

## ***How can the philosophy of education inform STEM Education Policy in schooling and higher education in a post-Covid pluralist and democratic Ireland: Growing back better***

Geraldine Mooney Simmie<sup>a</sup>

<sup>a</sup> School of Education, University of Limerick, Limerick, Ireland

### **ABSTRACT**

In this paper I make the case to open for critical scrutiny the purpose of STEM education policy in schooling and higher education in a post-Covid pluralist and democratic Ireland. Until now the policy (political) framing (representation) of STEM education policy in Ireland and elsewhere draws from a postpositivist stance of techné that is advocated by the state and industry and connected to transdisciplinarity, nature of science, science-in-context, skills sets and evidence-based inquiry scaffolded through one engineering model of STEM Pedagogy. The SMART (*Self-regulated, Motivated, Adaptable, Responsible and Technologically competent*) STEM student and teacher learns to fit in with a consensus view of the ideal human and demonstrate their comparative performance as measureable outputs ('what works best'). The critical scrutiny of STEM literature conducted here shows that we live in a fast globalising and digitising world where UNESCO (2021) asks us reimagine a new social contract for education. It is a timely question given that children and young people are nowadays growing up in a highly scientific and technological society where questions of the good life and STEM literacies need to be freshly interrogated. Here I share insights gleaned from a select literature review revealing the dilemmas of our time and offering new signposts forward. STEM education that balances science, philosophy and practical wisdom and underscores the limits of scientific reason in order to prepare students on one hand to combat populist anti-science attitudes and on the other to prevent falling into a narrow 'scientism'.

### **KEYWORDS**

STEM education policy, Ireland, postpositivist, techné, STEM pedagogy. SMART student, critical scrutiny, select literature review, limits of scientific reason

---

**CONTACT** Geraldine Mooney Simmie, [geraldine.mooney.simmie@ul.ie](mailto:geraldine.mooney.simmie@ul.ie)

### **PLEASE CITE AS**

Mooney Simmie, G. (2022) How can the philosophy of education inform STEM Education Policy in schooling and higher education in a post-Covid pluralist and democratic Ireland: Growing back better  
In E. Costello, P. Girme, D. Hyland, T. Kaur, O. Kelly, T. McLoughlin, & P. Van Kampen (Eds) Proceedings of the CASTeL 9th STEM Education Research Conference (66-78) Dublin City University.  
<https://doi.org/10.5281/zenodo.6953886>

© 2022 The Author(s). Published by Dublin City University

This is an Open Access article distributed under the terms of the Creative Commons Attribution License (<http://creativecommons.org/licenses/by/4.0/>), which permits unrestricted use, distribution, and reproduction in any medium, provided the original work is properly cited.

## Introduction

I am presenting this paper in the section of the CASTeL DCU SMEC Conference 2022 entitled ‘How STEM Education Research Can Inform Policy’. It is a crucial philosophical question to ponder and to get right in contemporary Ireland for a number of different and intersecting reasons. A perfect storm of reasons that includes a rapid advancing globalising and digitising world, a highly scientific and technological society and the increasing disparities in injustices and inequalities between a minority of super wealthy (elite) people and a growing majority of people struggling to make ends meet and to aspire to a good life.

It is happening at a time where Europe and Ireland appear to be emerging from the coronavirus pandemic only to be faced with the Russian war against Ukraine and the threat to the European peace project. A time of economic stress with growing inflation, increasing interest rates and the potential for industrial unrest. A storm taking place in a post-truth era when democracy is under threat of slow suffocation, from on one hand a populist far-Right movement promoting a populist anti-science stance and on the other a relentless push for a narrow science view of ‘scientism’ that only allows a technocratic lens of evidence as the one lens to view humanity and education for a market-led view for human capital change and development (Edling & Mooney Simmie, 2020; Verma & Apple, 2021).

In the last two decades of this century, the field of education has undergone rapid change in its positioning in the academy and in government policy priorities. For more than fifty years education was firmly positioned in the social sciences, underpinned by the foundational disciplines of history of education, philosophy of education, sociology of education and the psychology of education. After the Gulbenkian Commission Report in 1996, the western world set about amalgamating all the sciences. The field of education was to become a social science, a natural science and an applied science but not in equal measure. Now many of education’s more complex and sophisticated concepts, such as *Bildung*, being and becoming, democracy and public interest values were quickly diminished if not entirely removed or lost to a new discourse of learning and situated learning (Ball, 1995; Biesta, 2012, 2013, 2016, Selwyn & Gašević, 2020). Transdisciplinarity became central, STEM education was introduced, inquiry based learning, evidence-based policy making and new technocratic modes of management and measurement started to dominate (Hattie, 2012; Stohlmann, 2019).

To date the field of education divides between those who argue that education is a moral, intellectual and apolitical endeavour and those who argue that education is a moral, intellectual and political endeavour. The latter argue for recognition of the political because of the inextricable links between knowledge and power [privilege] and the deliberate intentionality of educators to bring about change [through seeking to change the gaze of students in a preferred and publicly stated policy (political) direction] (Freire, 1971/2018).

For those whose research and theorisations lie in this latter field of critical studies, in my case in the field of critical feminist research policy analysis, our studies of public policy and practices are concerned with understanding and critically interpreting the representation and framing of reforms in education and in STEM education and seeking to reveal the hidden assumptions embedded in the definition of problems. My research questions aim to critically interrogate connectivity between national and global reform movements and the contribution made by research, including qualitative studies that are often neglected in public policy reports and yet can explain the multiple dilemmas and possibilities inherent in policy imperatives of change. Research questions that are not only concerned with curriculum, pedagogy and assessment as selections from culture but with expansive questions of what it means to be

human in this early part of the 21<sup>st</sup> century, how to live well with self and with others and partake in the shared responsibility of co-constructing a just global world. Critical questions of who benefits are never far away as is grappling with theoretical perspectives provided by critical sociology and philosophy (Mooney Simmie & Moles, 2011, 2020).

My research studies analyse policies in education and in STEM education (in relation to teaching and teacher professional development) taking policy backgrounds and contexts into account and contrasting this with education understood as a practice of human freedom [emancipation] and transformative possibility. This view of education is found in the philosophical writings and theorisations of Paulo Freire (Freire, 2018/1971) and Maxine Greene (Greene, 2017) and related theorists and underpins my reflexive positioning in all of my research and policy studies (e.g. Galvin & Mooney Simmie, 2019; Mooney Simmie, 2007, 2021; Mooney Simmie & Lang, 2019; Mooney Simmie & Edling, 2019; Mooney Simmie, Moles & O’Grady, 2019; Mooney Simmie & Moles, 2020, 2011; Mooney Simmie & Sheehan, 2022). Education as a practice of freedom acknowledges the aspiration for nurturance of an inner (soul) life and for critical mediation with the wider social and material world. The discipline of education therefore does not stop at a focus on ‘self’ and ‘resilience’ or indeed at the edge of the classroom or ‘institution’. Within the aims for education, and STEM education, the teacher works within a number of paradoxes, including seeking to induct children and young people - through qualification, socialisation and subjectification - into the reliable and changing canon of knowledge and into the cultural world(s) and at the same time always making space for something new and better to emerge (Ball, 1995, 2003, 2021; Biesta, 2012, 2013, 2016; Edling & Mooney Simmie, 2020).

It is in the discursive gaps between policy and practices that this journey of human being and becoming and change plays out as well as securing the reform needs of the state and of industry. Minding the gap between policies and practices therefore becomes the leadership task of teachers, teacher educators and school leaders (Mooney Simmie & Sheehan, 2022). This is in keeping with an existentialist view of the irreducibility of human dignity and the need to retain spaces for democracy to flourish in any dynamic democratic society (Lynch, 2022). This articulation of the former purpose of education is often referred to by Biesta (2013) as the ‘beautiful risk’ of education – paraphrasing the words of WB Yeats as the lighting of a fire rather than the filling of a pail - while the latter purpose is defined by Edling and Mooney Simmie (2020) as the teacher and teacher educators’ democratic assignment.

While one of education’s tasks has always been to secure democracy - in self-proclaimed democratic nation states - how this is done has varied and is not always agreed. A rather thin version of democracy relies on teaching about and for democracy and inculcation into the regulatory norms of obedience necessary for becoming a compliant member of civil society. By contrast a thicker view of democracy [a reconstructivist view] understands that while induction into the existing social order is necessary this is not sufficient and more is needed (Edling & Mooney Simmie, 2020). Democracy needs to have the agility and flexibility to change as change is required. Therefore, students need to experience at first-hand democracy as a living project in schools and colleges and enjoy safe spaces to present contrarian views of society and debate controversial *Socio-Scientific Issues* (SSI), such as genetic engineering, climate change, artificial intelligence (Hodson, 2003). Clearly a new activist imaginary is needed in schools and colleges that invites students and teachers to experience and to play their part in the (re)construction of the world (Edling & Mooney Simmie, 2020).

I justify my selection of critical research policy studies in education, and in STEM education because such studies call on the social sciences to interrupt public discourses of policy texts

and practices in ways that reveal contemporary knowledge-power interplays and the framing of teachers and students [increasingly as units of human capital] within the intersectionalities of social justice and gender justice. Over time my studies started to also draw from feminist theorisations of Maxine Greene and others (Greene, 2017). What feminists bring to critical studies is the capability to widen the problem beyond a reductionist framing and the foregrounding of the issue of gender beyond a dualistic world dominated by either patriarchy and/or matriarchy. I am interested in critical feminist scrutiny of gendered relations of power in education and STEM education policy, how gender is defined and how gender issues can become essentialised and quickly silenced, domesticated and/or neutralised.

In this SMEC 2022 proceedings, I assert that pertinent questions of this kind need to be asked of scientific literacies and STEM education policies given the traditional essentialist nature of these subject areas and their continued dominance in state systems as hyper rational fields of endeavour and a pipeline for STEM related industry and research.

I assert here that if students of STEM subjects in schools and colleges are to be introduced to the benefits of access to a good life –and playing their part in the co-construction of a just society and global world - coming from immersion in STEM Education [e.g. access to counter-intuitive thinking, scepticism, curiosity, experimentation, divergent thinking], and in decolonising ways in the classrooms and schools then it is vital STEM Pedagogies draw from epistemological plurality and are not confined to just one dominant STEM Pedagogy, such as found in policy aspirations for students and teachers to work in schools as if they were emulating professional ‘scientists’ and/or adopting one engineering model of STEM Pedagogy, a model of continuous improvement and problem-solving (Margot & Kettler, 2019; Stohlmann, 2019). This is a central argument at the heart of this critique.

STEM Pedagogies if they are to support emancipatory and transformative possibility in education need to be considered in the plural rather than in the singular and within policy recognition that not everything of value in human development and change can be atomised and measured. While I argue that management and metrics clearly play a role in the necessary scientific knowledge base for education, any overreliance on management and measurement – in STEM Policy Education – has the potential to be deeply damaging to the human spirit, human flourishing, the moral development of the child and young person and to the necessary immeasurable love labor, care and the relational heart work of teaching and teacher learning and the wider critical aims of a dynamic democracy and public interest values (Biesta, 2012, 2013, 2016; Edling & Mooney Simmie, 2020; Lynch, 2022; Mooney Simmie, 2021)

Ball et al. (2011) showed that policy should never be made equal to practice in a series of studies in *Discourse Cultural Studies in the Politics of Education*. Their papers arose from case studies of the policy process with a number of schools in London. Ball (1995, 2003) and other sociologists in education argue that if policy is made equal to practice then we achieve a *Totally Pedagogised Society* based on a narrow functionalist view of individualism and institutionalism. Fielding (2007) points to the intellectual poverty and social costs arising when schools and educational institutions are redefined as *High-Performing Learning Organisations* in a market-led discourse of learning.

My research interest is in the primacy of the student and teacher as subjects, where the objective is always in the service of the subjective (Mooney Simmie & Moles, 2011, 2020). I argue that working from an essentialist view - advocating for one model of STEM Pedagogy - may well result in intellectual poverty in the STEM classroom and exert a social cost for children and

young people, especially for girls and boys coming from lower socio-economic and different cultural backgrounds in contemporary schooling in Ireland.

I have structured the paper as follows. First, I interrogate the theories of pedagogy and show how pedagogy is viewed in teacher education and in research as a contested construct. Second, I conduct a critical scrutiny of the postpositivistic stance advocated in contemporary STEM Education Policy that moves beyond former views of epistemic knowledge in favour of techné and prioritisation of skills, competences and science-in-context. Third, I conduct a critical review of a select STEM literature and the (re)positioning of scientific literacy. Finally, I conclude with key insights as the study reveals new thinking for securing scientific literacies for all, a hypothesis I argue is worthy of further research and consideration.

### ***Theories of Pedagogy***

Pedagogy can be viewed using multiple ontological and socio-cultural lenses. A critical scrutiny of these lenses is nowadays urgently needed given the recent global policy imperatives from the state and industry to push deeper into the classroom in order to mandate how policy must be implemented through select pedagogical practices. Policy imperatives and mandates that are taking place against the backdrop of western education coming under intense pressure in terms of new crises in the economy and politics. Crises in the economy and politics have always and ever been the seed-bed for educational policy change and reform (Arendt, 1954). In a time of fear it may be harder for the state to push back on corporate lobbyists and other powerful vested interests in order to reflect more deeply about the most appropriate pathway forward for human and societal change and development.

The politically expedient thing for policymakers appears to require positivistic research – using its prowess in mathematical modelling and data analysis - to provide evidence-based solutions as best approximations for a future that can be controlled and predicted (Gulbenkian Commission, 1996). Evidence-based syntheses coming from large scale quantitative studies broker no philosophical arguments and open no public spaces for refutation and contestation. Philosophical insights and theorisations are considered as nothing more than (personal) opinions that have no standing in comparison to fact and number. Several recent and timely philosophical studies reveal many real and symbolic dangers with this misrepresentation of science in the field of education (McIntyre, 2011; Rømer, 2019; Selwyn & Gašević, 2020).

Gore (1993) draws from a critical feminist perspective to argue in her doctoral thesis that pedagogies of struggle are necessary to take into account the tensions, contradictions and differential power relations embedded in all pedagogical practices. This notion of pedagogy as struggle retains the complexity, incoherence and messiness of the discursive spaces between policies and practice, the need for teachers to be trusted to make localised autonomous judgements and to pay attention to the particular needs of children and young people rather than implement a universalist routine of diagnostics and evaluation within a prescribed model of human capital theory (Lynch, 2022; Mooney Simmie & Moles, 2020; Tan, 2014).

In a seminal paper, Lingard (2007) provides a rich overview of the field of pedagogical theory showing how the terrain divides between abstract, political and theoretical perspectives and empiricist reality perspectives. Lingard (2007) shows how pedagogy is simultaneously interested in questions of ‘knowledge generation’ and ‘identity negotiation’. This suggests that rather than one model, no matter how sophisticated that policymakers need to acknowledge the complex interweave between knowledge acquisition and co-construction and the negotiation

of identity and knower dispositions taking place in classrooms and revealed to the student by way of for instance, the recognition, care and valuing of students, the inner directed moral commitment of teachers and school leaders to act as co-inquirers.

Lingard et al. conducted a large-scale research project in pedagogy in Australia – the Queensland School Reform Longitudinal Study – mapping, analysing and theorising teacher pedagogies as Productive Pedagogies in the context of new schools reform agendas. Findings from the study conducted between 1998 and 2000 showed that while teachers were for the most part caring in their practices they generally offered low intellectual challenges. A Pedagogy of Indifference was also found in relation to recognition and celebration of human ‘difference’ and diversity and the plurality of human condition. This is a finding that is worthy of deeper interrogation when we consider teaching science and mathematics, engineering and technology and computer science subjects to children and young people in contemporary Ireland. Within the STEM disciplines how do policy makers, teacher educators and teachers in Ireland view this ‘identity negotiation’ aspect of the pedagogy task?

According to the theorisations of Nancy Fraser (Fraser, 2009), the ‘difference’ domain needs to move beyond mere recognition and inclusion of the Other to a more activist imaginary in relation to social justice, gender justice and epistemic justice. Lingard (2007) cautions against the mandating of particular pedagogies at system level as he argues that this would be highly ‘restrictive of teachers’ professional practices and professional conversations, and forgets that trust is central to effective pedagogical reform’ (p.262). This point is also taken up by Mooney Simmie and Moles in studies of teachers subjectivities showing how the system puts teachers’ bodies and souls to work for the principle of the market-place rather than for facilitating openness and appropriate levels of risk (Mooney Simmie & Moles, 2011, 2020).

Nowadays, philosophical studies of pedagogy theory – such as found in critical pedagogy, pedagogy as praxis, productive pedagogies and speculative pedagogies – seek to (re)conceptualise the necessary struggle for pedagogies within an open invitation to disrupt prescription within the academy and public policy making. Such theories provide a rich understanding that pedagogy is not the static and fixed concept that is often portrayed in reform policies of pedagogy expressed as disciplinary power and the pursuit of prediction.

Any argument for better control and prediction as the optimal way forward to navigate a future of uncertainty in education and pedagogy is today highly questionable in a global world emerging from the Coronavirus pandemic. This viral interruption on a global scale, suggests that preparation for life-long education is best served by focused experiences in the present, premised on grappling with a future of uncertainty and a transformative view of pedagogy.

### ***Postpositivistic stance in STEM Pedagogy***

In the early years of this century, education and STEM Education policies focused on what type of new student and teacher was needed for a 21<sup>st</sup> century of new requirements coming from a rapidly globalising and digitising world and future workforce. New alliances and assemblages happened quickly as forms of democratic governance replaced former notions of democratic nation states. Slogans such as ‘we are all in this together’ shut down spaces for debate of contrarian views, nowadays often reframed as negative thinking and even deviant thinking. The OECD alongside large scale quant studies introduced a new ideal type of teacher, student and school as units of human capital within the primacy of the economy and the subjugation of moral, social, cultural and political considerations (Mooney Simmie, 2021).

The classroom was flipped from former views of an inner directed professional teacher toward a new direction of student-centred, inquiry-oriented and collaborative learning and the new role of the teacher as facilitator of students' learning needs. It was now the responsibility of the teacher and school to ensure that every child was included and the role of the state in this regard was reduced to quality assurance only. Wider issues of inequality and injustice were reframed as issues of the individual and the responsibility of the excellent teacher and the autonomous school and no longer the responsibility of the state and society (Lynch, 2022).

A modernist view of epistémé was changed in favour of a postmodern view of techné. This can be seen in STEM education policies that advocate for teaching that facilitates inquiry and evidence based learning, teacher-led professional development, culturally sensitive ways of teaching and the use of real world exemplars (Margot & Kettler, 2019; Stohlmann, 2019). The emphasis on techné is connected to socio-cultural contexts, interdisciplinarity, multidisciplinary, transdisciplinarity, nature of science, science-in-context, skills sets and competences. This new SMART (*Self-regulated, Motivated, Adaptable, Responsible and Technologically competent*) STEM student and teacher need to learn to fit in with a consensus view of the ideal human while in constant comparison with manageable and measurable outputs and performances of 'what works best' (Hattie, 2012; Rømer, 2019).

Any holistic criticism of this model of STEM Pedagogy needs to identify the possible beneficence of this pedagogical approach as well as drawbacks. Here I posit that giving students affordances to partake in a model of continuous improvement and problem-solving provides opportunities for students to think through probing questions as they learn how to conduct independent research, to use digital technologies, to gain in perseverance, to build resilience and to work with peers to learn how to engage in design thinking and critical thinking about real world problems (Margot & Kettler, 2019; Stohlmann, 2019). However, drawbacks are to be found in the formulaic and technocratic thinking that underpins this pedagogical approach, and in the inherent assumption that all learning is codifiable and measurable and connected to self-regulation and personal perseverance and resilience- and not interdependent and deeply connected to differential power relations, cultural contexts and privilege and public policy constraints. The dominance of this model of STEM Pedagogy denies other pedagogies, including the necessity for problem-posing, the need for interplays with theory and pedagogies of struggle (Gore, 1993; Lingard, 2007, Verma & Apple, 2021).

### **Critical Review of STEM literacies**

Science has a unique way of looking at the world with its own language, grammar, syntax, scientific methods, research approaches, modes of analyses, ethics of research and its own academic/professional communities of practice. The natural sciences place strong reliance on rational reasoning, personal detachment, neutrality, objectivity, counter-intuitive knowledge and empirical rationality. While the canon of scientific knowledge is a reliable source it is also a dynamic system where new knowledge once accepted in the scientific community replaces former knowledge. Science has a complex and uneven history and philosophy and it is nowadays argued from several directions that science teachers need to be fully conversant with this history and philosophy (Cobern & Loving, 2020).

Here I assert that philosophically informed STEM teachers may be best placed to develop curiosity and scepticism in their pedagogical approaches as they open new spaces for creative and critical thinking with students while, at the very same time, assuring the acquisition of content knowledge and the negotiation of subjectivities (Mooney Simmie & Moles, 2020). STEM Pedagogy as a human and social endeavour requires teachers to engage with the living

contradictions of their practices, to breathe life into the STEM curriculum, to display care and affectivity while animating students to actively engage with the many controversial SSI issues in ways that display ethical awareness and a new activist imaginary in order to support wise political decision-making in the co-construction of the world (Hodson, 2003; Hodson & Wong, 2014). In this way STEM education involves teaching STEM content knowledge to children and young people in different ways, approaches that support induction into the social order while making way for something new to emerge (Edling & Mooney Simmie, 2020).

The concept of science literacy was first introduced into the school curriculum in the 1950s and was primarily centred on the needs of the economy and national security (Li & Guo, 2021). The intention was to project a positive image of science with the purpose of keeping alive the public commitment of funding for scientific research and a pipeline of qualified scientists. Variations on this theme have lasted for more than seventy years and reveal how science literacy is a changing cultural and socio-political concept that is highly dependent on the needs of the era (Bybee & McCrae, 2011).

Erduran, Kaya & Avraamidou (2020) open the question of the reconceptualisation of science literacies in school science and show how they are underpinned by issues of social justice and the necessity for productive interplays between science education and the wider world. They position the problem within crises such as migration, vaccine equity and intersectionalities playing out between people of different class, race, caste, gender, ethnicity and religion. They argue that science education needs ‘to support science teachers’ learning of strategies to promote students understanding of NOS and social justice in unison’ (p.109) and ‘to promote a just and democratic society by valuing diversity’ (p.110). They refuse a narrow consensus view of science education and their human rights perspective affords respect for all.

The case for philosophically literate STEM teachers is made by Cobern & Loving (2020) with the purpose of guarding against a narrow ‘scientism’ (p.213), which they describe as an authoritarian firm view of science that seeks to present absolute truth and a final form. They support STEM teachers engaging in philosophical co-inquiry as this will support the interruption of routinized practices and assist their articulation of the many hidden assumptions and paradoxes underpinning teachers’ contradictory practices. Their study signals a strong turn to the humanities to support deep learning and problematizing the type of science literacies needed today and moving away from just one way of looking at science.

The concept mapping of science literacy was first carried out by Roberts (2007) and presented as Vision I (*theoria*) and Vision II (*techné*). Vision I arises from a fundamental (epistemic) understanding of knowledge that emphasises science as a discipline with propositional and procedural knowledge. This reflects a positivistic stance that seeks detachment from the living contradictions of practice and socio-cultural and political entanglements with the wider world. Vision I gave way in this century to a broader socio-cultural perspective - Vision II - a post-positivist stance that is advocated by the state and by industry, in STEM Education Policy that is sensitive to socio-cultural context (science-in-context), interdisciplinarity and learning about SSI issues. However, Vision II is narrowly focuses on the instrumental, on excellent instruction, on learning about issues rather than any activist imaginary seeking to critically interpret and/or to grapple with controversial SSI issues.

In recent times, a third vision (Vision III) is advocated in the critical science literature. Vision III, includes Vision I and Vision II approaches to knowledge acquisition and identity negotiation and, at the very same time recognises the need for an activist imaginary that



includes attention to criticality and reflexivity. Vision III understands science as a human endeavour, a sociological project taking place in schools and in the public forum of an ethical and political (democratic) society. Vision III draws from critical theory, critical consciousness and reflexivity and moves the problem beyond instruction and meaning-making to deep learning and critical mediation with others and with the wider socio-cultural (political-scientific-highly-technological) world.

Hodson and Wong (2014) critique the consensus view of the nature of science that has taken hold of much of the literature in STEM education, with the aim of providing clarity of definition, standards, and benchmarks and argue that this has ‘a strong whiff of orthodoxy and carries the implication that those who disagree with the specification will be considered deviant’ (p.2644). They fear that a ‘consensus view promotes a static picture of science and fails to acknowledge important differences among the sciences’ (p. 2645). Sjöström and Eilks (2021) present a Vision III concept of science literacies using the concept of *Bildung* in recognition of the broader educative task of learning how to live well as persons in a fast changing scientific and highly technological society and global world. They argue for a new concept of science literacy that broadens its focus, and recognises its reflexive dimension as a sociological construct in a globalising world. Their theorisation of *Critical Reflexive Science Literacy* is framed as ‘a politicised vision of science education aiming at dialogical emancipation, critical global citizenship, socio-eco-justice’ (p.82).

### **Conclusions**

When extolling the advantages that science brings to humanity and the world, such as vaccination successes by scientists without borders in the coronavirus pandemic, it can be easy to gloss over the many cautionary tales from the history of science. There are limits to scientific reason that need to be acknowledged (McIntyre, 2021). This is especially important in political systems that claim to be democratic, where majority rule is designed to work within a paradoxical understanding that the public space always allows for contrarian views and the protection of minority views and human rights (Edling & Mooney Simmie, 2020).

My argument here is that if evidence (metrics) becomes the one (dominant) lens to judge the success of STEM Education then policymakers will have fallen headlong into a narrow ideology of scientism (Hyslop-Magison & Naseem, 2010). Scientism offers a misrepresentation of STEM education through failing to acknowledge other ways of knowing and to having the intellectual humility and the moral fortitude to accept that there are limits to scientific reason (McIntyre, 2021). Here I have shown that there are undeniable merits in introducing students and teachers to using evidence to make claims, such as drawing from counter-intuitive knowledge in their practices and using STEM Pedagogy for problem-solving and a journey of improvement. However, in an era of post-truth and at a time of a new crisis in politics and in the economy any overreliance on metrics and management fails to acknowledge the primacy of the human subject at the heart of education and overrides the many complex and sophisticated concepts associated with being and becoming human, with entering a lifelong journey of being educated including for example, the ethical and relational nature of STEM Education, the immeasurable love labor, care and affectivity needed for a wholesome journey of human development and the need for securing spaces between policies and practices that assure human emancipation and the possibility of a dynamic democracy.

The current postpositivistic drive toward *techné*, with policy imperatives for consensus is shutting down spaces for authentic dialogue, building trust, contrarian views and ultimately for opening spaces for new thinking and the not-yet-thought. One Australian school principal

explains some of the detrimental consequences of this rather narrow policy imperative: ‘In closing down dialogue and setting normative standards, an evidence hierarchy is inherently anti-democratic, as it closes the public space, reducing social relations to obligations.....the barriers go up.....what should be open to question and not reductively represented as self-evident, including research methodologies and outcomes, are standardized and ranked’ (Howie, 2020, p. 683).

I have argued here that STEM Education is a human and relational endeavour, a sociological project that needs to be understood as an open and dynamic system - for assuring human emancipation as well as living well in a vibrant dynamic democracy - rather than a static and predictable system. This ‘beautiful risk of education’ (Biesta, 2013) includes the necessity for epistemological plurality and the need to acknowledge in STEM education policy in Ireland that not everything of value in ‘identity negotiation’ as human development and change can be codified and measured. It is a hypothesis worthy of further research and consideration.

### **References**

- Arendt, H. (1954). *The Crisis in Education*. In H. Arendt, *Between Past and Future*. London, Penguin, 170-193.
- Ball, S.J. (2021). Response: policy? Policy research? How absurd?. *Critical Studies in Education*. DOI: 10.1080/17508487.2021.1924214.
- Ball, S.J. (2003). The teacher's soul and the terrors of performativity. *Journal of Education Policy*, 18(2), 215-228. DOI: 10.1080/0268093022000043065
- Ball, S.J. (1995). Intellectuals or technicians? The urgent role of theory in educational studies. *British Journal of Educational Studies*, 43(3), 255-271. DOI: 10.1080/00071005.1995.9974036
- Ball, S.J., Maguire, M., Braun, A., & Hoskins, K. (2011). Policy subjects and policy actors in schools: some necessary but insufficient analyses. *Discourse: Studies in the Cultural Politics of Education*, 32(4), 611-624.
- Biesta, G. J. J. (2012). Giving Teaching Back to Education: Responding to the Disappearance of the Teacher. *Phenomenology & Practice* 6(2), 35-49.
- Biesta, G. J. J. (2013). *The Beautiful Risk of Education*. London: Routledge.
- Biesta, G. J. J. (2016). The Rediscovery of Teaching: On robot vacuum cleaners, non-egological education and the limits of the hermeneutical world view. *Educational Philosophy and Theory*, 48(4), 374-392, DOI: 10.1080/00131857.2015.1041442
- Bybee, R., & McCrae, B. (2011). Scientific Literacy and Student Attitudes: Perspectives from PISA 2006 science. *International Journal of Science Education*, 33(1), 7-26.
- Cobern, W., W. & Loving, C. (2020). Chapter 11 The Nature of Science Card Exchange: Introducing the Philosophy of Science. In *Nature of Science in Science Instruction Rationales and Strategies*. William F. McComas. Editor, pp. 213-222. Springer.

- Edling, S. & Mooney Simmie, G. (2020). *Democracy and Teacher Education: Dilemmas, Challenges and Possibilities*. London: Routledge.  
<https://www.routledge.com/Democracy-and-Teacher-Education-Dilemmas-Challenges-and-Possibilities/Edling-Mooney-Simmie/p/book/9781138593251>
- Erduran, S., Kaya, E., & Avraamidou, L. (2020). Chapter 6. Does Research on Nature of Science and Social Justice Intersect? Exploring Theoretical and Practical Convergence for Science Education. In *Nature of Science for Social Justice*, Hagop A. Yacoubian & Lena Hansson, Editors, pp.97-113. Springer.
- Fielding, M. (2007). The human cost and intellectual poverty of high performance schooling: radical philosophy, John Macmurray and the remaking of person-centred education. *Journal of Education Policy*, 22(4), 383-409. DOI: 10.1080/02680930701390511
- Fraser, N. (2009). *Scales of Justice Reimagining Political Space in a Globalizing World*. New York: Columbia University Press.
- Freire, P. (2018/1971). *Pedagogy of the Oppressed With a New Introduction by Donaldo Macedo and an Afterword by Ira Shor*. New York: Bloomsbury.
- Galvin, M. & Mooney Simmie, G. (2017). Theorising participation in urban regeneration partnerships: an adult education perspective. *Journal of Education Policy*, 32 (6), 809-831. <http://dx.doi.org/10.1080/02680939.2017.1320731>
- Gore, J. (1993). *The struggle for pedagogies critical and feminist discourse as regimes of truth*. New York, NY: Routledge.
- Greene, M. (2017). *The dialectic of freedom. New introduction by Michelle Fine*. Columbia University, New York: Teachers College Press.
- Gulbenkian Commission (1996). *Open the Social Sciences: Report of the Gulbenkian Commission on the Restructuring of the Social Sciences*. Stanford: Stanford University Press.
- Hattie, J. (2012). *Visible Learning For Teachers Maximizing Impact on Learning*. Oxon, Abingdon: Routledge.
- Hodson, D. (2003). Time for action: Science education for an alternative future. *International Journal of Science Education*, 25(6), 645-670.
- Hodson, D., & Wong, S.L. (2014). From the Horse's Mouth: Why scientists' views are crucial to nature of science understanding. *International Journal of Science Education*, 36 (16), 2639-2665.
- Howie, M. (2021). In 'obey'-ance: one principal's critical reflexive engagement with research in a culture of compliance. *The Australian Educational Researcher*, 47, 679-692.
- Hyslop-Margison, E.J., & Naseem, M.A. (2010). *Scientism and Education*. Springer.
- Li, Y., & Guo, M. (2021). Scientific Literacy in Communicating Science and Socio-Scientific Issues: Prospects and Challenges. Systematic Review. *Frontiers in Psychology*, 12, 1-15.

- Lingard, B. (2007). Pedagogies of Indifference. *Journal of Inclusive Education*, 11 (3), 245-266
- Lynch, K. (2022). *Care and Capitalism. Why affective Equality Matters for Social Justice*. Cambridge: Polity Press.
- Margot, K.C., & Kettler, T. (2019). Teachers' perception of STEM integration and education: a systematic literature review. *International Journal of STEM Education*, 6(2), 1-16.  
<https://doi.org/10.1186/s40594-018-0151-2>
- McIntyre, J. (2021). *The Limits of Scientific Reason Habermas, Foucault, and Science as a Social Institution*. Maryland, US: Rowman & Littlefield.
- Mooney Simmie, G. (2021). Teacher Professional Learning: a holistic and cultural endeavour imbued with transformative possibility. *Educational Review*. DOI: 0.1080/00131911.2021.1978398
- Mooney Simmie, G. (2007). Teacher Design Teams (TDTs) – building capacity for innovation, learning and curriculum implementation in the continuing professional development of in-career teachers. *Irish Educational Studies*, 26(2), 163-176. DOI: <http://dx.doi.org/10.1080/03323310701295914>
- Mooney Simmie, G., & Lang, M. (2018). Deliberative teacher education beyond boundaries: discursive practices for eliciting gender awareness. *Teachers and Teaching Theory and Practice*, 24(2), 135-150, DOI: <https://doi.org/10.1080/13540602.2017.1370420>
- Mooney Simmie, G., & Moles, J. (2020). Teachers' Changing Subjectivities: Putting the Soul to Work for the Principle of the Market or For Facilitating Risk? *Studies in Philosophy and Education*, 39 (4), 20-34.
- Mooney Simmie, G., & Moles, J. (2011). Critical Thinking, Caring and Professional Agency: an emerging framework for productive mentoring. *Mentoring & Tutoring: Partnership in Learning*, 19(4), 465-482. DOI: <http://dx.doi.org/10.1080/13611267.2011.622081>
- Mooney Simmie, G., Moles, J., & O'Grady, E. (2020). Good teaching as a messy narrative of change within a policy ensemble of networks, superstructures and flows. *Critical Studies in Education*, 60(1), 55-72. DOI: <https://doi.org/10.1080/17508487.2016.1219960>
- Mooney Simmie, G., & Edling, S. (2019). Teachers' Democratic Assignment: a critical discourse analysis of teacher education policies in Ireland and Sweden. *Discourse: Studies in the Cultural Politics of Education*, 40(6), 832-846. DOI: <http://doi.org/10.1080/01596306.2018.1449733>
- Mooney Simmie, G. & Sheehan, C. (2022). The positioning of moral leadership in primary education: perspectives and contextual understandings of school principals in Ireland. *International Journal of Leadership in Education Theory & Practice*, first-on-line. <https://doi.org/10.1080/13603124.2022.2077457>

- Noddings, N. (2007). *When School Reform Goes Wrong*. New York: Teachers College Press.
- Paraskeva, J.M. (2021). *Curriculum and the Generation of Utopia Interrogating the Current State of Critical Curriculum Theory*. London and New York: Routledge.
- Roberts, D. A. (2007). Scientific Literacy/Science Literacy. In S. Abell, N. Lederman (Eds.). *Handbook of Research on Science Education*, Chapter 25, pp.729-780. Lawrence Erlbaum.
- Rømer, T. A. (2019). A critique of John Hattie's theory of Visible Learning. *Educational Philosophy and Theory*, 51(5), 587-598.
- Selwyn, N., & Gašević, D. (2020) The datafication of higher education: discussing the promises and problems. *Teaching in Higher Education*, 25(4), 527-540. DOI: 10.1080/13562517.2019.1689388
- Sjöström, J., & Eilks, I. (2021). Chapter 4 Reconsidering Different Visions of Scientific Literacy and Science Education based on the Concept of Bildung. In Y. J. Dori et al. (eds.). *Cognition, Metacognition, and Culture in STEM Education, Innovations in Science Education and Technology book series, ISET*, (24), 65-88. Springer.
- Stohlmann, M. (2019). Three modes of STEM integration for middle school mathematics teachers. *School Science and Mathematics*, 119, 287-296.
- Tan, E. (2014). Human Capital Theory: A Holistic Criticism. *Review of Educational Research*, 84(3), 441-445. DOI: 10.3102/0034654314532696.
- UNESCO (2021). *Reimagining Our Futures Together A new social contract for education Report from the International Commission on the Futures of Education*. Paris: United Nations, Educational, Scientific and Cultural Organisation.
- Verma, R. & Apple, M.W. (2021). (Editors). *Disrupting Hate in Education Teacher Activists, Democracy, and Global Pedagogies of Interruption*. New York & London: Routledge.