their rationale, which elicited enthusiastic debate amongst the two groups. As hypothesised, students comfortably leaned toward engineering perspectives which focused on the design, for example - 'Why didn't they make a ship to deal with the cold temperature and ice?', although others thought more widely reflecting on why there was a lack of communication evident within the disaster i.e., radio issues, pointing to the 'English' petal or considered why they were not aware of the icebergs – pointing to 'Geography' to investigate [Figure 4]. Exploring questions through the discipline wheel was helpful in challenging the students to move away from solely 'thinking like an engineer', intending to develop their epistemic humility and to recognise the benefits of professional collaboration with other disciplinary experts, allowing for integration of knowledge domains outside of engineering (Neely, Fell and Fritzsche, 2018).

This challenge provided some interesting discussion, which typically acknowledged how other fields of knowledge could indeed have something to offer to an engineering problem. Interesting, each group made good attempts to feed back to their peers the questions they had interrogated providing some justification for the disciplinary connections made. To demonstrate synthesis of this new knowledge, the facilitator invited students to think about how they could apply epistemic insight to their future engineering careers. This final task presented a challenge by applying interdisciplinary thinking to the abstract notion of a future role as engineers. However, it demonstrated a shift in some students thinking, as they began to consider the benefits of other fields of knowledge and expertise aside from their own engineering specialism, which was encouraging.

Conclusions and Lessons learnt

The workshop revealed that to sustain epistemic insight, these students need a greater immersion into epistemic learning, more than what was established in a one-off session,to successfully signpost different disciplines in response to their relevant and contemporary questioning. It was evident that exploring familiar engineering topics such as turbine design and materials' capabilities engaged the students to consider how interdisciplinary thinking could be relevant to their profession. However, some had difficulty making links between disciplines and to formulate discipline related interdisciplinary questions. This may be due to missed opportunities to develop epistemic agency in the school space up to KS4, demonstrating the importance of embedding epistemic insight pedagogy into teaching practice.

As anticipated, students tended to drift toward their specialism when exploring questions, viewed as an increasing problem of specialisation which begins to assert at A-level and into undergraduate studies. Therefore, it is argued a more in-depth discussion of Big Questions and ongoing engagement with Epistemic insight through secondary school into higher education learning will help to progress critical thinking skills and encourage epistemic agency, and for these student engineers equipping them to make wise and compassionate decisions. In addition, this workshop highlighted the value of interdisciplinary collaboration for these engineering students when designing innovative technologies, systems, and structures, helping them to confront the daily challenges humanity is faced with in a wise and compassionate way, and to meet the Royal Academy of Engineering aims help grow future engineering talent, build global partnerships which can influence policy and engage the public (Royal Academy of Engineering, 2022).

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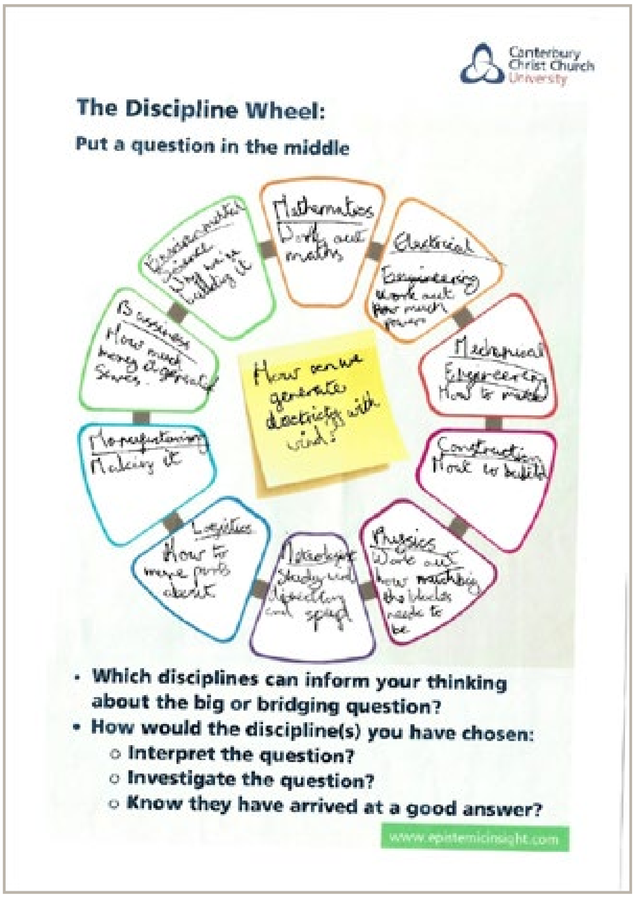
FIGURES



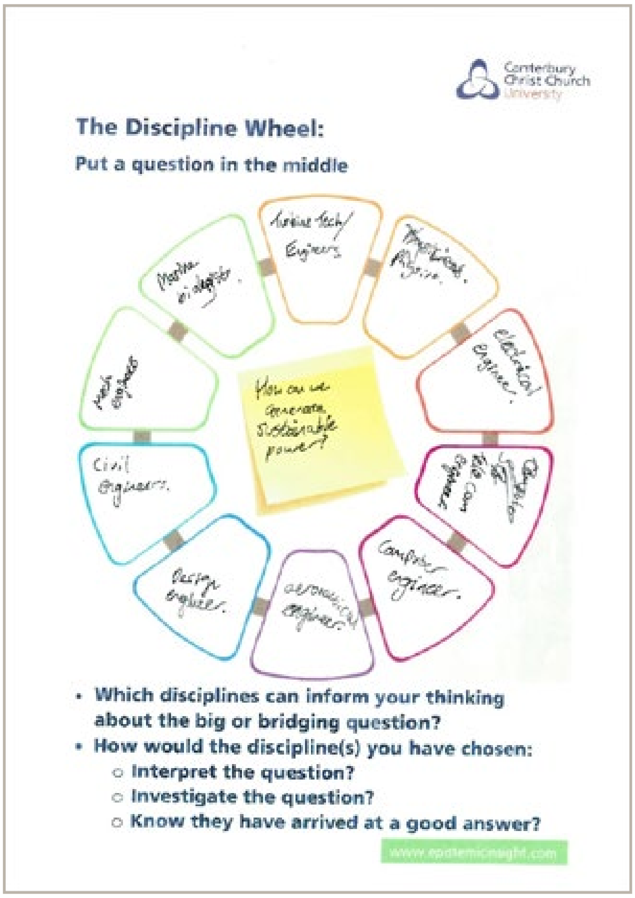


Figure 1. Examples of students' work during the wind turbine activity.

Figure 2 – Analysing the 3D Titanic model

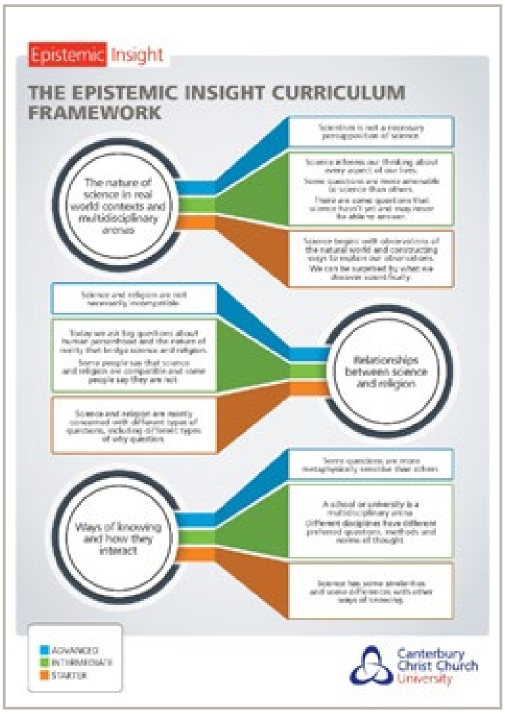


Figure 3

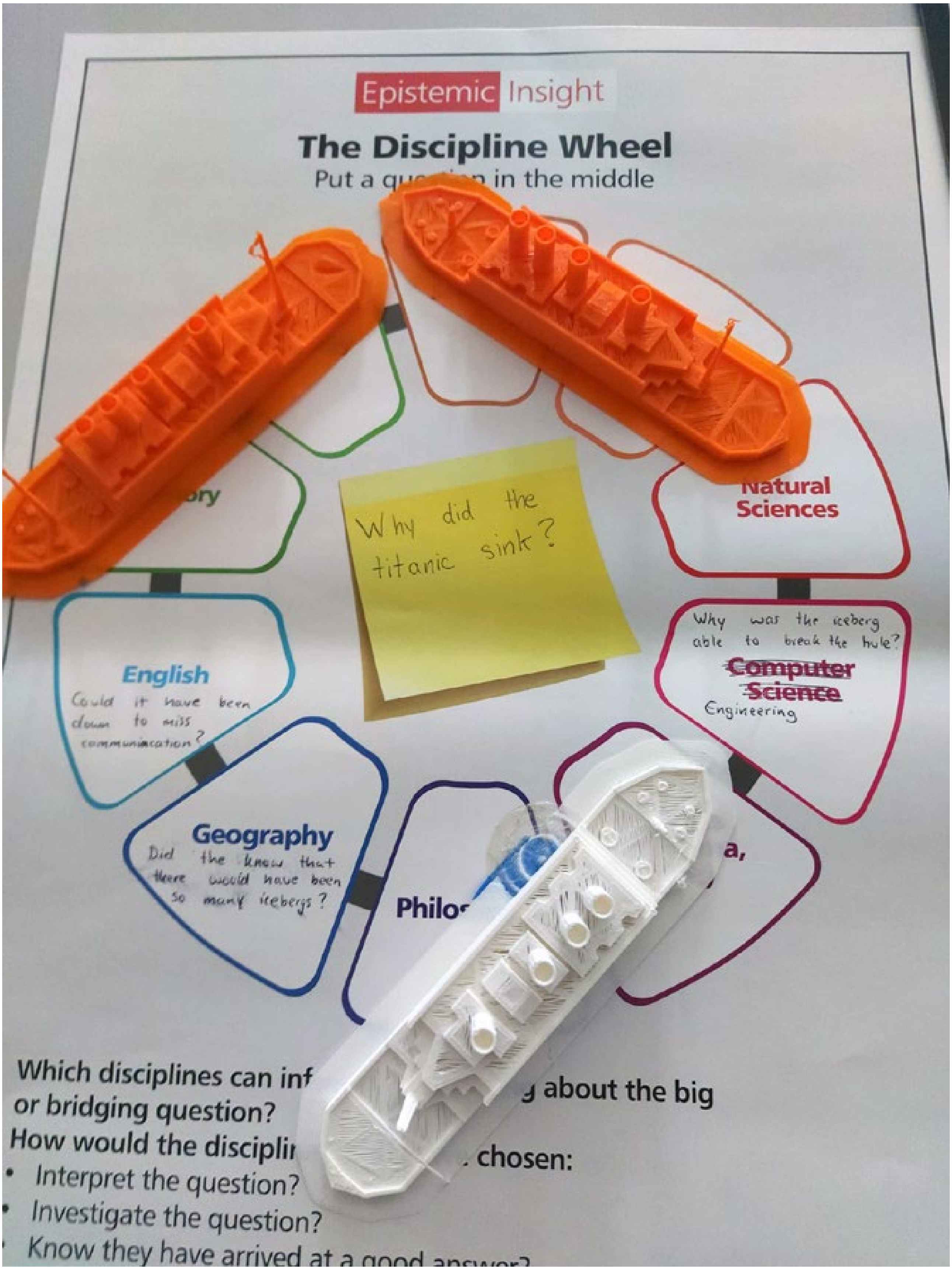


Figure 4 – Asking interdisciplinary questions

A CASE STUDY OVERVIEW OF HOW RESEARCH CO-CREATION IS SUPPORTING THE DEVELOPMENT OF "EPISTEMICALLY INSIGHTFUL" CURRICULUM TRANSFORMATION IN ENGLISH SECONDARY SCHOOLS

Finley Lawson and Michelle Lawson

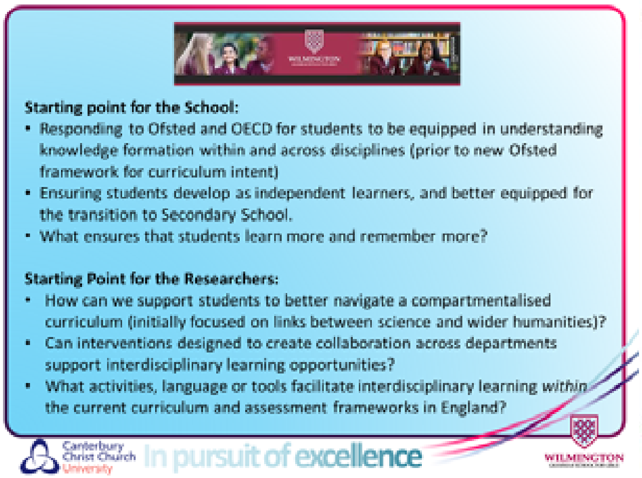
The following article provides an overview of the process we have undertaken at LASAR to co-create research with practicing teachers as part of the Permeable Walls project in the Epistemic Insight Initiative. Whilst there is a raft of evidence regarding the value of research engagement for teacher education (see e.g. Orchard and Winch, 2015) and school communities (see e.g. Sharp et al., 2006), successful research collaboration require both the engagement of research interested colleagues in schools and external researchers who are able to support the workload and dissemination (Sanders et al., 2006). However all too often this relationship can divide the research-engagement into desk-based research done by teachers and "academic research" done by research organisations (including HEIs). This can reduce teachers' agency (actual or perceived) to shape the format of the research to fit their setting, and lead to a perception of additional workload for low returns to the school.

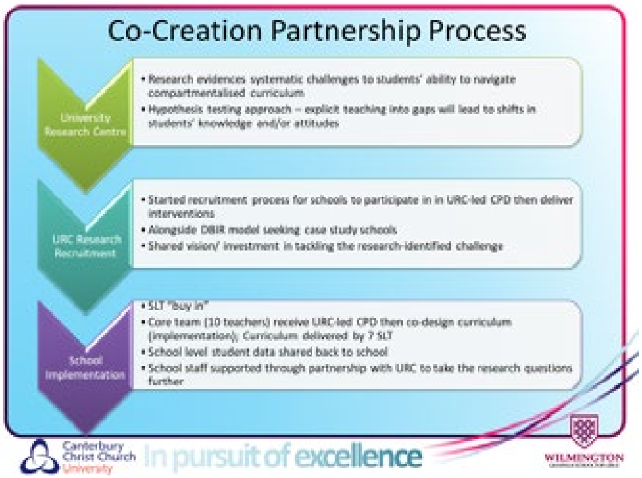
As a research centre we often find that workload and (lack of) alignment between research aims and school priorities can contribute to schools' hesitancy to take on the additional commitment required by research initiatives. McAleavy notes that even where teachers and schools have "research leads" they are 'in uncharted waters without a compass. There is no blueprint for the work of the research lead and the coordination of research activities in schools is not necessarily straightforward' (2015, p. 9). We hope that this article will appeal to readers who are interested in understanding how co-creation, collaboration, and shared understanding of the questions can support schools and universities to push the frontiers of our educational knowledge and practice together. To this aim we are sharing the process that we (as a research lead and a secondary school headteacher) have found meets the needs of the school, whilst ensuring the integrity of the research. To do this we draw on highlights from a joint presentation given in slightly different formats at the TEAN (Teacher Education Advancement Network) annual conference 2022 and the Epistemic Insight Conference 2022 on Transforming interdisciplinary learning through epistemically insightful curricula[1].

Starting Point for the Co-Creation Process

By recruiting schools for a case study approach to understanding the impact of epistemic insight interventions on staff and students' understanding of the relationships between disciplines we can work with schools that have a shared commitment or investment to the aims of the research. This supports high return rates for students' questionnaires, as well as increasing staff "buy in" as the drive and agency is shared by the school and the research team meaning that staff aren't simply having research "done to" them.

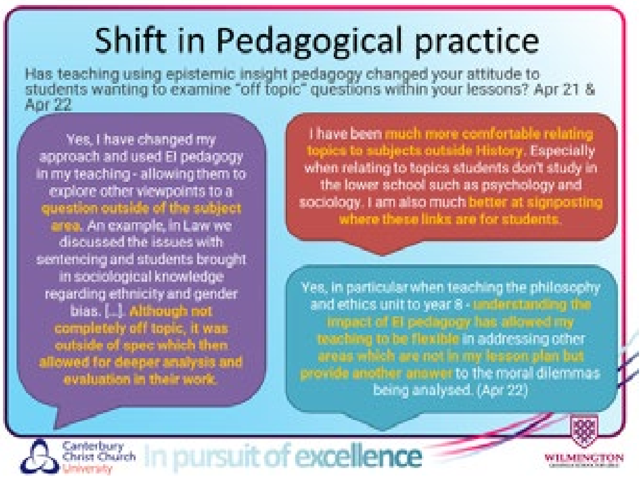
1 Wilmington Grammar School for Girls, Dartford and the LASAR centre have been co creating and delivering research into an Epistemic insight curriculum for year seven (age 11) students since January 2020.





Co-Creation Partnership Process

The co-creation process looks in this format to be a linear move from centre to school instruction, however this isn't the case. What it more accurately refers to here is the process by which we arrived at the co-creation model, and a Design-Based Implementation method (DBIR). In DBIR there are evidence-driven and research informed interventions, and practices that form the focus of the joint work (see Underwood and Kararo, 2021) – in this instance these were the pre-identified gaps in students' ability to navigate a compartmentalised curriculum alongside a set of pedagogical tools such as the discipline wheel and shared epistemic insight learning objectives. The co-creative process then investigates how these tools and gaps can be addressed within each specific context – in this manner DBIR recognises the specific challenges associated with developing designing educational interventions/solutions that can be implemented in multiple settings and lead to sustained change/ improvement in addressing the identified issues (Fishman et al., 2013; Underwood and Kararo, 2021). The drive for sustainability underlies the implementation aspect of DBIR, in this sense the goal of the current work is to close the circle so that the findings from the school-based research feedforward into the continuing research and wider conversation around teacher education and CPD.

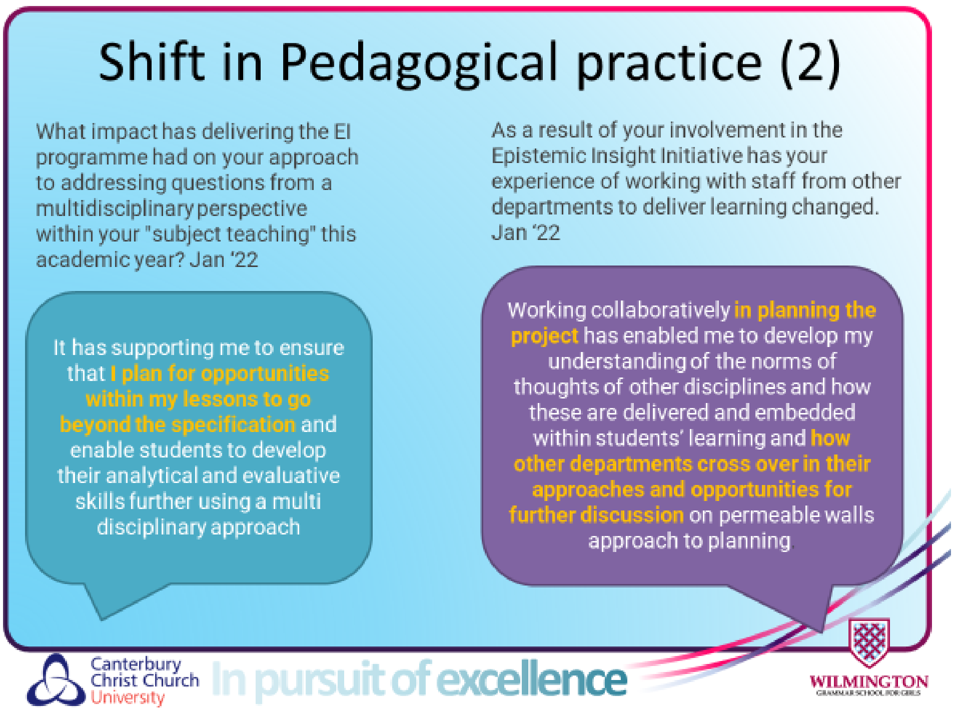


Developing a Research-Engaged School (School-University Partnership)

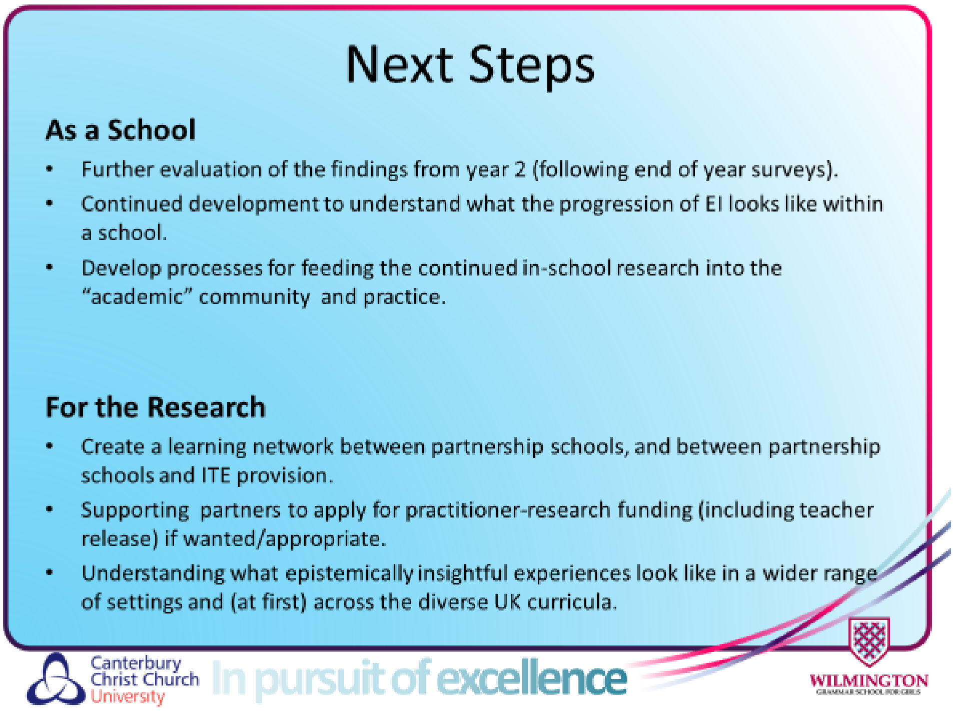
The iterative design process, saw teachers provided with CPD engaging with both the aims of the Epistemic Insight Initiative and the curriculum purpose in relation to the wider school ethos/vision. Initial planning of the year 7 curriculum by the teaching team came back to the research team and school senior team to assess the connection to both aims and ensure teaching resources highlighted Epistemic Pedagogy. After the first and second years the implementation was reviewed considering the delivery and research findings. The engagement with co-creating research and the shared vision for the potential of the curriculum transformation has led to a change in the delivery and practice of CPD within the whole school. Teachers are supported to develop their agency through "professional Learning communities" that undertake research projects during the school year about learning and teaching, some of which focus on the scalability of epistemic insight within the school, and others relate to wider pedagogical issues – the learning communities choose all questions these are not determined by senior leadership. The broadening of epistemic in the school in informed by continued collaboration with the research team to make use of the interim research findings through "school level" data.

Shifts in Pedagogical Practice

The following two slides show the impact of participating in the co-creation of the research and delivery of the epistemic insight curriculum[2] on the wider pedagogical practice and confidence of staff. These are findings that will be drawn out in further detail during interviews and focus groups at the conclusion of the project.



2 This refers to delivery of the year 7 students only – the data doesn't include staff working on epistemic insight in other areas of the school



Next Steps for the Research Process

In many sense the next steps for the both the school and the research team share a drive to understand how the existing work can be scaled to include the whole school and, as mentioned above, start to close the loop so that the research ecosystem brings the research-engaged school more fully into the wider educational research conversation, where the university acts as a facilitator to support the learning communities it engages with to inform and influence the direction of policy and practice in teacher education and school curriculum design. There is much more that could be said about both the process design and the impact of the co-created research programme however this will form the content of further papers following the final analysis of data.

EPISTEMIC AGENCY: AN AVENUE LEADING TO BETTER ENGAGEMENT

Aryn Litchfield

Abstract
The communication of knowledge is almost as important as the knowledge itself. If knowledge is received uncritically, or worse, simple not engaged with, then it is fair to suggest that communication has failed. When knowledge is communicated at an exclusive level or delivered in a fragmented way, this can lead to problems, creating 'Ivory Tower' type thinking and epistemic gaps forming. How do we prevent such gaps from occurring? We believe a potential avenue worth exploring is one which encourages epistemic agency through multidisciplinary exchanges of knowledge, creating the necessary space for individuals to become more insightful about the knowledge that is being communicated.

Introduction

The director of the LASAR centre (learning about science and religion) Berry Billingsley was invited to participate in an episode of 'inside science', a BBC Radio 4 program that explores contemporary topics and issues in science. The episode called 'building better engagement' hosted by Victoria Gill asks the question to Berry and two other guests, Sam Illingworth and Ozmala Ismail, "why science communication matters in society and how it might be done better" (BBC Radio 4, 2022). It's an important question and in formulating an answer, we need to recognise some of the fundamentals of communication: there's a speaker, a message and a listener. Given its charter we could propose that the BBC's goal is for the listener to interpret the message in a way that adds to their understanding of science. Achieving this goal could take many forms including bringing in a new scientific insight, remedying a misconception and dispelling misinformation. However, it doesn't stop there, because the story must also succeed in 'hooking' the listener's attention, and this in itself might seem to conflict with the goals of dispelling misinformation and presenting science with clarity. Finally, and before returning to what was discussed in the programme, there is one more goal that our team on the Epistemic Insight Initiative would want included. Good science communication can help to give listeners the gift of insight into how knowledge works – or in other words, help them to increase their epistemic insight.

So, how far did this radio programme go with covering this checklist of key ideas, with Berry and two other guests in the studio? Dr Oz Ismail is a dementia researcher who also finds time to do stand-up, public engagement and a podcast called, 'Why Aren't You A Doctor Yet'? Sam Illingworth is an Associate Professor at Edinburgh Napier University who investigates science and communication between disciplines. He is also a poet and writer, and has a podcast called The Poetry of Science.

Gill provided an early opportunity for the guests to make some of these points with her question:

Beyond being accurate and evidence based does the science-based communication generally get it right? Why is it important to have people getting involved into this conversation? (BBC Radio 4, 2022). The idea of "getting it right" is not limited to the transference of correct information but should also create fertile space for critical thinking to occur regarding the nature of that information. A potential key to achieving this is contained in the latter part of Gill's question, namely, getting people involved in the conversation. Medic, Oz Ismail suggested that science needs to happen in collaboration with the wider society, it is "Important to bring people with us on the scientific journey" as difficulties arise when information is shared at an exclusive level (BBC Radio 4, 2022).

Epistemic insight is defined as 'knowledge about knowledge especially knowledge about disciplines and how they interact'. The term was constructed for use in the education context where ideas like inclusion, diversity and respect are seen to be essential. Pedagogies to raise epistemic insight include finding ways to engage students' epistemic curiosity, building their capacity to think critically about the nature, application and communication of knowledge and providing the motivation and encouragement to ask and explore Big Questions. Berebichez notes that "the ubiquity of scientific information" has often left the public confused regarding the interpretation of that information (2019). In essence the ubiquity of information made readily available through general media creates challenges in identifying epistemically informative answers. As Oz Ismail's point makes clear, some of the good work that public communicators can do is to seed and encourage enquiry and dialogue between 'experts' and 'public' that goes beyond the programme itself.

Epistemic Agents

It might be the philosopher in me, but I would prefer to have the term 'people' that Gill and Ismail use defined as epistemic agents. The term 'epistemic agents' requires some unpacking as there might be potential confusion regarding another term, an 'epistemic community', which Lovell and MacKenzie (2011) identify as a community of experts that help inform decision making and policy through their knowledge and expertise. No doubt, an epistemic community contains epistemic agents, but for my purposes here, I will define an epistemic agent as an individual who is actively involved in the pursuit of knowledge. For clarity, I agree with Patton that, "Epistemic communities can be epistemic agents" as both essentially have the same aims (2019). Naturally there are some conditions on who qualifies as an epistemic agent, which Patton describes as: *The agent must be able to choose from among the available alternatives with reason, and for the motive of acquiring knowledge (2019).*

In other words, the 'agent' is a person who can freely navigate through various sources of knowledge, and using critical thought, position themselves optimally to be insightful about that knowledge. Such a view is well addressed through the 'Epistemic insight initiative' who have long held and defended the stance that 'knowledge Silo's' do not promote movement towards being insightful about knowledge, but rather it fragments it (Billingsley, Hazeldine, 2020). To elucidate the point, if knowledge is constricted to exist in a specific domain at the exclusion of other domains, then epistemically valuable information is being overlooked.

To contextualise Oz Ismails comment in terms of 'Epistemic insight': From my perspective, we need to bring epistemic agents with us on the journey of knowledge, and this means being able to engage in multidisciplinary conversations, thereby communicating knowledge through interdisciplinary lenses. In a sense, an epistemic agent is an unrealised concept if the individual is operating solely within a particular domain, as such a condition, no doubt impedes opportunities for knowledge-sharing and inter-dialogue to occur. In terms of Gill's initial question about "getting it right", communication is certainly getting it wrong if it does not engage the wider community of epistemic agents, and instead separates itself as an exclusive identity.

The idea of exclusion by way of communication certainly conjures up a rather interesting image, namely the "Ivory Tower": "The ivory tower of science is a widespread stereotype according to which science and society exist largely in isolation from each other" (Sonnert 2002). Broadley speaking, certain barriers exist between expert communities and wider society. For example, "Expert language" especially found in peer reviewed journals can act as a type of barrier as they are often inaccessible to non-scientists or non-academics. Risien and Storksdieck reference the process of social differentiation, implying that a separation is manufactured between science and society, creating a barrier in which residents of the tower struggle to communicate effectively with non-residents, or in their specific example, scientists-non-scientists (2018).

Rethinking the Ivory Tower

Perhaps the most extreme residents of the ivory tower are those that Sonnert describe as upholding the splendid isolation of the ivory tower (2002). The use of "splendid isolation" is ironic in a sense, for example, positioning a concept of isolation within a scientific objective pertaining to the pursuit of knowledge seems counter intuitive. In saying all this, we do need to recognise that to some extent 'fields of expertise' do benefit from creating distinctive identities. However, by championing epistemic agents, we do so by acknowledging their voice as belonging to the wider community. A direct criticism of "ivory tower" thinking is that it rejects its own entry into such a community, instead, creating an "us and them" type of narrative. Sonnert's metaphor of building bridges seems to take the middle-road, appealing to the theme of active science-society dialogue which has obvious benefits as

Salinero highlights

> *Open dialogue between those who are stakeholders (nearly everyone), our future scientists, and policymakers can lead the way to a whole new level of understanding of human health and ultimately to a healthy thriving planet (Salinero, 2018).*

In a metaphorical way, the building of bridges does not remove the tower, but paves the way for communication to occur with greater frequency and with greater depth; the identity of science is taken seriously, but communication is free flowing. Science existing as an insulated silo in a sea of other complex systems works against this idea of openness, as Salinero comments: "A scientific workforce that engages in open exchange of data and nuances of information with a society it has engaged with trust and authentic listening will have the basis for discovery within complex systems (Salinero, 2018)".

The point I wish to make is that knowledge is a complex, and when we recognise that, it becomes clear that fragmenting it leads to an unnecessary number of misperceptions occurring. In the program Billingsley suggests it is "not just how do people understand the science we are explaining, but actually what do they think science is?" (BBC Radio 4, 2022). The example she gives is that a group of children were asked to discuss an activity they carried out at school designed to help them to understand the heart as a pump. Students insisted that they were not doing science because they were outside, wearing their PE kit and doing star jumps (BBC Radio 4, 2022). The idea that science is "apart from everyday life", seems to me to be evidence of a perception that science belongs only to scientists and only in the space of thinking scientifically.

Sam Illingworth (poet and science communicator) suggests that science research should be objective, but it can be communicated with elements of pathos - without it there is a disconnect between science research and the community (BBC Radio 4, 2022). The struggle that is being described is that often the joys and curiosity that led one to pursue knowledge and discovery through the vehicle of science, seems to almost hide itself in the communication of that knowledge. The same can perhaps also be said for other disciplines as well as science.

Joining up the epistemic dots

Returning to Sonnert's mention of splendid isolation, it is clear to see how this can create a negative self-perpetuating perception of science. However, the "expert" language of science is integral to science (the same could be said for any discipline), so it would be incorrect to read into this any sense of there being a necessity for dilution. The implied meaning here is quite simple and Billingsley highlights it well by stating: these languages are like different disciplinary lenses - science can engage with science through its own lens but can engage with the world through one of those other languages as well (BBC Radio 4, 2022).

Contextualising Oz Ismail's earlier point, a question we should reflect on is: "how do we take epistemic agents with us on the scientific journey"? I would say that creating fertile ground for multidisciplinary dialogue to occur, calls for learners/listeners as epistemic agents to develop that interaction together and help each-other fill in the epistemic gaps that might be apparent. To provide an example, the following causal puzzle introduced by Kistler (2006) is one I am particularly fond of: Socrates drank hemlock at dawn. What killed Socrates?

To answer the question, consulting Toxicology, we can identify that Hemlock contains properties that, if ingested in sufficient quantity by a human, will cause death. The answer is correct, but it is missing the historical context namely the socio-political factors leading up to Socrates demise I.e. he was found guilty of "corrupting" society and his punishment was death. The picture develops further if we explore the notion that the accusation levied against him is specifically regarding "religious corruption" insofar that he was directly accused of dissuading young Athenians from worshipping the accepted Athenian God's. Cartwright states "in reality the cause of any factor is always very complex" (2002), and as we can see, the 'cause' of Socrates demise is multifaceted. In essence, the point of the puzzle is to indicate that while hemlock is certainly the cause of Socrates death, other factors are clearly vital to developing a causal picture that fully answers the question.

Final thoughts

The title of the BBC Radio Four program gets at the heart of what I have attempted to convey in this article, namely, to build better engagement we need to create the type of environment where multidisciplinary conversations occur and knowledge generation flourishes. A good starting point is to recognise that we, who pursue knowledge, are epistemic agents with a desire to become more insightful about the nature of knowledge. In a recent written statement supporting the 'Epistemic Insight Initiative' Professor John

Bryant writes:

> *I am further excited by the new initiative on the 'Future of Knowledge.' I believe science is entering a new era of discoveries and innovations that are extraordinary, exciting, and challenging to us as humans. (2022)*

The admixture of optimism and challenge is echoed by the Philosopher Robin Collingwood who once remarked that he did not have the answers ready-made, only the avenues available to explore them (1924) Likewise, facing these exciting and challenging developments, building better engagement by encouraging the salient vision of co-creation through multidisciplinary interactions is a good avenue to explore. There is little doubt in my mind that the future of knowledge is very much in the hands of the epistemic agents of today.

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ASSESSING EPISTEMIC INSIGHT IN PRIMARY INITIAL TEACHER TRAINING

Dr Caroline Thomas and Sherralyn Simpson

Abstract

The Epistemic Insight Initiative at Canterbury Christ Church University seeks to develop student teachers' understanding of 'knowledge about knowledge', specifically knowledge about disciplines and how they interact (Billingsley, Nassaji, Fraser and Lawson, 2018, p.1121). Student teachers can explore innovative pedagogical practices across taught modules and during their placement experiences in partnership schools. One noteworthy aspect of this Initiative is student teachers' demonstrations of their engagement with epistemic insight through formal assessments completed during their initial teacher training courses. Processes concerned with developing and implementing new forms of assessment are rarely straightforward. They demand extensive planning, collaboration between module tutors, and evaluation of the assessment's effectiveness to refine student experiences and maximise their learning. This article draws on two case studies to exemplify how assessments of epistemic insight have been embedded in two primary initial teacher training courses. The first assessment focuses on two curriculum-based assessments introduced during the undergraduate course, and the second on a classroom-based research project introduced into the postgraduate course:

1. *Bachelor of Arts in Primary Education - Level 5 Subjects in the Curriculum Module*
2. *Primary Postgraduate Certificate in Education - Researching Teaching and Learning Module.*

The article and accompanying appendices provide insight into student teacher responses to the assessments, including two student teachers who presented their learning at a Faculty research conference for staff and students. Student teachers learn to effectively link theory to classroom practice and constructively critique the influence of epistemic insight on their professional development.

Introduction

Student teachers' immersion in the Epistemic Insight Initiative supports them in delivering the curriculum effectively from a multi-disciplinary perspective when they adopt an epistemic insightful approach. Billingsley, Nassaji, Fraser and Lawson (2018, p.1121) define epistemic insight (EI) as 'knowledge about knowledge'. It refers to the attitudes and intellectual capacities required to appreciate how knowledge and scholarship work within and across subject boundaries (Billingsley, Abedin and Nassaji, 2018; Billingsley, 2017). When teachers become epistemically insightful, they can ultimately enable their pupils to gain 'disciplinary knowledge' (Ofsted,2021) and 'epistemic knowledge' (OECD, 2022b). Disciplinary knowledge describes what pupils learn about the diverse ways science establishes and grows knowledge through scientific enquiry, which is an essential aspect of the Science National Curriculum (Ofsted, 2021). Epistemic knowledge involves pupils learning to think and act like a practitioner, which provides relevance and purpose to their learning.

By encouraging pupils to investigate questions like 'Why do spinners spin?', pupils can engage in scientific enquiry and test models of cardboard spinners that resemble the flight of sycamore seeds in the natural world. They can use scientific observation to form and test ideas about how spinners spin. They learn that science begins with observations of the natural world and constructing ways to explain their observations. They can begin to discuss and understand the nature of science in real-world contexts: the mechanism for the wind dispersal of sycamore seeds, how the seeds are uniquely designed for flight and how and why objects fall to the ground.

Similarly, teaching lessons that cross disciplinary boundaries can promote pupils' insights into what makes science distinctive compared with other ways of knowing. For example, this can entail a lesson inviting pupils to compare and contrast how natural objects, such as flowers, can be interpreted from art and science perspectives. By adopting an epistemic insightful approach to their teaching, student teachers can become research-informed and research-engaged practitioners. They gain the agency they require to research aspects of their teaching and can respond to the unique perspectives of the pupils they teach.

Student teachers enrolled on the BA in Primary Education, Postgraduate Certification in Education, and Schools Direct route to qualified teacher status at Canterbury Christ Church University experience the Epistemic Insight Initiative. They have the unique opportunity to work with epistemic insight research team members and module tutors to co-create pedagogies for testing in schools. Such experiences deepen their understanding of the methods of inquiry, processes and norms of thought embedded within National Curriculum subjects. Furthermore, they can inspire pupils' curiosities in the Big Questions. Big Questions require exploration by several disciplines to understand phenomena. They include questions about the nature of reality and human personhood (Billingsley, Nassaji, Fraser and Lawson, 2018, p.1128). Examples include questions like '*What does it mean to be human?', 'What are the origins of the universe?' 'Will people be able to live on other planets in the future?'* Through exploring such questions, pupils can appreciate that they do not have simple agreed-upon answers. They can understand how science interacts with other disciplines they study in school and that various methods of enquiry are required to address them.

Course modules include keynote lectures and practical workshops that promote student teachers' epistemic insight. Tutors facilitate exploration of Big Questions, reflection on the nature of science, and analysis of the similarities and differences between science and other disciplines across modules. Student teachers learn about the methods of inquiry adopted by scholars of different disciplines when forming new knowledge. Tutors signpost student teachers to the effective pedagogies and curriculum resources developed and tested in schools and initial teacher training by Canterbury Christ Church University's epistemic insight research team. These pedagogies include:

1. A focus on the critical role of observation in science as a method of enquiry and recognition that some methods can be more scientific than others.
2. A comparison of two disciplines using a bridging question that spans both disciplines. A question such as *'Why did the Titanic sink?'* invites exploration of how science and history scholars approach such a question and discussion of each discipline's unique contribution to addressing the question. Student teachers can appreciate that science and history scholars can ask different questions.
3. Provision of opportunities to ask Big Questions, such as *'Are we what we eat?'*, the use of pedagogical tools to investigate the contributions disciplines can make in addressing such questions and evaluating their strengths and limitations. Appendix 1 provides an example of the Discipline Wheel, a pedagogical tool developed to facilitate the investigation of a Big Question. A Big Question is placed in the middle of the wheel, and the surrounding disciplines prompt discussion about the contribution each can make to addressing the question and the forms of enquiry used. From the perspective of science, an investigation into the influence of diet provides one insight into the nature of human personhood. From the standpoint of religion, the nature of the soul, religious beliefs, traditions and values can be considered.

Assessing primary initial teacher training students' epistemic insight

Two case studies demonstrate how the inclusion of epistemic insight into ITE assessments was successfully planned and implemented by tutors and insightfully responded to by student teachers. Case study one focuses on two assessments introduced into a Level 5 *Subjects in the Curriculum Module* as part of the undergraduate BA in Primary Education. The first modular assessment examines effective pedagogy: the role of observation in science and planning for this in the primary classroom. The second examines planning for cross-disciplinary learning. Case study two focuses on a classroom-based research project: student teachers plan a research project, investigate and analyse pupils' responses to Big questions, bridging questions and scientific inquiry. Incorporating epistemic insight into student teachers' assessments recognises the critical role of assessment in enabling student teachers to become research-informed practitioners. The assessments encourage them to make constructive links between theory and classroom practice and critique the influence of epistemic insight on their professional development.

Both case studies illustrate how student teachers demonstrate epistemic insight when providing evidence that they can think and act like scholars. They can, for example:

1. Explain that science and other disciplines ask different questions and investigate questions differently.
2. Provide examples of preferred or valid questions that science and other disciplines answer.
3. Frame Big Questions and a bridging question that spans two disciplines.
4. Use pedagogical tools, such as the discipline wheel, question boxes, and discipline hats, to address Big Questions/bridging questions in the primary classroom.
5. Demonstrate awareness of the powers and limitations of science.
6. Explain how science begins with children making simple observations of their world.
7. Evaluate what methods can be used to answer questions, recognise that some questions may be more scientific than others, and suggest ways to improve their methods when investigating questions and problems.
8. Explain what a good answer to a question looks like in different disciplines.
9. Plan lessons or schemes of work that enable pupils to ask questions and learn across disciplinary boundaries.

Perspectives of tutors and researchers working with student teachers and analysis of student teacher responses to the assessments suggest that they learn how to be curious, creative, and reflective critical thinkers. They gain the capacity to transform pedagogical practices in their schools. The OECD Learning Compass 2030 emphasises the importance of agency (OECD, 2022a). Trainees become epistemically insightful teachers, understanding how knowledge works and can be applied through interdisciplinary approaches to learning. They can create practical 'hands-on' techniques for studying science in real-world contexts, engaging pupils and promoting positive attitudes toward science.

1.1.1 Case Study 1: BA in Primary Education 'Subjects in the Curriculum' Module (Level 5)

1. Assessing Epistemic Insight: The importance of observation in science

For the last three years, second year (Level 5) BA Primary Education student teachers have investigated the nature of Big Questions, cross-disciplinary questions and epistemic insight. In the first year of the course, student teachers gained insight into the purposes of various subjects within the primary curriculum. They learned about child development theory and ways of planning lessons using different approaches to teaching and learning.

The science tutor team introduced into the first part of the double module, *Subjects within the Curriculum,* an assessment requiring student teachers to reflect on the importance and limitations of scientific observation. The students wrote a 4000-word assignment entitled *'Why is it necessary for a teacher of science to have a thorough understanding of the importance and limitations of scientific observation?'* Details concerning this assessment are included in appendix 2. Tutors incorporated opportunities for students to explore the nature of science and Big Questions within modular sessions through hands-on science. Student teachers learned how to inspire their pupils' engagement in science and plan practical science lessons. The Essential Experiences in Science investigation cards and teacher resources provided a helpful model for students to follow when planning science lessons (Billingsley et al., 2020). The cards include the types of questions teachers can ask to promote discussion on the nature of science amongst pupils. There is an example of a Big Question card in appendix 3, which investigates why clouds stay up and do not fall out of the sky using simple, cost-effective equipment. Primary school pupils undertaking this investigation look at clouds made up of water droplets held together in the earth's atmosphere. They can explore how clouds form and begin to explain why it rains by observing how water droplets join together to form bigger droplets that hold their shape.

An essential part of the assignment required students to produce a lesson plan to support children's observation skills development. The assessment encouraged student teachers to test their lesson plans and conduct scientific investigations. A requirement was to create and evaluate examples of the observations they would expect pupils to make and discuss how they would assess pupils' learning. They had to devise and reflect on an appropriate assessment for learning strategy. An analysis of student-teacher assessments indicates that they could focus on assessing children's observation and investigation skills. They could reflect on how observation enabled the development of scientific concepts rather than focusing solely on the factual knowledge children might learn.

Overall, the vast majority of students responded positively to the assessments. They demonstrated a strong understanding of the nature of scientific observation. They showed epistemic insight by giving examples of the types of questions science prefers to answer. They also included appropriate methods for pupils to answer science questions. They gained an awareness that science, as a discipline, uses methods of enquiry that involve prediction, testing, observation, undertaking measurements, pattern-seeking and causation. By testing out their lessons, they gained awareness of the factors influencing the quality of their observations, such as the relevance of the observations they made, precision in measurement, and the use of magnification aids to gain detailed observations of the properties of materials and characteristics of living things. They had to consider their pupils' needs, attention spans, possible misconceptions about the topic investigated, and how to use scientific observation to challenge these. They also considered what questions they might ask to promote detailed observations and inspire pupil questioning and pupil autonomy in the testing of ideas. Appendix 4 contains a presentation by a Level 5 student teacher, who reflects on teachers' understanding of the significance of observation in science, shared at the 2021 Faculty Scholarship Day on Epistemic Insight for staff and students. It includes her lesson plan to promote young pupils' observations of plant growth. She uses a table and observational drawings to illustrate the types of observations she expected pupils to make.

This student-teacher understood what it meant to be a primary science teacher. Her lesson plan indicates how the assessment enabled her to devise a question that science seeks to answer. She invited pupils to grow plants from mustard seeds and compare plants grown in different conditions. Pupils could test whether varying the amount of light and water influenced plant growth. She encouraged using a card peephole and a magnifying glass to help pupils focus their observations and record one aspect of each plant grown, such as a single leaf on each plant. Pupils could observe, record and make sense of the changes in the leaves colour, size and texture resulting from differences in the light and water they received. She invited pupils to predict what they expected to happen to the plants' growth based on their existing ideas and record their findings.

To invite interpretation of the findings, she asked: *'Are you surprised by what happened?'*

As the assessment required students to test their lesson plan and make relevant observations, they could consider the observations most applicable to pupils' understanding of the chosen phenomenon. The student's presentation indicates that she had learned about the value of observational drawings in focusing children's attention on the changes they could see in the plants over time. Ofsted (2021) emphasised that providing a high-quality science curriculum required a careful sequencing of knowledge to reveal the interplay between substantive and disciplinary knowledge. This approach would ensure that 'pupils not only knew 'the science' but also the evidence for it and could use their knowledge to work scientifically. They referred to substantive knowledge as the products of science, such as its models, laws and theories.

The assignment involved student teachers asking and answering several essential questions: What content should I teach? How should I teach it? How should I consider a diverse pupil group's existing ideas and potential misconceptions? How should I evaluate what learning has taken place? In her presentation, the student teacher comments on the importance of scientific observation in challenging the naïve theories pupils can hold about the world and the need to discuss with the class the processes involved in knowledge acquisition. She emphasised the importance of communication in enabling children to share ideas and form links between knowledge.

Student teachers could think about the nature of science, the importance of observation in enabling children's conceptual development and in challenging misconceptions, and how to promote positive attitudes towards science, such as respect for evidence. The assignment challenged students to move beyond focusing on transmitting scientific knowledge. They could reflect on barriers to observation amongst pupils and ways of overcoming these. The student teacher's comments reflect her understanding of the fundamental importance of observation in pupils' learning. She perceived that the assessment developed her confidence in writing 'interesting' lesson plans and her ability to facilitate opportunities for children to make scientific observations.

In an earlier version of the assessment, students were required to use '2animate' software to create animations to:

- Observe objects and/ or processes in a scientific manner.
- Explain how they could use this animation as a teaching tool to enhance children's understanding of the nature of scientific observation.

This approach was advantageous in tutors modelling cross-disciplinary learning approaches for student teachers. Science tutors teamed up with Information technology tutors to plan the assessment and explore the importance of technology and science in enabling the formation of new knowledge. Creative responses to the tasks included student teachers producing animations to stimulate discussions about scientific processes and natural phenomena. For example, they invited pupils to observe the world around them and explore natural processes, such as the germination of seeds, seasonal changes in the environment and the moon's phases. They produced animations that would help their pupils investigate how we see different objects and discuss how to connect components in an electrical circuit to produce electricity. The science team modified this part of the assignment in the second year of running the module. The assignment was improved by establishing a greater focus on student teachers undertaking observations themselves, testing their lessons and devising an appropriate assessment for the learning strategy for the lesson.

2. Assessing Epistemic Insight: Use of a Big Question to promote reflection on the nature of different disciplines.

In the second part of the module, student teachers focused on the foundation subjects within the National Curriculum. They selected a 'Big Question' that they could investigate through varying subject disciplines. They could devise a question or choose one from a list of possible questions. Students were required to create a scheme of work demonstrating how they would plan for each subject to investigate their chosen 'Big Question'. They produced a detailed, annotated mind map of ideas and developed their thinking further as a table/grid. Tutors encouraged students to use the epistemic insight 'Bubble tool' in appendix 5 to exemplify their thinking. The bubble tool invited reflection on and comparison of the types of questions different disciplines pose. The student teachers were required to demonstrate how the Big Question could be investigated through a series of activities, specifying relevant subject-specific objectives linked to the National Curriculum. The assignment title was: *What do types of knowledge and approaches to learning from different subject disciplines contribute to an investigation of a 'Big Question' through a cross-curricular approach?* The assignment details are included in appendix 6.

An analysis of student-teacher assignments indicated that student teachers could devise bridging questions they wanted to explore with pupils. They could also reflect on the learning processes pupils would engage in to address their questions from the perspective of two disciplines. At the end of his course, one student teacher recalled how this assessment encouraged him to explore the distinctive nature of subject disciplines and how to promote cross-disciplinary learning amongst pupils. He focused on religion and design technology and how creating a board game could allow reflection on the question: *Why do people believe that God exists?* This question is of interest in a technologically advanced society driven by science, where people might explain what happens on earth using the laws of physics without any intervention from a higher authority. It invites reflection on people holding religious beliefs in a higher authority watching over them, judging their actions. By planning, making and playing a board game, the student teacher aimed for pupils to reflect on their views about God's existence. They would learn about the different types of questions design technology, and religion ask. Through design technology, pupils could consider questions about the game's purpose, the user and questions that drive innovative processes. Religious education helped them to consider questions about religious beliefs, practices and values in different religions.

1.1.2 Case Study 2: Primary PGCE' Researching Teaching and Learning Module

3. Assessing Epistemic Insight: Promote reflection on the nature of different disciplines

The PGCE *Researching Teaching and Learning* module enabled student teachers to work with University tutors and undertake a small-scale qualitative classroom-based research project concerned with their tutors' research areas. The assessment required student teachers to reflect on the importance of research in developing their classroom practices.

In the first year of the module running, students worked with Dr Thomas, a researcher in epistemic insight, to devise cross-disciplinary questions and explore pupils' responses to their teaching. During the second and third years of the module's history, student teachers had opportunities to explore pupils' ideas about the nature of science, Big Questions and their understanding of scientific observation. Student teachers gained inspiration for research from the Big Questions resources, workshops and pedagogical tools produced by the University's epistemic insight research team. Students could draw on activities and resources modelled in university sessions to inform their teaching and research.

Analysis of three groups of student teacher assessments over the period 2020-2022 indicated that they could demonstrate epistemic agency in various ways. Student teachers could devise bridging questions that span science and another discipline and Big Questions. They could plan lessons to investigate a small group of pupils' responses to these questions. For example, one student invited pupils to explore colour through the lens of science and art. Her question was, '*To what extent can children make a connection between the science of colour and its use in art?'* She invited pupils to explore two well-known paintings by famous artists and think about how scientists and artists examine and respond to colour. Another student's question was, *'What are children's perceptions of how animals are used in the world?'* She investigated what knowledge a small group of pupils possessed about animals, their uses, and their emotional responses to their usefulness. Another invited pupils to explore the scientific evidence for deforestation, an environmental issue, and their attitudes to this. Her question was, *'How do pupils respond to the issue of deforestation?'*

The student teachers could explore how to use such questions to stimulate enquiry and critical thinking in schools, including the schools that did not include opportunities for cross-disciplinary learning. They could analyse pupils' responses and present their findings in a concise oral presentation. Under their tutor's guidance, they could design and implement appropriate data-collection instruments to collect data on pupil responses relevant to pupils' ages and stages of development. These data collection methods emphasised pupil voice in research, the importance of teachers holding learning conversations with pupils and listening to pupils' views on the learning experiences presented.

The assignment included a review of pertinent literature on the nature of science and epistemic insight, and relevant research. This review helped contextualise their studies and enabled student teachers to become research-informed practitioners. Student teachers produced 20-minute presentations about their research and what they had learned about using research to form new knowledge and develop their pedagogical practices. The presentation included their analysis of their learning outcomes as research-engaged teachers and their pupils' learning. From a research perspective, they became equipped with the tools to use research to inform their teaching and learning as early career researchers.

Appendix 7 consists of a PGCE student's summary presentation based on her assignment, which she presented at the 2021 Faculty Conference on Epistemic Insight. She was interested in exploring how young children could connect their learning in science with real-world contexts. She built on their interest in space exploration as a stimulus for her study. The question pupils investigated was, *'How do astronauts live in space?'* She was surprised to learn that the pupils had a limited understanding of what scientists do and that pupils failed to see themselves as scientists when undertaking scientific investigations in the classroom. She perceived that they tended to look to their teacher to provide the answers to their questions rather than finding things out for themselves through inquiry. They also drew on their own food choices and previous learning about food and healthy eating in school when suggesting what astronauts might eat in space.

Student teachers have produced fascinating and creative responses to this assessment using their interests or prior expertise to engage pupils. Some student teachers were eager to explore the relationship between science and the disciplines studied for their first degree. A student teacher with a first degree in religion explored children's understanding of the dialogue between science and religion through the question, *'How do humans share their world with humans?'* His project entailed exploring with pupils how people can act as custodians of the planet and take responsibility for recycling materials. Two other students demonstrated interest in investigating pupils' understanding of the relationship between science and religion when exploring the universe's origins. They explored pupils' perspectives on what science and religion had to say about this question. One explored how Year 5 and 6 pupils might integrate a science perspective with any religious views they held after a lesson exploring creation narratives and the 'Big Bang'. He found that most pupils initially perceived that science provided the answer to this question.

After teaching them, he noticed a shift in their thinking. They began to see that religion provided a valuable perspective and that scientists could also hold religious beliefs concerning the universe's origins. This student-teacher concluded that it was essential to provide opportunities in the primary classroom for pupils to explore Big Questions and the compatibility of science and religion.

Two students with expertise in music explored *'How can we hear and interpret sounds from a science and music perspective?'.* From a science perspective, they invited pupils to investigate how to make sounds and how the ear hears sounds when vibrations of air reach them. From a music perspective, they invited pupils' to explore their interpretations and emotional responses to different sounds and music. Pupils could gain epistemic insight by comparing the preferred methods for investigating sound in each discipline and exploring the various ways science and art record and describe sounds. From a physical education and science perspective, another student worked with children to devise science and physical education method to investigate whether humans could outrun a cheetah. A student with expertise in art explored children's ideas about art and science and how they perceived they learned about plants when observing and representing them from the perspective of science and art.

Two interesting studies focused on student teachers exploring the nature and interpretation of evidence in different disciplines with their pupils. A student teacher with a degree in archaeology investigated pupils' interpretation and use of sources of evidence from the perspective of science and history. Her question was, *'How do pupils perceive the ways in which evidence is used in history and science?'* She demonstrated epistemic insight by inviting pupils to work like historians and scientists. In history, they reflected on what they could learn about the clothes the Romans in Pompeii wore by interpreting Roman mosaics. In science, they investigated the construction and use of materials in mosaic-making. She intended that pupils gain a bigger perspective on an artefact than they could gain from using the methods and norms of thought associated with one discipline alone. She researched the term 'evidence' in the National Curriculum. Her study reflected how historians use sources of evidence to construct a knowledge of the past, which are open to interpretation, and scientists use evidence to test ideas and support or refute arguments. She found that through investigation, children gained knowledge about the methods used and how to critique and evaluate sources of evidence. The pupils also tended to interpret historical sources using their existing ideas about the clothes they and their families tended to wear.

Similarly, another student teacher explored how children interpreted pottery by examining an ancient Greek vase portraying an ancient Greek myth from science, history and artistic perspectives. His question was, *'How do children interpret pottery from the perspectives of different disciplines?'* Pupils gathered evidence on the materials used to make the pot. They explored how it was made and could discuss what the evidence told them about the lives of the ancient Greeks and the pot's use.

Another focus of student teachers has been to widen pupils' ideas about the role of scientists in society. For example, one student teacher investigated '*What are children's perceptions of science and history concerning the question 'What role have scientists and famous discoveries played in history?''* Another student teacher introduced pupils to sports scientists and how science is applied in sports equipment design to promote performance. Another sought to explore the diversity of student perspectives on scientists. She sought to challenge any stereotypical views pupils held about scientists through her teaching about scientists. Student teachers have also researched the use of practical experiments to enable pupils to understand environmental issues, such as the impact of plastic on living things in the oceans.

Student teachers could opt to research pupils' experiences of epistemic insight in the Early Years Foundation Stage (EYFS) to Year 6. A student working with children in the EYFS devised a question relevant to the children's ages and developmental needs: *'Why are wheels round?'* She enabled the pupils to make vehicles with different shaped wheels and test them on various surfaces to answer their question. The focus was on exploring young pupils' interpretations of science and the language children used to describe their early science experiences.

Student teachers learned to be curious, creative, and reflective critical thinkers. They gained the capacity to influence or transform pedagogical practices in schools. They ultimately enabled their pupils' to gain epistemic insight. Their research analyses indicated that the pupils began to demonstrate an awareness of the nature of science, its powers and limitations and its role in society. The pupils could compare the methods scholars of different disciplines use to investigate Big Questions.

Reflections on the assessments

For practices and thinking habits associated with epistemic insight to become entrenched across education settings, student teachers required inspiration from their tutors and the opportunity to test out and reflect on the pedagogical practices and models of curriculum planning introduced in workshops and whilst in school. Providing safe spaces for students to test new ways of working helped trigger changes in their pedagogical practices and could help them sustain this long-term. Student feedback from individual interviews with a sample of 20 students following their final placements in schools suggested that such experiences positively influenced their intrinsic motivation, creativity, confidence, and pedagogical content knowledge.

Provision for epistemic insight within course modules and assessments facilitated student teachers' entitlements outlined in the ITT Core Content Framework (DfE, 2019). Trainee feedback suggested that they could develop the five areas of 'great teaching': behaviour management, pedagogy, curriculum, assessment and professional behaviours. Tutors mapped module sessions and the assessments to this framework. Standard 3, concerned with student teachers demonstrating good subject and curriculum knowledge, was particularly relevant to the assessments exemplified in the two case studies. For example, standard 3.2 emphasised how 'secure subject knowledge helps teachers to motivate pupils and teach effectively'. Student teachers also learned how 'effective teachers introduce new material in steps, explicitly linking new ideas to what has been studied and learned' (DfE, 2019, pp.13-17). The assessments engaged student teachers' reflection on how they could provide an epistemically insightful curriculum. Ultimately, student teachers could help their pupils learn what is distinctive about different disciplines and how disciplines can work together to provide practical solutions to real-world problems. For their pupils to gain epistemic insight, they needed to work with Big Questions and real-world issues that cannot be resolved from the perspective of a single discipline. Student teachers' completed examples in appendices 4 and 7 provided insight into their developing epistemic insight.

Student teacher assessments incorporating epistemic insight indicated that they could analyse and critique approaches to teaching and learning. Student teachers could become equipped with the knowledge and skillset required to encourage their pupils to ask and investigate Big Questions from a multi-disciplinary perspective in the University's partnership schools. Our research indicates that student teachers could move beyond having a compartmentalised view of knowledge, often stimulated by their experiences of a school curriculum organised as separate subjects. They could reflect on the relationships between disciplines and whether they had anything in common.

Conclusion

Introducing epistemic insight into primary initial teacher training modules has been an exciting initiative involving extensive planning and enthusiasm amongst colleagues. The challenge of assessing student teachers' epistemic insight has been addressed through innovative course design, the careful crafting of student assessments, and the unique ways tutors have willingly worked collaboratively to trial and refine new ways of working.

This paper demonstrates a research-evidence approach to epistemic insight assessment within initial teacher training. The two case studies exemplify how incorporating epistemic insight into modules has enabled student teachers to learn about the distinct nature of science and other disciplines. Encouraging student teachers to become epistemically insightful has meant encouraging them to think about what it means to be a scholar and teacher of different disciplines. They could plan ways of incorporating epistemic insight into their classroom practice. The ultimate aim was for them to become equipped to develop school children's epistemic curiosity and interdisciplinary thinking, viewed as imperative for the 21st century (OECD, 2018, 2021).

Interviews with students, evaluations of modules and analysis of student assessments indicated that they gained confidence in planning practical hands-on science lessons to teach children about the nature of science. Student teachers could appreciate the importance and limitations of scientific observation. The postgraduate research assessments enabled student teachers to promote positive attitudes toward science amongst pupils, encourage pupils to reflect on the role of different disciples in addressing the Big Questions and learn about the work of scientists in society.

Student teachers' feedback indicated that the *Essential Experiences in Science resources*/Big questions investigations cards (Billingsley et al., 2020) had been invaluable in enabling them to plan and teach effective practical science lessons and cross-disciplinary learning experiences. Student teachers could easily access the resources. Teacher guides and the Epistemic Insight Initiative pedagogical tools support their use. Student teachers' assessments indicated that they could use these resources flexibly and adapt them to meet the needs of their pupils.

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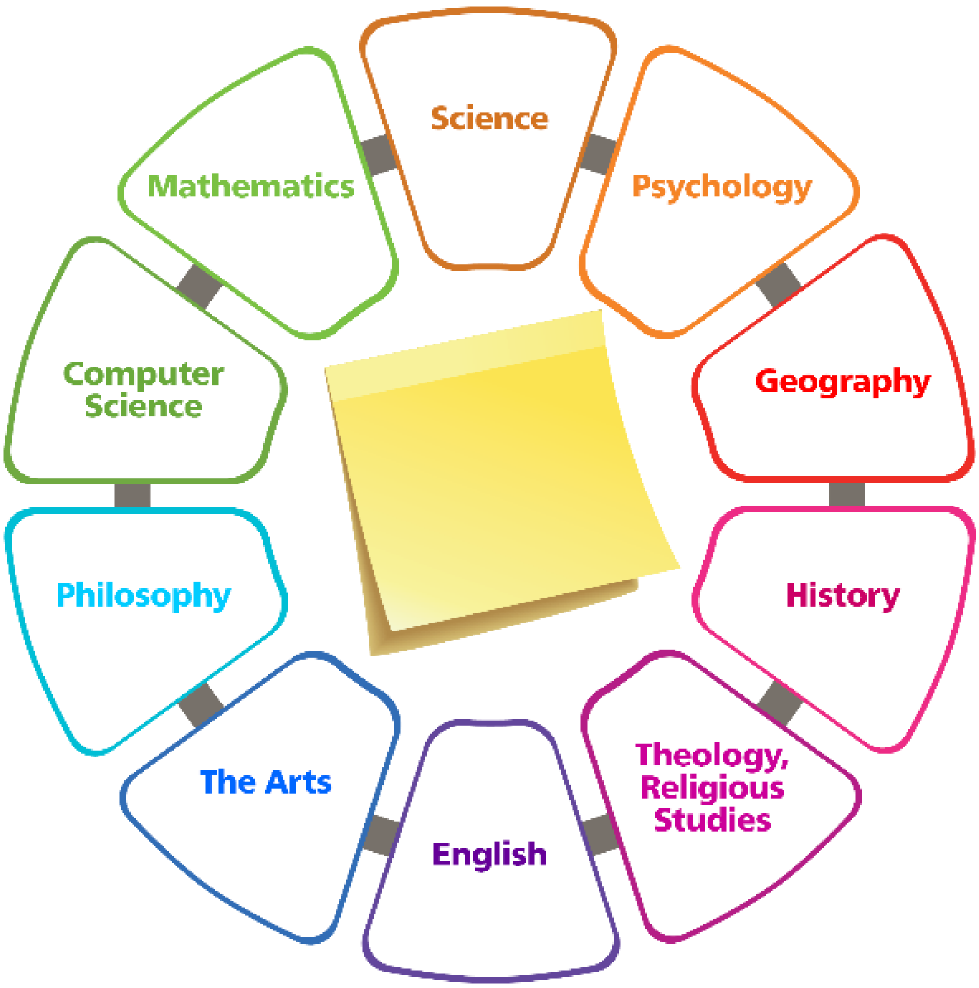
Appendices

Appendix 1: Epistemic Insight Initiative Pedagogical tool – The Discipline Wheel



Appendix 2: Case Study 1 - Example Assignment (Epistemic Insight: the role of observation in science)

Module: Subjects Within the Curriculum 1-Essay

Module Code: MPETT2SCE

Assignment Title: Why is it necessary for a teacher of science to have a thorough understanding of the importance and limitations of scientific observation?

Assignment Word Count /Weighting: 4000 words (equivalent) 100% of the module.

There are three parts to the assignment totalling 4000 words or equivalent.

What should be submitted:

Section A

A 2400 word written assignment.

Section B

Lesson Planning in science, 1000-word equivalent

Section C

Evaluation of the observational skills required for the assessment strategy/ies for the lesson in Section B, 600-word equivalent.

The reference list should be placed at the end of section C

Assessment Criteria

The assignment is marked against the general assessment criteria for HE Level 5, which can be found in your programme guide and on your CLIC Learn VLE.

Additionally, at the end of Level 5, you are required to demonstrate the following Learning Outcomes:

Learning Outcomes

By the end of this module, students should be able to demonstrate:

1. Knowledge and critical understanding of learning and teaching in specific subject disciplines.
2. An understanding of the principles of planned learning and teaching and how these have the potential to be applied across the curriculum.
3. Deep subject knowledge in relation to one subject area with an understanding of the limits of their knowledge

Additional Guidance

Section A (2400 words)

In this assignment title, you need to consider:

- How observation informs and underpins the process of working scientifically
- How scientific observations can lead to questions that challenge existing understanding as well as generating new information
- How the above impact on the teaching and learning of science in the primary classroom.

Section B (1000-word equivalent) Lesson Planning

- Write a lesson plan (maximum two sides of size 12 font) for a practical activity that encourages the development of children's scientific observation skills.
- Undertake observations that can be used for assessment purposes (relevant to the above lesson plan) of objects or processes that occur in a scientific manner. Provide evidence of undertaking the former, e.g. drawings, photos, data etc. This could include the use of technology.

Your learning from this section (Section B) may be used to support your argument in Section A.

Section C (600-word equivalent) Analysis of Assessment

- Explain and analyse the observations required by the teacher and the overall assessment strategy, identifying the impact and implications for the teaching of the lesson in Part B. Reflecting on how/what you have learnt can be applied to other areas of the curriculum.
- Your learning from this section (Section C) may be used to support your argument in Section A.

Appendix 3: An example of Essential Experiences in Science Investigation Cards

Appendix 4: An example of student reflections on the importance of observation in science – presentation for the faculty conference and lesson plan produced by a Level 5 Primary ITE student

The importance of scientific observation – informed through research for the Year 2 science assignment

- Observations are a "fundamental aspect of the learning process" (Ward and Roden, 2016, p.35)
- Teachers can help scaffold observations but should facilitate opportunities for autonomy
- Helps challenge "naïve theories about the world" (Pine, Messer and St. John, 2001) in a positive way, using them as starting points
- Observational comparative drawings can promote close observation
- Communication both peer on peer and whole class discussions can allow for greater reflection on the processes rather than solely focussing on outcomes
- Gaining the children's interest and developing their subject knowledge is vital before an observation to provide them with motivation and theory to apply to what they see.

<table>
<tr><td>Section B: LESSON PLAN</td><td colspan="2">Subject: Science</td><td rowspan="2">Links to the National Curriculum: Plants
Statutory requirements: “find out and describe how plants need water [and] light … to grow and stay healthy”
Non-statutory: “setting up a comparative test to show that plants need light and water to stay healthy” (DfE, 2013, p.11)</td></tr>
<tr><td>Date: 25/11/20</td><td>Duration: 50 mins</td><td>Year 2</td></tr>
</table>

Implications From Previous Learning / Common Misconceptions:

Children will have already become familiar with the basic structure of common flowering plants in Year 1. Prior to the lesson, children will have set up a comparative test, planting mustard seeds in varying conditions: with light and water for the control plant, with light and no water, with no light and with water and with no light and no water. The teacher should take photographs of the plants at intervals of the plant’s growth to support the assessment (image D). They will predict their printed grid of what will happen to the mustard seeds regarding their growth in each condition. There will be room for them to later add their drawings and write a conclusion. Possible misconceptions could include believing that seeds and bulbs need light or not understanding how too much water can damage the mustard seeds. Children may also struggle to notice differences between the plants (Ward and Roden, 2016).

Learning Intentions/Success Criteria

LO: To observe mustard seeds which have grown with different amounts of light and water and use my observations to determine what conditions plants need to grow and stay healthy.

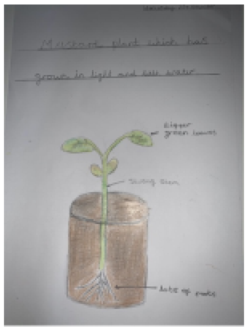
LO: To record my findings through a comparative observational drawing, using this to draw my conclusions.

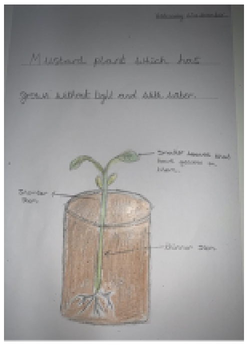
Success Criteria:

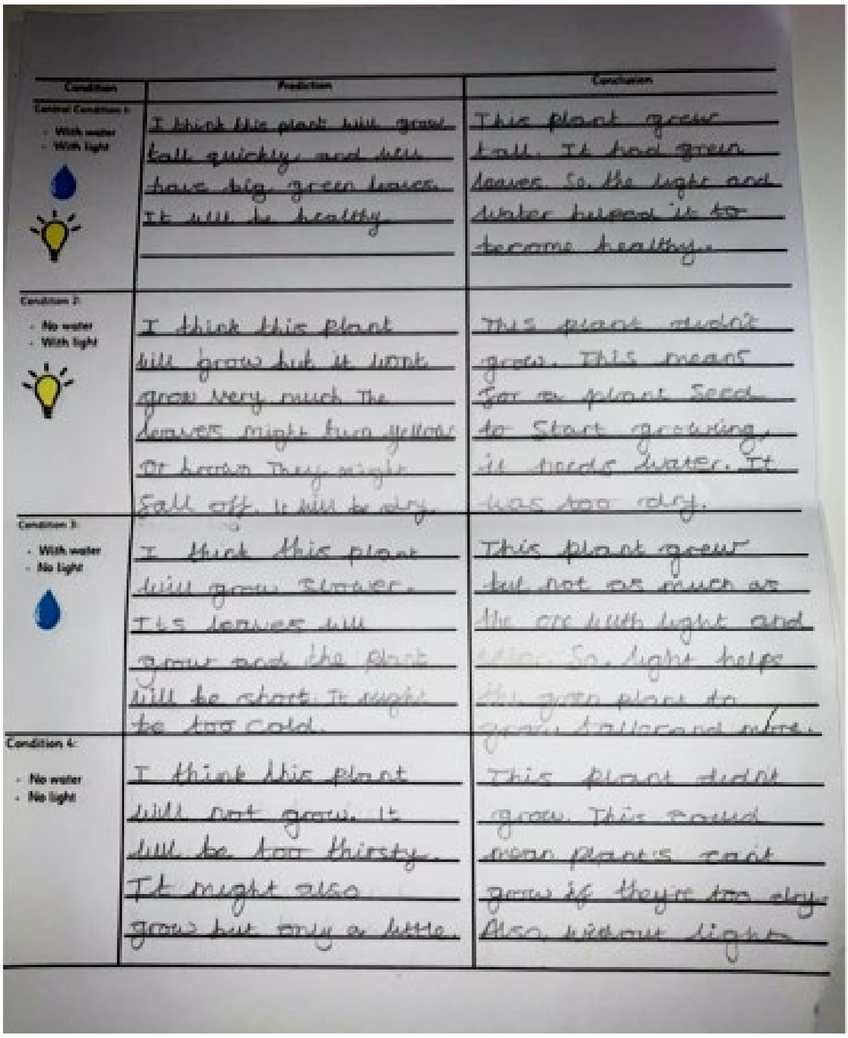
- The child can observe some of the differences between the plants which have grown in different conditions. For example, noting that plant ‘A’ is taller whereas plant ‘B’ is shorter. Common differences may include height, colour size or the number of leaves.
- The child draws two observational drawings, using equipment to focus on key differences between two plants. The drawing should include relevant detail, showing physical differences. For example, two drawings which include different uses of colours for the leaves.
- The child is able to write a conclusion, drawing on the group discussion and their drawings, to explain why they think these changes occurred and what this means regarding what plants need to be healthy and grow.

Being able to link theory and practice as a result of research

- Feel more confident in my ability to facilitate opportunities for children to develop their ability to scientifically observe
- Able to address misconceptions in the classroom effectively, seeing them as a positive step towards learning rather than simply being ‘wrong’
- Know the difference between formative and summative assessment, and how to track this progress to support learning in a sequence of lessons
- The role of communication in allowing children to share ideas, and promote links between knowledge
- How to write interesting lesson plans, thinking of the resources, allocation and roles of different staff etc. I was able to research a wide range of plans, ideas and resources online which will be very useful for planning lessons in the classroom in the future
- I develop my understanding of the curriculum for KS1 and the continuation of learning which would take place from lessons focused on observation







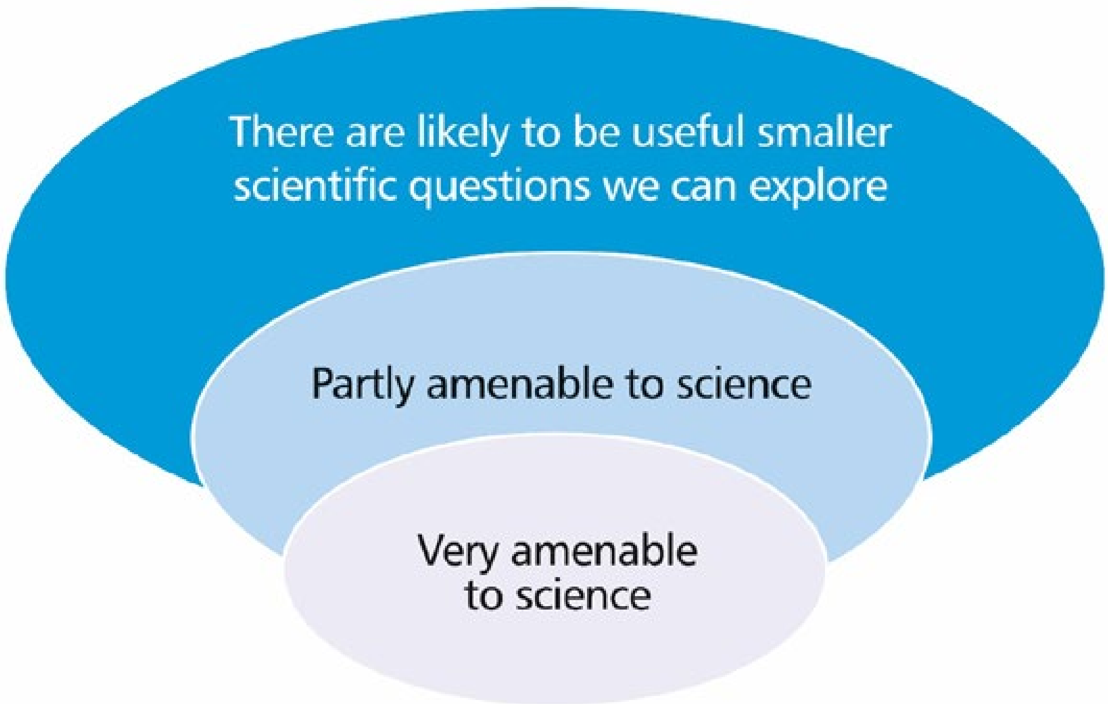
Condition	Prediction	Conclusion
Control Condition 1: - With water - With light	I think this plant will grow tall quickly, and will have big, green leaves. It will be healthy.	This plant grew tall. It had green leaves. So, the light and water helped it to become healthy.
Condition 2: - No water - With light	I think this plant will grow but it wont grow very much The leaves might turn yellow or brown They might fall off. It will be dry.	This plant didn't grow. This means for a plant seed to start growing, it needs water. It was too dry.
Condition 3: - With water - No light	I think this plant will grow slower. Its leaves will grow and the plant will be short. It might be too cold.	This plant grew but not as much as the one with light and water. So, light helps the green plant to grow taller and more.
Condition 4: - No water - No light	I think this plant will not grow. It will be too thirsty. It might also grow but only a little.	This plant didnt grow. This could mean plant's cant grow if they're too dry. Also, without light

Indicative Time	What am I going to teach? What do I want the children to learn?	How am I going to facilitate this?
Starter- 10 minutes	Pupils look at their predictions from the previous lesson and then at the plants growing in different conditions. The children will be recapping their expectations for the plant's growth.	The teacher will write the different parts of the plants on the whiteboard, such as stem and leaves to help children start to compare specific and detailed differences regarding the plant.
5-10 minutes	The teacher will lead a discussion about what plants need to stay healthy, relating to the control plant. They will encourage children to connect their ideas to their previous learning of the structure of plants, including leaves and stems, and think about what they believe plants need to grow.	Some questions could be: "Are they surprised about what happened?" "Why do you think these changes have happened?" "Why do you think this plant's leaves may have gone like that?" and "How can this help us to work out what each different part of a plant needs?" The teacher should encourage questioning in a child-centred and constructivist way, eliciting children's explanations (Chin, 2007). The teacher or assistant will complete the in-class assessment grid, tracking children's understanding of the discussion.
15 minutes	Children draw two observational drawings, comparing the control mustard seeds with the mustard seeds, which grew in a different condition. They should focus on one element of the plant for this, for example, the difference between the leaves and draw one plant enlarged. Their drawing will encourage them to use their senses to observe closely. They will label the plant's differences, for example, 'smaller leaf'.	A card peephole and a magnifying glass can help students focus on one aspect of the plant in more detail. The children can focus on the detail of the plant, making their observations of differences easier.

5 minutes	Children will use their drawings to help them draw conclusions surrounding what their observations mean regarding what plants need to grow.	The teacher can prompt students who may be in the 'working towards' criteria to engage with the scientific equipment and engage the child in further open-ended questioning. These drawings and filled-in tables will later be assessed and marked in relation to Assessment for Learning (Black et al., 2003).
Plenary- 10 minutes	Children can reflect as a whole class on the differences they have observed and share their conclusions regarding their original comparative test plan.	By sharing observations and conclusions, children will become confident in their ability to draw conclusions. They can reflect on why other people may have taken a different approach. The teacher could ask questions like "how did what you find compare with what you expected?" (Roden, Ward and Ritchie, 2007 p. 181) to develop their analysis, interpretation and explaining skills. Teachers, again, should use the in-class assessment grid to assess the class' understanding and achievement of the Success Criteria.
Role of adults: The adults will be used to mix the soil and vermiculite prior to the children planting the flowers (SAPS/FSC, 2016). Adults should facilitate open person-centred questioning regarding the changes that have occurred between different plants. The adults will help the children to identify what changes they see initially and structure the discussion surrounding why these changes have occurred. For example, plants need light to grow. A possible explanation of plants needing light may be because it gives the plant energy (only a basic explanation should be given in Year 2). Adults act as the facilitator for the children's discussion and explanations. The adults will take the plants out of the cupboards and place them in an area where children can access and view them. The adults will provide the equipment useful for children's observational drawings and complete various assessments throughout and after the lesson regarding individual and whole class assessments.		
Classroom Management: Children need to be aware of safe handling techniques. Plants should be kept on the tables, resting within a shallow container. Children should also be kept in small groups to look at each plant, allowing each to have a sufficient view without the increased risk of breaking or knocking over the plant. They will raise their hands when participating in the discussions on the carpet. Named lolly-sticks will be used to encourage questioning from children, and Dojo points to reinforce positive behaviour, work and effort.		

Health and Safety: Risk: Low - Allergic reactions to plants could impact students or staff. To prevent this, the plants used will not be ones which typically cause allergies. After handling or touching any plants, the students and staff will wash their hands. Students should be made aware of safe handling techniques. Risk: Low – Soil contamination could occur to students or staff if cuts and grazes are not properly cleaned and taken care of. Cuts and abrasions should be covered, and hands should be washed thoroughly after handling soil. Students should be made aware of safe handling techniques.
Extension/Further Activities: Extension Question: "Do you think the plant [previously in a poor growing condition] will recover if it was now exposed to light and given water?"

Appendix 5. Epistemic Insight Initiative Pedagogical Tool – The Bubble Tool



Appendix 6: Case Study 1 - Example Assignment (Epistemic Insight: Comparing two disciplines through the use of a Big question or question that bridges two disciplines)

Module: Subjects Within the Curriculum-Portfolio

Module Code: MPETT2SCP_subjectsinthecurriulum2 (2)

Assignment Title: What do types of knowledge and approaches to learning from different subject disciplines contribute to an investigation of a 'Big Question' through a cross-curricular approach?

Assignment Word Count /Weighting: 4000 words (equivalent); 100% module weighting There are two parts to the assignment totalling 4000 words equivalence.

What should be submitted:

This assignment is a 4,000-word portfolio with two parts: A portfolio consisting of a written critical exploration of the interconnections between two subjects with an illustrative scheme of work. Scheme of work (2,000-word equivalence) and an essay (2,000 words). The essay must have a reference list attached.

Scheme of work (2,000-word equivalence)

Consider the subjects of the Foundation Curriculum that you are studying in this module this year. Choose a 'Big question' that you feel can be investigated through these subject disciplines. You can devise your own question, but a list will be provided of possible questions to choose from, too.

Create a scheme of work that demonstrates how you would plan for each subject to investigate your chosen 'Big Question'. This should take the form of a detailed, annotated mind map, which can be developed further as a table/grid. You may wish to include the Bubble tool (see below) to exemplify your thinking.

Demonstrate how the question could be investigated in a series of activities. You need to state:

- For which year group is this relevant
- subject-specific objectives (linked to the National Curriculum)
- learning outcomes
- possible questions and approaches.

Essay (2,000 words)

Explore in essay form the rationale for your scheme of work. The key question to answer, at length, is:

What do types of knowledge and approaches to learning within your two foundation subject disciplines contribute to an investigation of a 'Big Question' through a cross-curricular approach?

You must cite subject-specific literature throughout your writing and provide a reference list.

You will also need to explore:

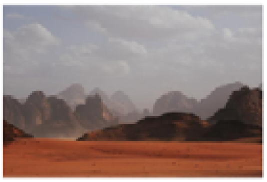
- What are the principles, skills, and knowledge of each subject which, when combined, can enhance pupils' exploration of 'Big Questions' effectively?
- What are the strengths and limitations of each subject's approach used to address the Big Question in this assignment?
- If there is not equal weighting between the two subjects in addressing the question, you will need to explore the reasons for this.
- What are the positives and negatives of taking a cross-curricular approach to planning and teaching?
- Please refer to the additional guidance below.

Appendix 7: Case Study 2 - Example of one PGCE student teacher's learning from a classroom-based research project planned, implemented and assessed on the Researching Teaching and Learning module whilst working with a tutor from the Essential Experiences in Science Project

(The student teacher permitted the sharing of this presentation.)

How do Astronauts Live in Space?
An insight into children's views on how lessons in the classroom relate to real world contexts

By Amy Sexton



Introduction

Exciting developments in science are often at the forefront of our news, for example, the development of new vaccines and the successful landing of the mars rover. However, recent research is showing that interest in science in schools is decreasing (Van Griethuijsen et al., 2015)

Ofsted (2013) stated that best practise in science education occurred when there was ample time for scientific inquiry following student's curiosities.

This study will focus on the links children make to the real world through an investigation that crosses subject boundaries. It will look to answer the question:
How do children connect their learning in science with real world contexts?

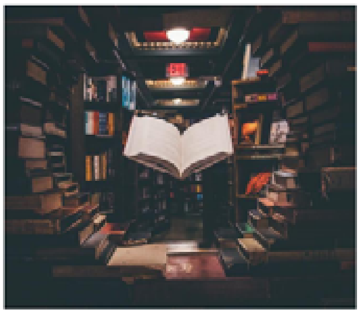
Research in the area

'Gender stereotypes in preschoolers' image of scientists' (Blagdanic, Kadijevic and Kovacevic, 2019)

'I'm good at science but I don't want to be a scientist': Australian primary school student stereotypes of science and scientists'
(Scholes and Stahl, 2020)

Scientific Knowledge
(Van Uum, Verhoeff and Peeters, 2016)

Cross Curricular links and Real World Connections



Department for Education (2013)
National Curriculum

Microsoft (2018)
'Why Europe's girls aren't studying STEM'

Zhai, Jocz, and Tan (2014)
'Am I Like a Scientist?': Primary children's images of doing science in school'

Methodology

School Setting

Small rural school

24 Year 1 and 2 students

Two groups of 4 students took part in the interview

(Tisdall, Davis and Gallagher, 2008)

Ethical consideration

A member of the senior leadership team acted as gatekeeper and gave consent for the research.

Children gave assent to take part.

The children were reminded of their right to withdraw at any point.

(Fargas- Malet et al., 2010)

Full risk assessment was conducted

Confidentiality and anonymity maintained and data was stored safely and securely.

(BERA, 2018; Tisdall, Davis and Gallagher, 2008)

Issues

This research took place shortly after the children had returned to school following a national lockdown.

The research took place on a Friday afternoon.

Methodology

Discussion about the project and introduction to the tasks

Drawing task

Practical task

Space station video and discussion

Two group interviews Semi-structured with four pupils in each group

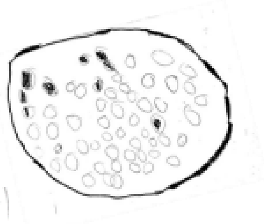
Thematic Analysis:
Braun and Clarke (2006)
Outlines the steps to be taken to conduct a thematic analysis. These were followed in analysing the data.

Thematic Analysis

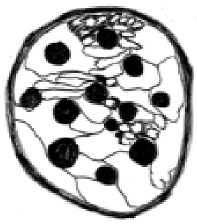
How did the children link their learning to other contexts – Key themes:

Taste and their own likes/dislikes

- 10/24 children drew pizzas
- 4 out of 8 mentioned that they chose part of their meal because it was yummy.



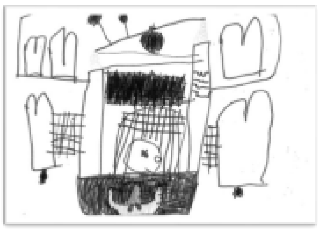
"I was really hungry, these are my most favourite foods"



"I thought about my favourite foods and how yummy they are"

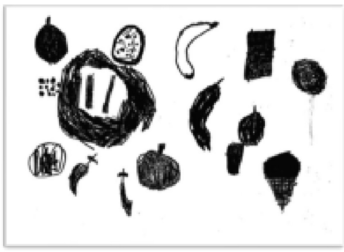
Longevity of food

- 2 out of 8 referenced that the food would last a long time



Healthy Foods

- 4 out of 8 mentioned healthy eating when describing their choices.



Zero Gravity

- 1 out of 8 made reference to food not floating away
- 1 out of 8 wanted the food to be messy to make it fun

How the children linked their learning to real world contexts:

What material would you use to package your food? 8 responses

Foil
(5 responses)
"I am going to wrap it up and throw it into space. I am going to wrap it up in tin foil"
"I would use a tin foil bag"
Cling film
"I would put it in this foil stuff see through foil"
Other
"I'd use my sleeve"
"I would just teleport it"

How could our experiment help Astronauts?
4 responses

"By saving the food so that when … he gets in the rocket and exploring space"

"If you had your lunch in there and you put it in a thingy, and you could shoot it into and control it to see where it would go."

"It might help them with wrapping and stuff"

"So it can't just float out"

What is your favourite thing about science in school?

"I like a million and sixty things about science because I learn about things I don't know"

"you get taught a lot of things"

"nothing"

"fun activities"

"Play"

"I like science because they tell you a lot about everything and then you know what stuff is called when you talk"

"Learning about space"

"make drawings and talking about what you've learnt"

Conclusion

How do children connect their learning in science with real world contexts?

- The children were able to make links to previous learning in science and other areas of the curriculum with ease.
- Though they could apply their learning to themselves, they found it difficult to apply it to a context outside of the classroom.
- The children appeared to view science from a more traditional view, seeing themselves as there to learn from the teacher rather than leading their own learning through inquiry. They also had a limited understanding of what a scientist does.
- These show that perhaps the children have been impacted by lockdown and have not been experienced to much inquiry based learning. They also might not perceive themselves as scientists as suggested by Zhai, Jocz and Tan (2014).

Implications for Practise

Implications for my own learning and practice

- Scientific inquiry needs to be carefully planned to ensure that children experience high quality teaching.
- Epistemic insight initiatives show how 'big questions' allow children to make cross curricular links which are particularly useful. They also allow children to follow their own curiosities which helps build an intrinsic motivation.
- Ample cross curricular links may help to ensure that stereotypes are dispelled and should therefore be promoted in the classroom.
- Children have to see themselves as scientists in order to understand the power of sciences and how it has real world connections.

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THE UNITY OF KNOWLEDGE AND THE FAITH-REASON DIALOGUE AS PEDAGOGIC TOOLS TO TEACH SCIENCE IN CATHOLIC SCHOOLS AND UNIVERSITIES

Dr Elisabetta Canetta

Introduction

The primary meaning of s*cience is knowledge* in the largest possible sense, while the original meaning of *scientific knowledge* – coined by the Greek philosopher Aristotle (384 – 322 BC) – refers to our capacity to know a phenomenon through what causes it (Barnes 1994, Book I.II; 71b9-12). This type of scientific investigation is called deductive and lasted for over 2000 years until the English philosopher Sir Francis Bacon (1561 – 1626) developed the scientific method we are familiar with, today (Bacon 2004, pp. 75–77).

In the Baconian method, which is inductive, we begin with observing a natural phenomenon and then we synthetise these observations into general theories. The past forty years have seen a further change in how we perceive scientific knowledge, which is currently seen more as technological advancements (Torpey 2000, p. 758) than a pure exploration of the cosmos and its laws. This change has altered the way science is taught in schools and universities, as clearly shown in the national curriculum for science; where the emphasis is more on the technological applications and progress of scientific knowledge than the mere investigation of the natural world through observation and experiments (Svendsen 2021, p. 47). A recent Ofsted Curriculum Research Review for Science (2021) has shown that pure science – as opposed to applied science and technology – is considered not only difficult but also as having no practical application to our daily lives—as well as to the benefit of humanity (Ofsted 2021, p. 10). The issue is not only whether the current position of science in education and our society should be upheld but also how science should be taught in Catholic schools and universities. In this paper, I will argue that a possible way to solve this issue is to use the idea of unity of knowledge and the faith-reason dialogue as pedagogic tools in the classroom.

From natural philosophers to scientists

Observation is key to any scientific pursuit because the first step taken by any *student of nature* is to observe natural phenomena, and then try to understand how they happen and what the laws that they obey are. The main scope of scientific inquiry is to gain insight into the hidden patterns followed by nature and to achieve a deeper knowledge of the laws governing the natural world. Since the main aim of science is to elicit the fundamental nature of knowledge, reality, and existence, it has always been associated with philosophy. Thus, those who were applying themselves to the study of nature were called *natural philosophers*.

The term *scientist* is fairly recent because it was coined by the English polymath, philosopher, and theologian William Whewell (1794 – 1866) (Whewell 2014, p. CXIII). The word scientist was harshly criticized by the majority of natural philosophers and cultivators of science during the 19th century mainly because of its apparent distortion and deterioration of the English language. Attacks against it continued until the American philologist Fitzedward Hall (1825 – 1901) defended the usage of scientist and predicted "that it will live" (Hall 1895, pp. 25-26), and we now know that Hall's prophecy was correct.

Another issue with the introduction of the word scientist was that it pointed towards a highly specialized and professional aspect of knowledge, which was at odds with the image of the natural philosopher as a liberally educated person whose primary aim in their scientific pursuits was to unveil the hidden truths of nature and the cosmos for purely intellectual curiosity. This was also the goal of cultivators of science who despite making a livelihood out of their scientific works understood their scientific inquiries not as money-making professions but as intellectual adventures for the sake of knowledge itself (Ross 1962, p.66).

Change in how science is taught in contemporary schools and universities

The change from a purely intellectual (liberal) to a mainly skill-based (utilitarian) view of science led to its shift from an idealised to a materialistic relationship with knowledge. This change has influenced the way science is taught in our contemporary schools and universities.

The idea of an educational institution where students can learn about different disciplines, has its origins in the Academia that the Greek philosopher Plato (ca. 429 – 347 BC) founded in the outskirts of Athens in 387 BC. This idea has evolved over the centuries from Plato's vision of education as a mentor who shared verbally their knowledge and understanding of natural laws and philosophical/theological concepts and theories with a group of students (Wallach 2002, p.7) to the contemporary idea of a school or university as a central player in shaping the culture and civilization of modern society. This is achieved by exposing students to intercultural dialogue and training them to put it into practice (Bladh 2020, p.83). In particular, the impact that education has on society at large is becoming more and more prominent due to a shift from educating only the few to opening education to everybody regardless of their cultural and economic background (Jalbout 2020, p.16). Furthermore, contemporary universities are market-driven and this has affected and still does influence the way knowledge is created and transmitted to learners (Tomlinson 2015, p.151), with the current trend being to stipulate a contract between the student and the university.

The first half of the 20th century has witnessed a dramatic increase in economic demand that has completely changed the science education landscape by transforming it into an applied science provider. The science graduates of the 20th century were no longer exponents of the privileged societal *élite* but learners from all the walks of life and cultural backgrounds who went to university to continue their education in specialized and highly applicable areas of knowledge. However, when considering these changes and the impact that they are having on 21st century science education in universities as well as in schools, it is essential to keep in mind that what has changed is not the syllabus – which is still anchored to the fundamental knowledge developed in the 19th and 20th centuries – but the way that knowledge is delivered to the students, namely through a multidisciplinary curriculum where science disciplines contain features and knowledge from other disciplines. This multidisciplinary approach to curriculum development is leading to the formation of highly skilled graduates who have a true appreciation and understanding of what a diversified culture looks like (Farah 2019, p.25).

Unity of knowledge as a pedagogic tool

To be successful, a multidisciplinary curriculum must be rooted in unity of knowledge, an idea clearly articulated by the English theologian St John Henry Newman (1801 – 1890) in his seminal book *The Idea of a University* (Newman 1996, p.76). However, despite the importance and actuality of Newman's philosophy of education, the latter has been harshly criticized during the 20th century because it has been considered irrelevant to contemporary education system due to its anti-utilitarian approach and its focus on a united knowledge (Roberts 1990, p.222; Reddings 1996, p.167; Collini 2012; p.59; Willets 2017, p.371). Furthermore, Newman's philosophy of education seems to be at odds with the aim of 21st century university education to equip students with both knowledge and those transferable skills that will make graduate employable in the current highly competitive job market. As the Scottish-American philosopher Alasdair MacIntyre (1929 –) has posited, Newman's vision of a university is not considered false by his critics but simply irrelevant (MacIntyre 2009, p.347) because contemporary university (1) focuses primarily on equipping students with highly specialized knowledge; (2) does not consider a *secular knowledge of God* – i.e. the study of theology as a purely academic discipline rather than as the foundation of religious faith – necessary to the present day graduate; and (3) must be able to justify to students and those who sustain them financially the need of a university education to enhance the graduate's career opportunities (MacIntyre 2009, p.350).

It is true that Newman's idea of university appears to depict students as ivory-tower indwellers almost completely detached from and oblivious of the societal needs of our contemporary society. It is also true that Newman's vision of education is dated and does not meet the current demands of our technological society. However, that idea is still valid and applicable when it comes to developing students into global citizens and individuals who are capable of exceeding the limitations of academic knowledge. In fact, the core of Newman's message concerned the ability of education to develop and cultivate the mind of students to enable them to become free thinkers capable of judging things righteously through a connected view and understanding of the world and its inhabitants. As the English Roman Catholic priest and Newman scholar Fr Ian Ker (1942 –) pointed out, "at the heart of [Newman's] philosophy of education is simply the capacity to think" (Ker 2011, p.20). Newman viewed education as inclusive and holistic and this is also the contemporary vision of what education must be. The united and universal knowledge of which Newman talked about should not be considered as an elitist and utopian type of knowledge that does not fit the demands of our current society and, therefore, the academic and epistemological needs of 21st century students. In fact, this type of knowledge would not only be impractical but also meaningless. What Newman meant was "that a university should in principle be open to teaching anything that is knowable" (Ker 2011, p.28).

But is it possible for just one person to possess a *united knowledge*? Yes, it is possible by means of a *liberal education*, namely by creating "a pure and clear atmosphere of thought, where the student can apprehend the great outlines of knowledge, the principles on which knowledge rests, […] its lights and its shades. [Hence, liberal education is] a habit of mind […] which lasts through life, of which the attributes are freedom, equitableness, calmness, moderation, and wisdom" (Newman 1996, p.77).

It is worth noticing that Newman's ideas about liberal education and universal knowledge are shared by many contemporary educators and teachers who criticize an increase in corporisation in education and wish to promote a holistic vision of the contemporary university (Deboick 2010) and a whole-person education (McAllister 2015; Christie 2011). However, educators who promote the unity of knowledge must always "respects the insights of the different disciplines when they speak of those aspects of experience which are the proper objects of their studies. It is a unity to be achieved by the search for synthesis, rather than by reduction to a falsely simplified common denominator" (Polkinghorne 1997, p. 89).

Study science in Catholic schools and universities

The Catholic approach to the study of science should train students to appreciate that each of the different sciences acts as "safeguard of others" (Newman 1996, p.76). A Catholic education should ensure that scientific knowledge is not transformed into technology but it is still a voice singing in unison with the voices of all the sciences the sacred mysteries of the natural world. This means that both types of scientific knowledge (pure/liberal and technological/utilitarian) must be considered because they act on two different levels:

- intellectual and contemplative (liberal knowledge);
- beneficial to an end-user (utilitarian knowledge).

The importance of the interplay between pure and technological scientific knowledge to help students discover their true identity as human beings is clearly stated by the American scholar Andrew DelBanco (1952 –) when he says that "students in programs focused on specific job skills […] need – and deserve – to have their minds stretched by the big questions raised by history, science, philosophy, and the arts. By the same token, students in traditional liberal arts fields need to gain the concrete skills that are required in a demanding labor market" (DelBanco 2012, p. xv).

Faith and science dialogue as a pedagogic tool in the classroom

Teaching science within Catholic education requires the use of a robust and well-articulated faith-reason dialogue in the classroom because, as St. John Paul II (1920 – 2005) tells us in his Encyclical Letter Fides et ratio, "faith and reason are like two wings on which the human spirit rises to the contemplation of truth" (John Paul II 1998, Blessing). Since its publication the Encyclical Letter has attracted a lot of attention and has had both supporters and detractors. The English Anglican theologian John Webster (1955 – 2016) was probably one the harshest critics of the Encyclical and criticized very strongly the appropriateness of exploring the relationship between philosophy and theology (Webster 2000, p.70). He also argues that overall, the Encyclical fails to clearly explain what the relationship between philosophy and theology is and offers only an assurance that such a relation exists and "needs to be taken very seriously" (Webster 2000, p.74). Webster also criticized the emphasis of the Encyclical on the common spiritual need to transcend the natural world that is embedded in any culture, and described it as "pretty clumsy stuff" (Webster 2000, p.73) because it does not take into consideration the political constructivism of different cultures.

If Webster disagreed with the importance of communal activities and unification of knowledge for the success of the faith-reason relation in the pursue of truth, the American Catholic theologian Thomas Guarino (1951 –) praises the pluralist approach of the Encyclical which "emphasizes the importance of contemporary philosophy, rejects univocal answers, and seeks new and creative syntheses to express the truth of the Christian faith" (Guarino 2001, p.686). However, I agree with Guarino that the strength of the conceptual pluralism encouraged by the Encyclical is dampened by its lack of engagement with the role that human subjectivity plays in the act of knowing the truth. By not considering the subjective dimension of knowledge, the letter fails to discuss the relation of human rationality with faith (Guarino 2001, p.692), which is an essential component of the faith-reason relationship.

Regardless of what we think about the Encyclical, this document is of particular importance in our contemporary educational system because not only it promotes an open dialogue and cooperation between different disciplines, but it also "act centripetally to counteract otherwise under constrained or centrifugal tendencies in secular knowledge" (Hampson 2006, p.482). I agree with Hampson that if taken separately, theology, science, and philosophy can lead to a knowledge of the world that is fragmented. It is only when these very different disciplines are approached within the milieu of Christian faith that they can work together harmoniously, while preserving their autonomy and individuality, and lead humanity to the truth (Hampson 2006, p.485).

If the dialogue between faith and reason must be kept open to ensure that humanity achieve knowledge of the truth, how can such a task be undertaken in an educational context? The answer to this question is complex because it touches on the highly controversial issue of the compatibility of science and religion and its influence on science and religion education. One perspective is that religious education should not be allowed to enter into the science classroom. On the contrary, it should be science that should step into the religious education classroom and help students understand the meaning and role of religion by means of scientific concepts and terms (Mahner 1996, p.102). A more positive position considers religion into a science classroom as a simple and effective pedagogic strategy to help students have a better understanding of reality (Reiss 2009, p.787). In addition, the interrelationship between science and religion is seen as playing a pivotal role in engaging students in the science classroom with controversial questions about the purpose of life, the dramatic climatic and environmental changes that we are currently witnessing, and bioethical questions (Saether 2019, p.157).

Conclusions

One of the main issues with contemporary science is that many contemporary scientists though in awe of the natural world and its wonders follow the utilitarian approach to science and stop at the surface of what they see around them; they are content with knowing *how* things work but not understanding *why* they work as they do. The fact that contemporary society perceives science as utilitarian has had a dramatic impact on the teaching of science in schools and universities, also because education has gone from being accessible only to a small number of people belonging to the societal *élite,* to being open to people from every walk of life and cultural-economic background. As a result, 21st century science graduates are highly skilled and possess a well-developed and diversified cultural awareness. The liberal attributes of Catholic education make it the perfect environment for teaching students what pure science is, to enable them to appreciate what true scientific knowledge is, so they are able to enjoy the mysticism of science. When teaching science within Catholic education it is very important to use the unity of knowledge and the dialogue between faith and reason as pedagogic tools to engage students in the classroom with big questions about the meaning and purpose of humankind and human life, the impact of human activities on the environment, and bioethics issues just to cite a few.

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EMBEDDED RESEARCH: WORKING WITH THE SWAMPY LOWLANDS AND ITS INHABITANTS!

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Introduction

Embedded research is a newly named approach to research and evaluation across practice settings relevant to all practice disciplines. Although, it can be aligned with better known approaches such as participatory and critical action research, realist evaluation, appreciative inquiry and ethnography that recognise the complex contexts in which professional work takes place and what matters to those experiencing and providing these services.

My experience has been in health care settings where I have always been an embedded researcher in the roles I have undertaken, first, as a consultant nurse in a nursing development unit based within a critical unit in London in the early 1990's where I used participatory action research. This was followed by being a practice based researcher using practice development – a methodology associated with 8 principles focussing on person centred approaches, the development of effective workplace cultures where everyone can flourish, collaboration, inclusion and participation with all stakeholders, combined with inquiry in, from and for practice (Hardy et al, 2021). Subsequently, a joint clinical chair between Canterbury Christ Church University and East Kent Hospitals University NHS Foundation Trust focussed on multi professional practice development and transformational research. More recently, I have been working between East of England stakeholders and the University of East Anglia to support the system and workforce transformation required for integrated health and care services. In parallel, national work for Health Education England, is focused on developing and positioning the capabilities of the multi-professional consultant practitioner role[3] as a system leader and embedded researcher (Box 1). This role focuses on impact, not from the perspective of the research excellence framework and its research outputs, but from research being a theory of change that impacts on the knowledge, skills behaviours and attitudes of actors, sustainability and realised benefits for society and communities (Belcher and Halliwell, 2021), and associated with the term 'actionable knowledge' in embedded research (Marshall 2022).

Box 1: Multi-professional consultant practice defined as:
'integrated expertise in the four domains necessary for enabling quality care at all levels of the health and social-care system:

- Expert practice (the consultant's main health/social-care profession)
- Strategic and enabling leadership
- Learning, developing, and improving across the system
- Research and innovation as an embedded researcher

This embraces the key skillset for systems leadership and systems transformation aided by clinical credibility in the consultant's own professional practice and underpinned by consultancy approaches that sustain quality.' (Manley & Crouch, 2020)

3 This embraces all the health care professions – all allied health care professions; clinical scientists; midwifery, nursing; osteopathy, pharmacy.

What is an embedded researcher?

Donald Schon's well known definition about professional practice provides an excellent starting point for understanding the key features of embedded research with its focus on the 'swampy lowlands':

> *'In the varied topography of professional practice, there is a high, hard ground where practitioners can make effective use of research-based theory and technique, and there is a swampy lowland where situations are confusing 'messes', incapable of technical solution. The difficulty is that the problems of the high ground, however great their technical interest, are often relatively unimportant to clients or to the larger society, while in the swamp are the problems of greatest human concern.' (Schön, 1984, p. 42)*

The embedded researcher therefore works with 1) the complexity of their contexts recognising that they are multi-facetted and requires a different epistemological understanding about what counts as knowledge when compared with that underpinning technical knowledge; 2) draws on co creation and co-production approaches (Graham et al, 2022) with people about what matters (https://wmty.world/); and 3) requires integrated expertise across a number of skills sets, not just research to achieve embedded and sustained person centred change (Manley & Jackson 2020).

Actionable knowledge draws on co production models for two reasons firstly it needs to be guided by what matters to people; namely, those experiencing and providing care and services, other stakeholders and students (https://wmty.world/) and secondly, involves all in its co-creation, interpretation and use (Marshall et al, 2022) to embrace co-production at the level of 'doing with' (Figure 1).

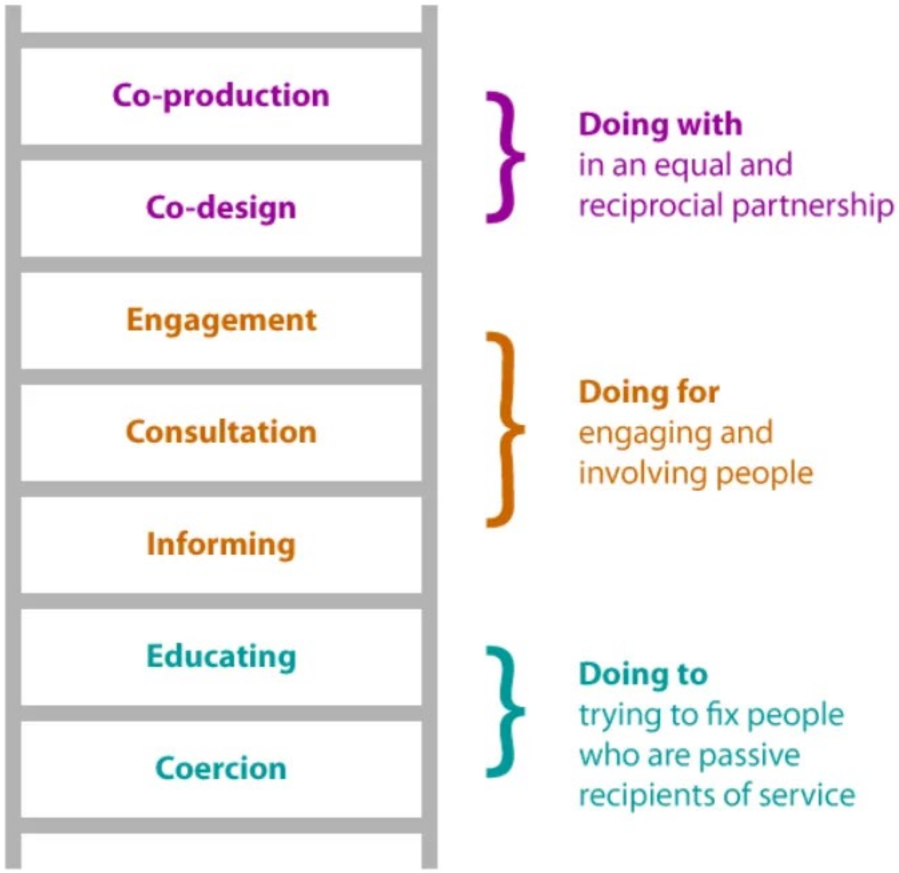


Figure 1: Ladder of Co-production by 'Think Local Act Personal'
https://www.youtube.com/watch?v=kEgsJXLo7M8

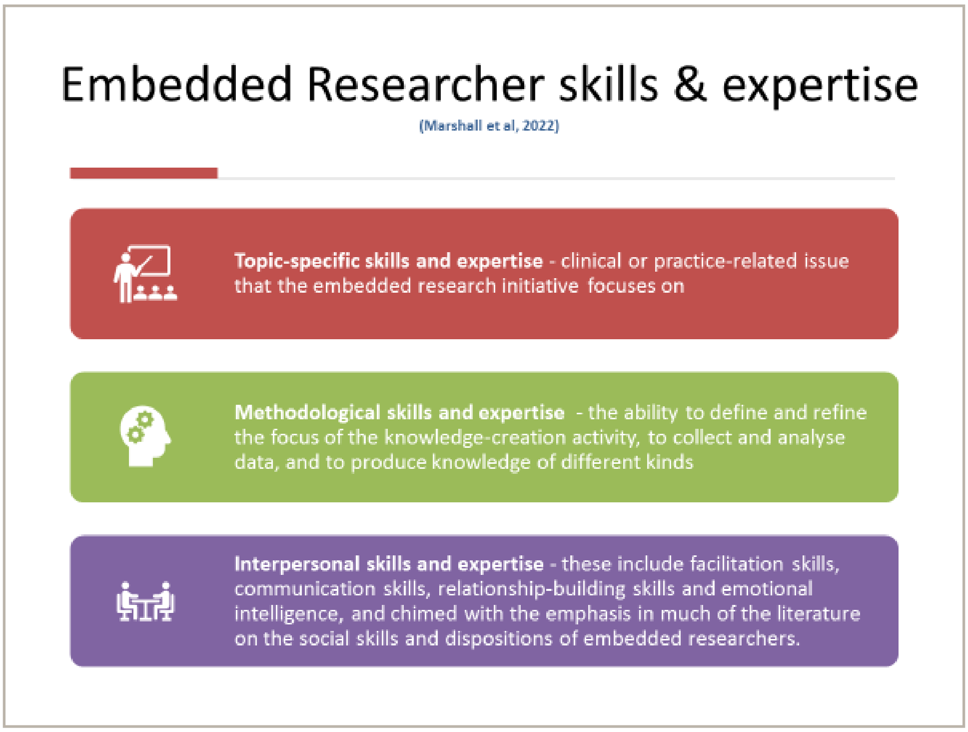
A two year National Institute of Health Research (NIHR) study across the UK completed an exploration of different models of embedded research in health care, often this has been linked to 'the researcher in residence' role (Vindrola-Padros et al; 2017), where a researcher is co-located with a health care service over a sustained period to help them address challenges or objectives they need to focus on (Marshall, et al; 2022). This research generated a comprehensive framework for understanding the facets of embedded research initiatives using a gardening metaphor based on a co-design workshop to describe: intended outcomes, power dynamics, scale, involvement, proximity, belonging , functional activities, researcher skills and expertise, relational roles, and learning mechanisms (Ward et al, 2021). The model resulting is applicable to all practice professions e.g. policing, education, social work, management etc. whilst recognising that further research needs to be undertaken on its impact over time.

The embedded researcher recognises and works with complexity in the context in which practice takes place and the many influences that impact on this. Working with the realities of practice and practice teams, embedded researchers have the potential for improving quality and sustaining changes through practice-based research and evaluation (Vindrola-Padros et al; 2017). Whilst specific projects can improve quality, safety and practice contexts, it is important to understand when quality and safety projects count as research and when they don't. Quality and safety projects contribute to research when they are, a) placed within the context of what is known or not known in the literature and b) add to the body of knowledge through systematic inquiry.

Within health care there is currently a strong focus on developing multi professional career frameworks that are wrapped around the needs of people and citizens, rather than the profession. The pinnacle of the career framework in health care is as a multi-professional consultant practitioner (Box 1) who's professional expertise provides credibility for systems leadership breaking down silos and boundaries. These capabilities are enhanced through: a facilitation skillset that takes an integrated approach to learning, development, improvement, knowledge translation, inquiry and innovation using the workplace as the main resource for learning; and, the ability to evaluate and embed changes arising from inquiry and research immediately relevant to the needs of practice and people across communities. Therefore, the key to being an embedded researcher is this eclectic and interdependent expertise drawn on, not just to evaluate, but to implement and embed change to achieve system and workforce transformation. These interdependent capabilities are also identified in the Venus model (Manley & Jackson; 2020) derived from several practice based studies in health care settings which explains how practice development because of its values and ways of working combined with facilitation, culture change, leadership and quality improvement and innovation achieve person centred sustainable workforce transformation.

The need to grow both capacity and capability at every level of the career framework in these integrated capabilities has been identified if real impact is to be demonstrated and achieved in practice (Manley et al; *in press*). Therefore, different models for developing embedded researches need to be considered that provide support to practitioners to become embedded researchers themselves in their own services. One such model is through a support partnership between service areas in an acute hospital and a university team with expertise in embedded research (Whitehead et al, 2022). This model in an acute hospital enables experienced practitioners in the fields of nursing, midwifery and allied health care practice to grow as embedded researchers through support relationships with a university combined with a programme that develops the integrated skillset of the Venus model but focusing on the needs of the service.

Marshall et al (2022) identify three types of expertise required as an embedded researcher; topic specific skills, methodological skills and interpersonal skills (Box 2).



Box 2: Types of knowledge required by an embedded researcher (Marshall et al 2022)

So, linking practitioners and services across different professional contexts with academic partners with the breadth of insights associated with methodological research is a strategy for growing capability and capacity when combined with a programme of support in the other areas required for embedding and sustaining change. It is not just doing research and evaluation that embedded researchers focus on, they also support practice settings with using and embedding research evidence into practice through knowledge translation and knowledge mobilization recognising that so much research is still not implemented and used in practice.

Successful implementation is a function of evidence, context and facilitation (Rycroft-Malone et al; 2004; Kitson et al, 2008) and again requires a skillset that can address these factors, as context includes the workplace culture, leadership and an evaluation ethos. Facilitation is the key workplace factor for enabling implementation in practice and needs to be holistic rather than technical in nature. Lastly, evidence requires a blending of different evidences – the research evidence together with professional expertise; people's own expertise and the nuances of the locality (Kitson et al, 2008)

Conclusion

Embedded research is a key concept that all practice professions can embrace, where research methodology and approaches are linked to other capabilities needed to focus on what matters to people; implement, embed and sustain change resulting. Growing this integrated approach is vital to build into both post registration, career development frameworks and undergraduate curricula in practice professions using models that grow actionable knowledge in the swappy lowlands to address messy problems. This approach will not only meet the needs of people and key public services but also will contribute to realised benefits in terms of communities, social capital and the effective use of our human resources.

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ARTICLE FOR INSIGHTS – OPEN RESEARCH AND EPISTEMIC INSIGHT

Claire Choong

What is open research?

Open research, also known as open science, relates to how research is performed and how knowledge is shared. It is a concept that can be applied throughout the research lifecycle. Research should be as open as possible, from its inception to the production and dissemination of the research output. There are many advantages to open research, which will be explored below.

Moral and ethical imperatives

Making research open access has important implications for social justice and the enrichment of lives; especially lives outside the university. Open access research is available to anyone, not just those who can afford the subscriptions and/or who are members of a university. If we believe in the enriching power of higher education then we have a "… moral responsibility to maximise the benefits of scholarly publishing for the larger society" (Willinsky, 2006).

If CCCU really is a "values driven organisation" (Honour, 2022), open access should be built into our culture. In order to do this, we need to move our focus away from the REF and towards the moral, ethical and radical aspects of open access. Gary Hall (2017) conceives of open access as a continuing struggle – much like the academic life. If we focus on the measures and targets around the REF, we see open access as almost nothing more than a bean counting exercise. But he also argues that open access is "less a project and model to be implemented, and more as a process of continuous struggle and critical resistance." He argues that open access should not merely be about making research accessible, but also needs to address "issues of access, experimentation and self-reflexivity in an ongoing critical manner", (Hall, 2017) so it should also be about encouraging re-use and experimentation.

Open access gives us an opportunity to step away from the status quo, observe it and re-imagine it. Being involved with open access can be a way of critiquing the current mainstream publishing processes, and thinking about the philosophies underpinning open access can help us explore the values and aspirations of our institution. Open access (particularly green open access – putting research outputs in an online repository) helps academics step outside 'the market' . They can share their work freely (to a point), without being subject either to the cost of APCs or the hidden costs [being treated as commodities] of sharing their work on academic social media.

Transparency, openness, verification, and reproducibility

From an ethical point of view, it is important to make research open because increased

openness usually equates to improved transparency, verification, and reproducibility. These factors are good for researchers, their institutions and the 'consumers' of the finished research outputs. Also, making research open from start to finish means it is more accessible to people who may be financially disadvantaged or otherwise on the margins of society. At the most basic level, making your research paper open access, or publishing in an open access journal, means that anyone can access it (as long as they have an internet connection) - it should be free at the point of use. Is it argued that research funded by public money should be publicly available (Sweeney, 2022).

Improving public value, research integrity, re-use and innovation

So open research, and open access in particular, improves the public value of research and should mean that research integrity is more robust, as the research can be (relatively) easily accessed and verified. It also enables re-use: one aspect of true open access is that the research output should be able to be reused – UKRI funders often mandate that a research output should have a Creative Commons license to comply with open access requirements to be eligible for funding. In turn, reuse of research should lead to more and better innovations – subsequent researchers can build on existing research more easily, because they can access it. Conversely, open research can also help prevent 'bad' research being used by future researchers, because more people can see it and assess its quality.

Making research open access gives advantages to our students, as well as to our researchers and the institution. Whilst at university, they can access lots of amazing resources through their library, but what happens after that when they go into the workplace or want to engage in lifelong learning? Making research open access enables people to reach their potential throughout their lives, not just while they are members of the university.

Universities often talk about research informed teaching, particularly with reference to the TEF, and a green open access repository can help make research informed teaching possible: Repositories collate and preserve research, so it's easily accessible to anyone. Students can search for the lecturers' research, download it, assess it and use it without cost. Although it might be possible for students to go to subscription journals and access this work, this is only the case if their university has paid for access to that journal. Having research in the repository also makes it easy for staff to access their own work and use it in their teaching, and to share it with colleagues.

Part of the power of higher education comes from the fact that it enables people to stand apart from society and the status quo and critically examine it. Open access can be a part of this 'alternative view', as it allows people to step outside the system and be part of creating a new one. In addition, the radical open access movement argues that open access should not only be about access alone, but also about re-use of, experimentation with and critique of research outputs. This facilitates a richer experience of research. People can not only read the research but can perhaps experience it in new ways. For example, an open access monograph allows the reader to explore what 'a book' is, what it means as a cultural and political object, among other things – is an e-book really still a book? Is how we read a book affected by its physical form?

Support collaboration within and across disciplines

In the context of Epistemic Insight, open research enables more opportunities for

collaboration within and access disciplines. Doing, publishing and sharing research openly encourages and enables collaboration between researchers, schools, faculties and institutions. If you want to know what someone is working on within your faculty, institution or further afield, you can often find work available open access on a university repository, even if they haven't published it as an open access article or in an open access journal.

Healthy research culture and environment

Because, in an open research culture, researchers (and everyone else) can see what (other) researchers are working on, this should make for a healthier research culture and environment. Mistakes might be able to be seen by everyone, but this means they are less likely to be repeated – so time and resources are saved, even if the researchers' pride is not.

Sustainability

The number of people in further or higher education worldwide grew almost seven-fold between 1970 (3 million) and 2009 (200 million) due to the sudden expansion of higher education in the developing world. This massive increase in the number of people in higher education was accompanied by a severe lack of scholarly information for these students. (Bodo, 2016). It should not matter where we are in the world, or which institution we belong to or are employed by we should be able to access the research outputs at the point of need, and whether or not we can access research should not depend on our income or indeed the income of our institution. Within the scholarly publication system itself, we need a focus on non-discrimination, equality and equity in the distribution of costs and benefits, in order to try to create a just and sustainable environment. Yamey (2008), argues that open access publishing is a socially responsive and equitable approach to knowledge dissemination, and subscription fees that exclude the poor from access to scholarly resource are a rights violation. As Willinsky (2006) says:

"the right to know is not solely about having access to knowledge that will prevent harm or reduce suffering, rather [it] is about having fair and equitable access to a public good".

Interestingly, he also argues that open access to knowledge can enable people to defend and advocate for other people's rights, something which should chime very strongly with our values as a university.

How does open access support sustainability? I suggest it does this in three ways: Firstly, universities are contributing to their own sustainability by meeting funder mandates for open access requirements. Even though we are trying to steer away from seeing open access in a REF-centric way, it's important to acknowledge this.

Secondly, open access research helps to facilitate the sustainability of future research and innovation – it enables anyone who wants to access research to read and build upon it. This should mean fewer instances of duplicated research, and also means that people can see examples of bad research, so they can try to avoid making the same mistakes in the future. In addition, green open access via university repositories offers a way of collating and preserving an institution's research output in an easily accessible centralised place – no more lost manuscripts!

Thirdly, it can be argued that open access publishing systems, such as new university presses and 'pure' open access online journals, are more sustainable than the current subscription-based publishing model(s). For example, encompassing justice and sustainability, UCL Press seeks to:

"…. change the prevailing models for the publication of research outputs. Grounded in the Open Science/Open Scholarship agenda, UCL Press will seek to make its published outputs available to a global audience, irrespective of their ability to pay, because UCL believes that this is the best way to tackle global Grand Challenges such as poverty, disease, hunger." (*Who We Are*, 2022)

OPEN RESEARCH AT CCCU

Research Space

Research Space Repository is Canterbury Christ Church University's institutional repository. It is an online archive of the University's research outputs. All CCCU researchers are encouraged to add their research outputs to Research Space Repository so that:

Journal articles and conference proceedings published with an ISSN are REF eligible. They must be deposited in the repository within 3 months of being accepted for publication in order to be eligible for entry into the next REF.

Your research is collated in one place so it can be found and shared easily.

Your research is kept securely online with a persistent URL.

You have a record of your research that you can link to and use to promote your research.

Other benefits of using Research Space Repository include:

Research Space Repository complies with international standards favoured by Google, ensuring deposits in the repository rank higher in search results.

Open access articles are cited more frequently than articles available via paywalls (Walker, 2022).

Institutional repositories provide for the long-term preservation of research and offer a show case for the University's research. Using Research Space Repository, or indeed any institutional or other open access repository, is an easy way of making your research open. In terms of articles, you can make them open access without paying the article processing charges (APC) that most publishers levy for this privilege. However, we welcome all types of research output and research data. Some examples of item types are photographs, performances, reports, online educational resources, conference papers, presentations and sound recordings.

Zenodo

Zenodo is a platform for making work open access. Unlike Research Space Repository, it is open to undergraduate students, as well as postgraduate researchers. However, it is not developed or hosted by CCCU. Academic staff and postgraduate researchers should always add their work to Research Space Repository, as this is the official open research channel for the university. Of course, you can always add your work to Zenodo as well. Here are some reasons why you might want to add your work to Zenodo – all of which also apply to using Research Space Repository:

"To experience and gain the understanding and skills to upload and share your work in future.

To log your idea and methodology before you carry it out – to be upfront and transparent about the approach you plan to use.

To add your voice to the existing research community in your field: is there a gap that is under-researched? Do you want to add your experiences to the literature in an area that affects you personally/professionally – sharing your work through an Open Science platform enables you to so whether you are a foundation, undergraduate or postgraduate student.

To carry out a "peer review"– critically engaging with another researcher's work. That student could be on your course or in other universities involved with the Epistemic Insight Initiative who are addressing the same question(s).

To share your research/ engagement with research in your field with a future employer – allowing you to make your assignments and or course-based reflections public so that you can share your research interests and experience with future employers." (LASAR, 2021).

Open Research Group

The CCCU Open Research Group, chaired by the University Librarian, Neil Donohue, brings together academic and professional service colleagues to consider the University's approach to open research. This includes looking at open access, open data and research data management. Currently in its early stages, it will develop policies and frameworks to facilitate and promote an open research culture, for approval by Research and Enterprise Integrity Committee.

Transformative agreements for open access

CCCU has signed agreements with a selection of academic publishers to enable more researchers at the University to publish their research articles open access. Authors submitting articles for publication in journals that are part of these agreements will have open access fees (usually known as APCs – Author Processing Charges) reduced or waived, depending on the agreement with the publisher. These open access costs form part of an overall CCCU payment for subscriptions and publishing. Full or part costs for eligible open access publishing have been met centrally, arranged by Library and Learning Resources via Jisc, the license negotiator for UK higher education. The agreements are known as "transformative", "transitional", or "read and publish" agreements, as they contribute to the global open access strategy to transition academic journals to open access (Transformative Agreements for Open Access, 2021).

Please do look at the Transformative Agreements for Open Access page on StaffNet (see link in reference list) if you are interested in finding out more about these.

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