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Finding balance in the triple nexus of research, teaching and public engagement

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ABSTRACT

A growing emphasis on the societal impact of Higher Education has driven an upturn in the integration of public engagement with research and teaching, positioning engagement as a strategic mechanism for enhancing research relevance, pedagogical innovation and funding competitiveness. Institutional identity has historically been framed through a distinction between research-intensive and teaching-intensive orientations. This framing is influential but can be misaligned with assessments of impact placed upon universities, particularly within some science, technology, engineering and maths (STEM) disciplines.

This paper explores how the research–teaching-engagement (R/T/Pe) nexus is enacted within Scottish universities, with a particular focus on STEM contexts, to explore how lecturers stimulate scientific curiosity and scaffold learning. Drawing on a qualitative study conducted between 2020 and 2024, the findings demonstrate that public engagement functions as a productive site for co-creation, enabling reciprocal flows between research inquiry, teaching practice and societal need. However, study participants emphasised that embedding engagement as a third mission alongside the traditional functions of a university (teaching and research) is challenging, especially when there is a dearth of support in some institutional settings.

Highlighting significant tensions between the realities of lecturer workload, wellbeing and individual research trajectories particularly in post-1992 institutions, the paper argues that the successful normalisation of the R/T/Pe nexus requires policy-level protections for explicit workload recognition. Lecturers who undertake formal pedagogical training are more confident when integrating public engagement into STEM curricula, therefore investment in postgraduate teaching qualifications is essential. The paper concludes with recommendations for institutional leaders to support integrated academic identities that align teaching, research and public engagement without instrumentalising scholarship.

Keywords: teaching/research nexus, pedagogy, phenomenology, autoethnography, public engagement

Introduction

Institutional identity in higher education (HE) is traditionally framed as a binary identity, either research-intensive or teaching-intensive (Boliver et al., 2018; Hewitt-Dundas, 2012). These seemingly immutable facets were established through the theories of Cardinal Newman (1801-1890) and Wilhelm von Humboldt (1767 – 1835). Newman is frequently associated with the secular reform of contemporary European universities, which polarised research and teaching according to Tight (2016). This impacted English collegiate traditions, and arguably influenced the attendant primacy of research over teaching in research-intensive institutions like Oxford, Cambridge and Trinity College Dublin (Papatsiba & Cohen, 2019). Conversely, the teachings of von Humboldt, the founding father of the University of Berlin, have influenced the direction of Scottish Universities with a clear policy direction to integrate research with teaching (Laiho et al., 2020; McLinden et al., 2015; Rayner et al., 2020). The linkages between teaching and research advance a pluralistic approach to knowledge creation and are described as a symbiosis between the two

activities (Brew, 1999). This paper aims to explore how these linkages are enacted within the context of public engagement activities in Scottish universities, reporting on a study conducted between 2020 and 2024.

The research/teaching nexus in higher education

Neumann (1992) first proposed the concept of the 'teaching–research nexus' (T/R nexus) to articulate the bridge between teaching and research in HE (cited in Brew, 1999; McLinden et al., 2015; Tight, 2016). The T/R nexus came to formal prominence through the policy recommendations of Healey and Jenkins (2009). This was also propounded by Brew (1999) who asserted that knowledge was "in crisis" and without fundamental institutional change to address this universities would have a diminishing role in society. Consequently, research and teaching are denoted as the core *commodities* of HE (Watermeyer & Rowe, 2021). However, the commodification of these aspects of HE accentuates the ways in which the intersection between teaching and research can be at odds with the vocational nature of the teaching profession (Matthews et al., 2021), echoing Brew's assertion that knowledge is indeed in crisis (Brew, 1999). Despite increasing focus on neoliberal measures of impact and public engagement little is known about how this is managed and balanced within a lecturer's workload.

Neoliberalism is a term used to describe a reaction to collective governance and is claimed to be a tacitly accepted norm in HE, driven by metrics that measure performativity (Kenny, 2017; Wilkinson & Wilkinson, 2020). The term was encapsulated in 1938 by economists Ludwig von Mises and Friedrich Hayek, who first described the essence of a free market economy liberated through entrepreneurial skills and supported by strong property rights (Baird & Elliott, 2018). Critics claim that this is at odds with the rich qualitative landscape of educational impact and academic identity (Baird & Elliott, 2018; Czerniawski et al., 2018; Johnston et al., 2019; Pirrie & Fang, 2021). Consequently, this can create a clear divide, or chasm between academic staff and public engagement professionals who feel undervalued in their role within a research cycle (Watermeyer & Rowe, 2021).

With an explicit link between funding and impact, avenues for public engagement can develop new funding opportunities for research-informed, or research-led teaching in HE which has significant potential to transform academic practice in undergraduate teaching (Joseph-Richard et al., 2021). But Scottish universities now face additional challenges as funding per undergraduate student has fallen by about 19% since 2013-14 which has increased financial pressure on institutions who, since Brexit, increasingly rely on international student cohorts to fill gaps within their operating costs (Dinca et al., 2019; Ogden & Thomas, 2024). This is undoubtedly an opportunity, but academic labour will become even more precarious than it already is, unless institutions explicitly invest in sustainable staffing models to support these expanded expectations (Wheaton, 2020).

Public engagement, the third pillar of the university

Newman and von Humboldt are often cited as the founding fathers of the theoretical debate concerning the public duty of the university in Europe (Hazelkorn & Gibson, 2018; Tight, 2016); yet the conceptualisation of public engagement as a third pillar of the university, alongside teaching and research, is nuanced and underexplored in the context of educational studies (Collini, 2012). Hazelkorn and Gibson (2018) have asserted that the von Humboldtian approach is more hands-on and public facing than the traditional "disembodied" ethos espoused by followers of Cardinal Newman which has beguiling prospects

for educators who wish to embed public engagement as a core element of their research and teaching. It is reported that conceptions of public engagement differ from person to person and vary according to different academic contexts (Cohen, 2019; Watermeyer & Lewis, 2015). As a starting point, to contextualise public engagement, this paper adopts a definition from the National Co-ordinating Centre for Public Engagement (NCCPE) 2017 report on the REF review:

> By 'public engagement' we mean interaction with people outside academia, in their capacity as citizens and members of communities of place or interest. We differentiate public engagement from engagement with policy making, business and the professions, but recognise in practice they often overlap. (Duncan et al., 2017).

However, public engagement, as a defining term, appears to be problematised and at odds with neoliberal HE policies based on the research excellence framework (REF) metrics and league tables (Boliver et al., 2018; McLinden et al.,, 2015; Watermeyer & Lewis, 2015). The REF assessment exercise runs in five-yearly cycles; the first was in 2014, and the next will take place in 2029. It is a system for assessing the quality of research in universities, which then determines funding allocations. The system has been criticised for its performative assessment of research excellence (Baird & Elliott, 2018) and when it comes to public engagement it has been easier for some disciplines to evidence. Academic disciplines are categorised within four 'panels' A, B, C and D. Panels C (Social sciences) and D (Arts and Humanities) are shown to be the most likely disciplines to evidence impact, or measures of public engagement. Whereas STEM subjects classified as Panel A (agriculture, allied health, biological sciences, clinical medicine, psychology and public health) or Panel B (engineering, chemistry, computer science, mathematics, physics, earth and environmental sciences) were noted to be least likely to mention engagement with the public in the 2014 review of REF impact case studies (Duncan et al., 2017). Undoubtedly this can restrict the potential of STEM, which puts the *student-as-producer* mode of knowledge creation at risk (Rayner et al., 2020).

The research, teaching, public engagement (R/T/Pe) nexus

Praxis is a word that describes how the process of knowledge creation is advanced by responding to real needs in society, linking the relevance of the curriculum to the wider community. In an educational context, real-world needs can feed real-world research, which can be used to integrate public engagement with research, to inform teaching, and develop "…the curriculum as praxis" (Freire, 2014; Rayner et al., 2020). Scholarly interest in the conception of the von Humboldtian notion of unity between research and teaching continues to grow in the twenty-first century (Joseph-Richard et al., 2021), yet it is often hard to achieve in practice despite supportive institutional rhetoric, which contributes to the bifurcation between research and teaching (Brennan et al., 2019; Matthews et al., 2021; Wheaton, 2020). Despite the T/R nexus featuring regularly in the rhetoric of policy and practice there is very little discussion of the triple nexus of research, teaching and public engagement (R/T/Pe) which is understudied (Stevenson & McArthur, 2015). Given that there were already studies underway to examine the T/R nexus in social sciences (Rayner et al., 2020) the R/T/Pe in STEM Panel B disciplines was the chosen focus of this study to understand the experiences of Scottish lecturers working with undergraduate cohorts in STEM disciplines.

Rationale

The study's aim was to understand lecturers' experiences of the R/T/Pe nexus (Stevenson & McArthur, 2015) while considering issues of personal, institutional and disciplinary identity (Duncan et al., 2017). The research questions were identified as:

R1: How do STEM Panel B disciplines in Scottish HE make integrative links between public engagement, research and teaching at undergraduate level?

R2: Does this activity align to von Humboldtian ideals, and how is knowledge generated accordingly?

The research questions were concerned with the extension of von Humboldt's theory to understand the views of lecturers in terms of its practical applications and whether there are recommendations that could improve curriculum and teaching practice to instantiate the R/T/Pe nexus (Stevenson & McArthur, 2015; Yau, 2019). The study commenced during the height of the COVID-19 pandemic in October 2020. This prompted research strategies to develop technical efficiencies alongside students as co-creators to prepare future generations to adapt to crisis situations as they evolve (Cross & Congreve, 2020). This underlined the need to strengthen links between science and society through the triple nexus of R/T/Pe, praxis enables students to be better equipped to deal with real-life research, which is important, as STEM skills are typically in undersupply in this respect in Scotland (Kemp & Lawton, 2013; SFC, 2019). The outcome of the study was to yield insight into the ways in which academic practice can be re-configured by embedding the R/T/Pe nexus to invoke an *impact identity*, that is, an extension of academic identity that privileges public engagement and normalises it within day-to-day scholarly practice (Menlove et al., 2019).

Methodology

The rationale for the study's methodological choice sits within social constructivism, the primary objective was to place reliance on participant views of the situation being studied (Creswell, 2014). Interpretative phenomenological analysis was chosen as the overarching methodology, with phenomenological interviews and autoethnography used to collect rich qualitative data (King et al., 2018; Lapadat, 2017). Ethical consent was sought via the University of the West of Scotland's (UWS) ethical approval process (no 16437), and this was granted on 18 June 2021 by the UWS ethics committee. Following an open call to participate, twenty-seven informants came forward, with ten selected for first stage interviews using a combination of purposive sampling through direct contact, snowball sampling via participant's and supervisor's personal contacts, online journal clubs and virtual conferences (Creswell & Plano-Clark, 2018; von der Fehr et al., 2016). As much of the research was conducted during the COVID-19 pandemic lockdowns of 2021, the use of digital platforms to recruit participants was heavily relied upon in the absence of face-to-face contact (Roberts et al., 2021). Consequently, participants naturally drawn to digital outreach and social networks may have emerged most readily and this should be acknowledged as a sampling limitation.

Given the indefinite and nuanced conceptions of the T/R nexus and the lack of research, definition and discussion in Scotland, there was a scant basis on which to propose a quantitative approach to understand the R/T/Pe nexus in teaching practice (Joseph-Richard et al., 2021; McKinley et al., 2020). A mixed-methods approach was considered given the pragmatism of actions, situations and consequences within practice-based education settings (Creswell & Plano-Clark, 2018; Mertens, 2020). However, the review of literature revealed that it is commonly understood that lecturers are susceptible to a tortuous identity conflict between the demands of teaching and research which deserved an individualised focus to develop a better understanding of how they perceive this (Empson, 2012; Kinchin & Francis, 2016). Increasingly,

there is an implicit institutional expectation for lecturers to take part in some form of public engagement. This can add to work pressure, which made the choice of qualitative interviewing a compelling mode of research to give voice to this phenomenon (Stevenson & McArthur, 2015).

The multi-layered perspectives surrounding the emergent research into public engagement align closely with the theoretical constructs of phenomenology, aiming to elicit, report, and make sense of variations amongst socially constructed concepts which are previously undefined (Sin, 2010; Watermeyer & Lewis, 2015). This is generally considered idiographic, that is, offering a detailed account concerned with a specific social setting, relationship, or process (King et al., 2018; Zahavi, 2019). Although Zahavi (2018) notes that phenomenology is usually applied to anthropology, sociology, psychology, and literary studies, King et al. (2018) prepone its use as an interpretative research method in practice-based disciplines, notably education and health. Interviews aimed to give insights into the ways in which a given person reacts to, or understands, their social reality, meaning that an interpretative approach to phenomenology was considered the best fit.

Interpretative phenomenology is widely used and accepted in education studies and suitably applicable to STEM disciplines. According to Han and Ellis (2019), interpretative phenomenological analysis (IPA) gives a close examination of individuals' lived experience in specific settings to provide a pragmatic approach to understanding the human condition, without resorting to abstract theorisation on human nature, which risks the danger of 'experts' imposing their own theories upon the study's participants (King et al., 2018). This aligns with Creswell (2014), who points out that, aside from discipline orientations, worldviews arising from a researcher's past research experiences or from mentor's or student advisor's inclinations must also be accounted for within an IPA methodology. The reality of this phenomenon can be more readily understood through a descriptive account of individual experience, rather than attempting to build an abstract theoretical understanding of the issues (Charles, 2017; McKinley et al., 2020; Reid & Gardner, 2020).

Sampling

The sampling characteristics of participants were developed to include an historical lens of HE which is anchored in political, social and cultural influences explored within the literature review – accordingly, sampling was restricted to HE settings (Collini, 2012; McKinley et al., 2020; Punch & Oancea, 2014).

Table 1 Sampling characteristics of participants.

Characteristic	Requirement
Institutional	Scottish universities only (Universities Scotland, 2020).
Discipline	STEM Panel B only: mathematics, computer science, environmental science, Earth sciences, physics and chemistry (Duncan et al., 2017).
Pedagogical	Actively engaged in research, and teaching undergraduate cohorts (Brew, 2010).

The study aimed to gather data from a sample of participants over the course of four semesters to elicit a phenomenological *structure of experience* (Van Manen 1997, cited in Sloan & Bowe, 2014). Accordingly, the findings that are reported, and the methodology used to achieve this, aim to fortify and explain methods that can be used by researchers to elicit a *structure of experience* within IPA. This not only enables reproducibility, but also to contribute to the methodological development of IPA as a research method in education studies to counter the rebuttal of Giorgi (2011) who claims the corpus of knowledge concerning IPA is too diverged from the core components of traditional phenomenology. As such the addition of reflexive inquiry was essential to understand the lifeworld of the participants and this was done at the outset of the study with a researcher positionality statement published on an academic blog www.researchblog.scot (Beattie, 2022) and this was followed up throughout the study using autoethnographic journalling (Amoroso, 2021; Blades, 2020).

Interpretative phenomenological analysis and reflexivity

The decision to use autoethnography alongside qualitative interviewing is congruent with reflexive practice in education and sits appropriately within an IPA methodology to address issues of bracketing in interpretative inquiry (Dörfler & Stierand, 2020; Starr, 2014). For example, Schmidt (2019) illuminated the benefits of autoethnography through identifying the connection between cognition and emotion as a means to transform educational practice. This was rooted in the essence of the phenomenological *lifeworld* or *Lebenswelt* as Edmund Husserl described, which explores the subjective interpretation of spatiality (lived space), corporeality (lived body), temporality (lived time) and relationality (lived human relation) (Eatough & Smith, 2008; Larsson & Holmström, 2009; Zahavi, 2019). As such, these methods were used in tandem to attempt a dialogue within the research in order that personal experience and assumptions of the researcher could be set aside and communicated with participants to share meaning concerning the phenomena they experience (Dörfler & Stierand, 2020). Autoethnography uses personal experience to explore and analyze cultural, social, and personal phenomena through reflection (Ellis et al., 2010). This can raise ethical issues whereby the researcher becomes the researched and appropriates information from informants to develop or facilitate storytelling (Lapadat, 2017). Therefore, responsibility is placed on the researcher to be aware of relational ethics (Ellis et al., 2010; Ettorre, 2016), and any issues arising were noted down in a reflexive research diary during data collection (Roy & Uekusa, 2020). Individual autoethnographic reflections were collected after the participant interviews and shared privately with participants, together with verbatim, anonymised interview transcripts for approval prior to assembling data in the findings and discussion sections.

Findings and discussion of lecturer's lived experience

All respondents who took part in the study consented to sharing information about their gender, career stage, category of institution and disciplinary field which is defined as units of assessment (UOA) (REF, 2018). Gender was recorded as a social construct (man/woman/non-binary), with three women and seven men taking part in the first round of interviews. In the second round, there were four men, and one woman interviewed. All personal data was anonymised, and participants were given pseudonyms listed in the table below.

Table 2 List of participant attributes

Respondent ID	***Role***	***Discipline***	***Gender***
Zeta E	Lecturer	STEM Panel B	M
Beta A	Lecturer	STEM Panel B	M
Gamma S	Lecturer	STEM Panel B	W
Epsilon M	Lecturer/Public engagement professional	STEM Panel B	W
Kappa M	Lecturer	STEM Panel B	M
Eta B	Lecturer	STEM Panel B	M
Alpha K	Lecturer	STEM Panel B	M
Theta A	Lecturer	STEM Panel B	W
Iota C	Lecturer	STEM Panel B	W
Delta I	Lecturer	STEM Panel B	M

Gender

Some women replied after the first round of interviews to say that they could not commit because of additional family pressures during the pandemic, while others did not respond at all. This is an important backdrop to understanding public engagement in STEM, as Kerr (2021) maintains that gender equality is a key asset of the UK's *soft power* – i.e. a coalescence of culture and political values to co-opt, rather than coerce, through the work of government, citizens, non-governmental organisations and cultural institutions, Scotland, in the past, has been viewed as a "macho nation" (Leith & Sim, 2020). In HE, women in STEM tend to be less equally represented, and in Scotland the disciplines of engineering and physics are noted as particularly male-dominated (Briggs, 2006; Caltagirone et al., 2021; Leith & Sim, 2020). Yet, teacher educators in HE are predominantly female, which may mean that women in STEM are routinely assigned roles within teams to take on teaching responsibilities (Czerniawski et al., 2018). Consequently, the reporting of gendered data is considered relevant to this study as it adds to these critical perspectives to feed into an understanding of the equity of education (Ozga, 2020). This was congruent with the findings of the study, which showed an unequal sample of men and women despite special efforts to reach women's STEM networks and support agencies in the initial sampling phases.

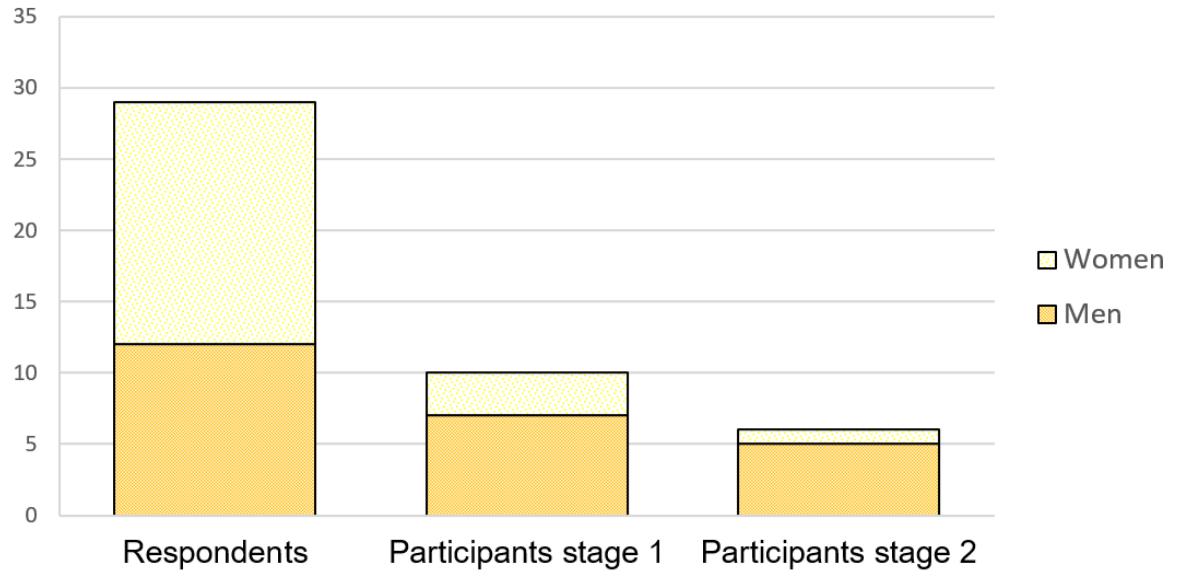

Figure 1 Gender equality of respondents and participants

Disciplinary focus

The results indicate roughly equal numbers of participants across all STEM Panel B disciplines within the study, with slightly more participants in chemistry and mathematical science. As such, the small-scale sample does not allow for multiple participants in each discipline, potentially representing a limitation.

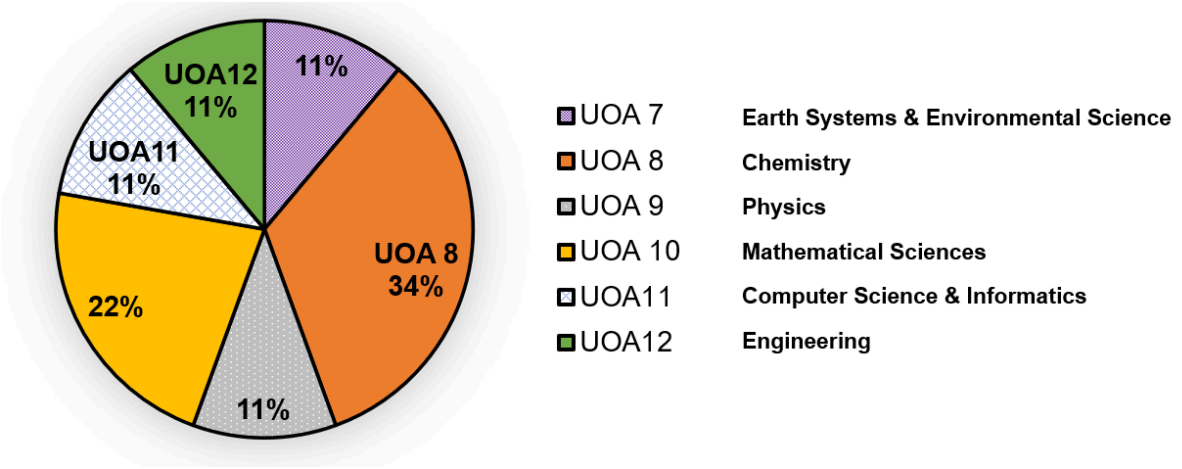

Figure 2 Disciplinary field of participants in the study

Structure of experience

Once first and second interviews were complete, transcripts were coded and memos noted to record resonance thoughts in line with the framework proposed by van Manen (1997), cited in (Sloan & Bowe, 2014), which highlights *noema* – what is experienced – and *noesis* – how it is experienced within an IPA methodology (Harris, 2011; Sloan & Bowe, 2014). These experiences within the phenomenological *structure of experience* were categorised as:

lived space – spatiality; for example, describing teaching practice when access to lab space to teach chemistry during the pandemic was restricted. This barrier was overcome by the lecturer finding using open-source software to carry out chromatography simulations online (Alpha K).

lived body – corporeality; examples of this structure of experience focused on feelings. Where public engagement was concerned some participants felt a visceral discomfort, "I hate public speaking, but it's my job" (Delta I).

lived time – temporality; this tended to show most time pressure was faced by women who have invisible roles as caregivers; "I was having to home-school two kids in primary school, there was triple teaching load, there was not time really to do anything else." (Epsilon M).

lived human relation – relationality; this structure of experience revealed dysfunctionality, particularly in post-1992 universities. One lecturer reflected on the dysfunction between R/T/Pe: "I'd get on better in America. In a healthy department in some middle-ranking university, with a supportive boss and head of department and everything, I know I'd do very well in that environment". (Zeta E).

This first cycle of coding, which Saldaña (2021) outlines as *affective methods*, investigated the subjective human experience of emotions and values. This contributed to the creation of participant portraits to inform an understanding of the interpersonal and intrapersonal experience of the participants. Accordingly, anonymised portraits of participants were written to record the natural attitude, or essence, of participants (Bruhn & Jimenez, 2020). The second cycle coding arranged and explored the themes from interviews. Transcripts were uploaded to NVivo Pro 12 to gather and curate primary data within the thematic coding framework and sub-themes identified in stage 3. Any themes outside the coding framework were recorded as open codes (Klein, 2012; Ryan & Bernard, 2016). Qualitative themes were categorized as:

Table 3 List of key themes from interviews

T1: Supporting undergraduate learners to develop research-mindedness
T2: The R/T/Pe triple nexus
T3: Hierarchies and institutional identity
T4: Reflections on practice and recommendations

The incidence of themes in interviews indicated that the most common concern centred on supporting learners to develop research-mindedness and there was some evidence to show this was common for roughly one third of those interviewed. However, the majority of the lecturers interviewed felt powerless to do this in their teaching practice due to lack of protected time to develop public engagement within the curriculum. This was most apparent at post-92 universities which is congruent with the findings of

Papatsiba and Cohen (2019). Some reported that when they had engaged in extra-mural public engagement, they had felt used or imposed upon by their university to deliver more public engagement events in the future for no additional pay, reward or promotion. Some lecturers reported a wish to leave their institution to develop public engagement activity in private practice or consultancy (Wheaton, 2020). This is very much echoed the experience of Zeta E, who mentioned that they had put their name forward for two REF reviews and published in several four-star journals, yet, despite this, the research capacity of their post-92 employer was too limited to take their application further. Consequently, Zeta E decided to step back from public engagement activities citing stress: "I wanted to make the world a better place, but the reality was it was an extra stress with time and family and doing things on Saturday morning at science festivals and evening classes and things, posed a stress on when you have family and kids."

Integrating the R/T/Pe nexus in undergraduate teaching

The triple nexus of R/T/Pe as defined by (Stevenson & McArthur, 2015) was not embedded into the practice of respondents, although most of those interviewed were aware of the T/R nexus. The capacity to foster the R/T/Pe nexus was shown to be most developed in early career researchers and lecturers who have received formal training in the form of CPD or a postgraduate certificate in academic practice to support science communication or publicly engaged research within their practice (Eta B, Iota C and Gamma S) (Labrosse & Bownes, 2023). Universities in Scotland are well positioned within the traditional pillars of research and teaching according to participants, but there needs to be more development to develop the interlinkages between teaching, research and public engagement. All participants indicated that undergraduate programmes allow too little time to grant ethical consent for a research project to fit within an academic year. One way of developing an undergraduate research cycle is through "live briefing", by linking to student work at different stages of existing research projects which have already granted ethical approval according to Gamma S (Davys & Crawford, 2019). Epsilon M had a specific public engagement remit and took a broad view on the ways in which public engagement can add value to learning outcomes, "Public engagement is probably a really good one because a lot of students are really enthusiastic, really excited about sharing or have other skills to share, you know, not necessarily standing in front of people, and that adds value when people are looking at employability skills."

Despite rhetorical recognition within institutions and departments that public engagement can positively impact teaching and learning this is still left as a discrete activity or "bolt-on" according to Eta B (Healey & Jenkins, 2009; Walkington, 2015). As Theta A pointed out, lecturers are forced to squeeze their working patterns to achieve a balance in their academic practice "…it's been the flexibility to kind of have more time for teaching, at one point, and then less time for research and then another side. Because depending on the institution that you're at your flexibility may be limited by contract structure." The effect of the pandemic was an enabler for the triple nexus, according to Epsilon M, "I would say definitely with public engagement and outreach, the pandemic has obviously stopped the very traditional way of doing things. Going into schools, being at a science fair. We've had to look at different ways of doing it and I have found that the students have been absolutely amazing at changing things and adapting." In contrast, some lecturers admitted that they felt this would be challenging for future practice: "We survived the pandemic, but we've had to change our teaching style, and I think that teaching style is going to be with us for a while, and I think that's fine for new academics coming in because that's what they're used to. I think people like me who've done it for seven years and longer are going to find that's the struggle, trying to keep up with the demand of what the next generation want as they come through" (Delta I).

The principal foundations of a university's purpose still sit within the traditional pillars of research and teaching and there is little longitudinal reporting of public engagement outcomes. Iota C noted despondently: "…we very rarely get to indulge in actually hearing years after that something we did had an impact on someone else. It's the dream, but, unfortunately, it's not very often so gratifying to do outreach." This indicates that academics cannot dare to dream or to indulge in their longitudinal impact as educators. Beta A expressed his frustration at being institutionally disempowered: "The university is happy for outreach if they can see the advantage of it from a university point of view." Was it the intention of von Humboldt to arrange the university into a neat machine organised along managerial precepts? It is unlikely. His 1854 treatise attacked the role of the state and he categorically stated that any state interference should be "condemned" (von Humboldt, 1854). This ultimately links to the unhealthy aspects of the commodification of public engagement and its managerial constraints (Kenny, 2017).

Institutional differences – ancient vs new

The differences between pre-92 universities compared to post-92 (in general, former polytechnics) were significant when it came to striking the balance between research and teaching and this undoubtedly affected participants' capacity to get involved with public engagement (Cohen, 2019). All of those who were working at post-92 universities felt they had little or no support to pursue their own research interests. This restricts academic identity according to Beta A who outlined institutional barriers "…you'll often get [professionals] in mathematical circles looking down on applied mathematicians", undoubtedly this affects his *impact identity*, "…as for research-led public engagement, there's none from me at all." When reflecting on the use of autoethnography as a research method in STEM, Beta A could not envisage any departmental support from his university, "I can imagine my head of division, being a professor of physics, would look at it and go, 'What on earth are you doing? Where are the facts? Where is the evidence-based stuff?" He identified resistance within students, "If I made an outreach module for the final year, I'd have a whole bunch of students going, 'No, I can't do that. I can't go out to schools, and I can't present, and I can't talk to people about [STEM Panel B]."

The driving force affecting a lecturer's ability to make time to balance teaching and research is funding and this tends to highlight the bifurcation between pre- and post-92 universities (Papatsiba & Cohen, 2019). Gamma S drew a comparison between permanent and temporary contracts as influencing factors, "I think there are different priorities. I think it relates a lot to money and how much money an institution has to spend on doing research and then doing teaching, and the balance between that with different members of staff." Zeta E and Alpha K noted that, increasingly, recruitment strategies in post-92 universities tend to look to hire staff specialising either in lecturing or research, which can act as a barrier to achieving unity between teaching and research. This issue has also become a point of interest for Eta B, "One discussion that is going on in [the EU] about should there be professors that do research only and no teaching. So, in [the EU] they, let's say they call it the *Humboldtscher principle*, i.e. from Humboldt". Unity between teaching and research is a principle that most respondents adhere to; but find hard to achieve in practical terms. According to Delta I "I don't balance it. I think, certainly when I started it, that kind of expectation was there, that you would be involved in the research, teaching, and if you look at our activity plan there was a bit about outreach, so it was expected as part of our job…when I had more time, before things were landed on my plate and I took more things on, then there was a better balance".

Reflections on practice: pure vs applied science

The definition of 'pure' maths or science is subject to philosophical interpretation. American physicist Ernest Lynton described it as "blind tyranny", denoting a blinkered adherence in universities, regarding pure science as the optimal form of research which was echoed by the findings of the study which showed significant differences between pre- and post-92 universities (Sandmann & Jones, 2019). This draws attention to the *noesis* of this phenomenon and how it is experienced. Zeta E asserted that only a teaching-led approach will support learning in pure science or abstract concepts, "Only 80% of my students at my first demonstration understand what I'm trying to show them, and I'd say, by the end of a module, 95–98% do roughly. So, it builds up from very basic fundamentals, and I just have to enable them…to realise and accept consciously what they already know intuitively. I believe that most people know already what I'm about to teach them." These challenges were also voiced by Theta A: "…a lot of the maths I was teaching was not really pure maths because it's not getting far enough down the technicalities to be only pure." There is undoubtedly more room to discuss the ways in which academia frames pure and applied science and this merits further investigation. Reflecting on my interviews with Beta A and Theta A, I recalled the realisation that, despite my knee-jerk avoidance of pure maths at school, my education in later life has brought me some understanding of the pure maths that underpins applied maths in everyday life:

> When I was training as a forest school educator, we learned about the Fibonacci sequence and how it is replicated in nature in pinecones and leaves. So that tells me there must be something natural about mathematical reality in day-to-day life. (Beattie, 2022)

How can the links between teaching and research be improved when it comes to pure research in science or mathematics? The perceptions of some participants suggest that applied science is viewed as more optimal for public consumption than pure science (Hains-Wesson & Young, 2016). For some STEM Panel B disciplines, it is easier to achieve tangible routes to public engagement, whereby public impact can be directly linked to an outcome that affects humans according to Gamma S; recognising that it is much harder to demonstrate public engagement strategies in pure science research (Hargittai, 2022). When asked, Theta A described the *missed impact* from open mathematical coding developed by students which was undervalued by his institution: "…it would be very difficult for them [post-92 university] to kind of take it into the public engagement machine so to speak, because it's still very technical." Beta A also noted the difficulties, lamenting, "I would find it quite difficult to talk to a general audience and make my research that interesting or excitable." This was confirmed by Theta A in relation to funding, "…those ideas that could maybe bring in research money or add something to a class can be very difficult".

Conclusion and recommendations

This study aimed to illuminate aspects of pedagogy to make recommendations for practice and determine whether "knowledge is in crisis" (Brew, 1999). The normalisation of the R/T/Pe nexus should be supported and funded appropriately and uniformly across all types of institution. In line with Papatsiba and Cohen (2019), this study found marked differences between the capabilities and capacities of lecturers working at pre- or post-1992 institutions in terms of their abilities to embed public engagement activity into their work. To remedy this, there should be a greater focus brought on the inequities between lecturers' contracts to find a balance in the R/T/Pe nexus (Stevenson & McArthur, 2015). With the exception of lecturers at Ancient or pre-1992 institutions, most participants reported that public engagement is undervalued at a contractual level and there are no protected hours to devote to it (Baird & Elliott, 2018;

Havemann & Roberts, 2021). Curriculum designs that embed public engagement as a recognised form of scholarly teaching are recommended, this could include developing modules for undergraduate science communication as a foundational, rather than optional module (Labrosse & Bownes, 2023).

To make ethical approval for undergraduate public engagement research more feasible, institutions should adopt proportionate, tiered ethics processes aligned with low-risk projects and undergraduate timescales. There was found to be a common understanding amongst lecturers that the timescale of undergraduate programmes is not long enough to develop research skills, sometimes not even by the final Honours year (McKenzie et al., 2018). Off-the-peg solutions may create better routes to develop discrete research projects that undergraduates can easily progress through broad-based research skills modules from the first year of university. Possible routes may be through developing a dynamic framework for social learning or live briefs within already established research projects including postgraduate studies (Annala & Mäkinen, 2016; Metzger et al., 2019; SFC, 2019; Strachan et al., 2019). Embedding pre-approved ethical frameworks with sustained support from academic developers would ensure ethical rigour alongside the required level of pedagogical accessibility (Healey et al., 2014).

Public engagement can often raise tantalising questions for STEM lecturers by student sparking curiosity to scaffold learning. But if public engagement is to be embedded as the third mission of the university alongside teaching and research (Collini, 2012), the purpose and paradigm of the university needs to be re-examined. This should not come at the cost of a lecturer's wellbeing, teaching load or individual research path (Gani et al., 2024). Given the primacy of co-creation and wellbeing as foundations for good academic practice (BERA, 2018; Labrosse & Bownes, 2023), this needs to be supported by HE policies to protect lecturer's time and workload to enable lecturers to develop teaching practice and curriculums that support the triple nexus. Across the themes identified within this study it is clear that more integrative links between R/T/Pe are needed to improve these outcomes. Very few studies have looked at the situation in Scotland (McKinley et al., 2020), and fewer still consider STEM disciplines, although some have examined social sciences (Rayner et al., 2020) it is recommended that pilot projects should be created to fill this gap.

Biography

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