Teaching (super) wicked problems: authentic learning about climate change

Introduction

Society faces many 'wicked' problems, including poverty, food security, access to healthcare and climate change. These problems arise through a complex set of social, environmental and economic processes which are closely interrelated (Peters & Tarpey, 2019). One of the few certainties is that young people of today will be engaged with addressing processes that cause them, and efforts to mitigate them, for the foreseeable future. Therefore, education systems have an important role to play in developing appropriate skills that will enable young people to contribute meaningfully to the societal challenges of wicked problems.

Young people are increasingly concerned by the slow pace of governments and society more broadly to tackle climate change, evident through the school strikes in 2019 and the following achieved by the climate activist Greta Thunberg. As these young adults progress into higher education, universities will need to respond to changing expectations from students, that their studies prepare them to make a significant contribution to addressing climate change challenges. They also rightfully expect that their university learning experience equips them effectively for their professional careers, developing their employability skills. One of the most important issues that graduate geographers will face in their professional careers is the impact of climate change on economies, societies and the environment (e.g. Gregory & Lewin, 2010). It is essential to progress their learning beyond scientific accounts of the changing climate into an applied, multidisciplinary understanding that better reflects the super-wicked nature of climate change and empowers students to be agents of positive change in a complex and uncertain world (e.g. Sproken-Smith, 2013).

The moral responsibility of geographers to educate students and society about the imperative of a sustainable future (Robinson, 2019) poses questions about how to best teach climate change and other wicked problems. The aim of this paper is therefore to critically understand the learning and teaching approaches used in UK and Ireland undergraduate geography programmes that facilitate authentic learning about climate change. Geography as a discipline sits at the intersection between the study of human society and the physical environment. Despite this it has struggled to assert itself to decision makers as a discipline central to addressing complex environmental problems (e.g. Bennett, 2013; Pretorius & Fairhurst, 2015). We conducted our research on identifying authentic practices through a survey of geography programme leaders, semi-structured interviews with academics, and a systematic review of the Royal Geographic Society-Institute of British Geographers (RGS-IBG) Annual Conference presentations. We focused on authentic learning practices because it is widely recognised as a powerful approach which enables students to experience and engage with 'real-world' situations. Geography teaching has the potential to be highly authentic, as much of the discipline is directly concerned with 'real-world' societal and environmental issues and the relationship between them. Pedagogies focused on authentic learning are therefore naturally well-suited to engaging students in the discipline, including fieldwork (France & Haigh, 2018; Hovorka & Wolf, 2009), autoethnography (e.g. Rink, 2020), modelling and simulation (e.g. Pease et al., 2019) and problem-based learning (Pawson et al., 2006; Pawson & Poskitt, 2019). More broadly, authenticity taps into societal debates about the value of university education, and is aligned with the focus in higher education of embedding employability into degree programmes (e.g. Robinson, 2009; Villarroel et al., 2018).

Our paper provides geography programme teams with insights into good practice and recommendations for enhancing their teaching around climate change and other wicked problems. In doing so, our paper also contributes to broader, ongoing debates around the nature of contemporary undergraduate geography education (e.g. Gormally, 2019; Lewin & Gregory, 2019; Sproken-Smith, 2013; Walkington et al, 2018), authentic learning (e.g. Pitchford et al., 2021) and climate change education (e.g Fahey, 2012; Haslett, Frances & Geyde, 2011; Perkins et al., 2018; Robinson, 2009; Robinson, 2015). The following literature review addresses wicked problems, climate change and authenticity. The results and discussion are structured around the themes that emerged from our survey, interviews and systematic review, and we conclude with suggestions on how to embed more authentic approaches to climate change teaching.

Literature Review

Wicked problems

The concept of 'wickedness' originates from the work of Rittel and Webber (1973). Their ideas were developed in a context of relentless social challenges in the US and accompanying social dissent, upheavals and protest movements (Crowley & Head, 2017). They argued that scientific, or instrumentalist, approaches had effectively dealt with 'tame' problems, which were relatively easy for governments and policy makers to grapple with. However, a variety of more complex and difficult issues remained unsolved and were termed 'wicked problems'. Rittel & Webber (1973) identified 10 characteristics that distinguished them from tame problems (Box 1). These characteristics highlight three key features of wicked problems: i) they are difficult to define and

are linked to other problems; ii) solutions are difficult to find and are linked to those that cause the problem; and iii) it appears impossible to know what a good solution might be (Peters & Tarpey, 2019).

[*Box 1 about here*]

Analysis shows that many papers referencing Rittel and Webber's seminal paper are in the discipline of geography or those closely associated with it, including environmental science, urban planning, sustainability, development studies and water resources (Termeer et al., 2019). The nature of geography as a discipline means that geographers have a knowledge-base and skill set that enables them to positively contribute to managing wicked problems, including: the methodological diversity within the discipline (Cantor et al., 2015); willingness engage in interdisciplinary research; integration of social and environmental knowledge (e.g. Popke, 2015); and fundamental understanding of the importance of spatial difference and temporal scales.

Climate change as a wicked problem

Climate change is widely recognised as the archetypal wicked problem. The effects of anthropogenic CO_2 emissions and other greenhouse gases on global climate, ecosystems and society are far-reaching and no single, clearly-defined solution can 'solve' these challenges. Advocates of taking rapid and substantial action on climate change argue that the costs of inaction now lead to much higher costs later (Helm, 2015; Stern, 2006; Vivid Economics, 2020). Efforts to mitigate climate change are highly political, with the risks and costs falling unequally within and between countries. Some proposed mitigating measures require economic trade-offs, and short-term economic costs are set against medium-term risks of irreversible ecological change. Many of the disruptive consequences of climate change on human health and wellbeing,

water resource management, and social cohesion in cities are themselves wicked problems. The scale and consequences of climate change within most political and business planning cycles are uncertain. A lack of leadership to effectively coordinate global approaches to reducing CO_2 and mitigating the effects of climate change, and an increasingly short time period before a climate 'tipping point' is reached (IPCC, 2018), has led to climate change being referred to as a 'super-wicked' problem (Lazarus, 2009; Box 1).

How a problem is framed highlights 'certain aspects of the situation at the expense of others, by drawing different boundaries around the issue and by putting forward different elements as the core of the issue….. Frames can be understood as strong and generic storylines that guide both analysis and action in practical situations' (Dewulf, 2013). He argues that too often climate change is framed as a tame technical problem rather than a wicked problem of governance. Because of the global nature of the problem, there is a commonly held view that climate change requires a global solution. However, it is becoming increasingly clear that solving climate change by taking action at the global scale only is naive, and instead adopting a self-consciously polycentric approach at multiple levels of governance will be needed (Mintrom & Leutjens, 2017). They point to the work of C40 Cities and Carbon Disclosure Project as contrasting organisations both taking action at city scale. The problem framing by C40 is that progress can be made from learning and sharing best practice in core city functions (traffic, building codes, waste management, water systems) while in contrast Carbon Disclosure Project takes a quantitative approach based on monitoring and modelling, and emphasises competition and 'first mover advantage' over collaboration. These superficially similar organisations adopting a markedly different problem framing shows the importance of framing in shaping

subsequent policy and action. Analysing such complex human-environment interactions at multiple spatial scales is a central tenet of geography research and practice. Geography as a discipline therefore has the potential to generate significant new knowledge and professional practice that can address climate change adaptation and effective mitigation.

Teaching climate change as a wicked problem

There has been considerable attention since 2019 paid to how climate change is taught in schools, with calls to make climate change more prominent in the formal and informal curriculum and using it to build students skills in critical thinking, debating and organisation skills (Barton, 2019). Geography teaching in schools, as one of the few disciplines where climate change is routinely taught, has been the focus of robust debate in the national and sector press about the prominence and sense of urgency given to climate change. A particular frustration among young people is the way climate change is framed as a problem that is far off, remote and placing excessive emphasis on modest 'benefits' such as domestic tourism from warmer summers (IPPR, 2020). What is important for this research is that most schools currently fail to address climate change in their teaching, and that the young people who have mobilised to critique their learning in school will soon begin their higher education experience. For a review of how climate change is taught in schools: Waldron et al. (2020) provide a detailed discussion on climate change education in Ireland; while Lee et al. (2020) review the shifting situation in England, making comparison with Scotland, Wales and NI (Lee et al, 2020). The marked rise in young people's engagement with climate change is now also re-focusing attention on climate change in the higher education curriculum. The National Union of Students tracker of student

attitudes shows that those who are ‘fairly’ or ‘very concerned’ about climate change has risen from 74% in 2014 to 91% in 2019 (NUS, 2019).

Between 2010 and 2015, climate change, as part of a broader education for sustainability programme, was a priority for the Higher Education Academy, which funded pilot projects and developed supporting materials to advance sustainability (including climate change) in the university curriculum (Advance HE, 2020). After a five-year gap, climate change has re-emerged as a strategic priority in the higher education sector with the Climate Commission for Higher Education (EAUC, 2020) in the UK and a growing number of universities declaring a climate emergency, some declared in partnership with their city council (see https://www.climateemergency.uk/universities/ for current list). The recent resurgence of interest in climate change teaching and its inclusion in some university teaching strategies builds on an existing body of work on education for sustainable development (ESD). Readers interested in following this body or research further should consult the recent review paper by Hallinder and Chatpinyakoop (2019) and Cicmil and associates (2017) for a discussion about putting the principles of ESD into practice. In the higher education sector in Ireland, young people increasingly expect their degree programmes to equip them to address the wicked problems of societal inequalities, climate injustice, racism, plastic in the food chain and housing shortages. The Human Capital Initiative (a employability skills focused HE development fund) has been criticised as being instrumentalist and not fostering the skills and aptitudes that graduates need to address wicked problems including creativity, fresh thinking, and passion for discovery (Prendergast, 2020). There is a difficult line between schools and universities being places that equip their students to help address wicked problems, and passing on the responsibility and even

blame for wicked problems. Commentators argue that we should stop putting responsibility for pressing societal problems such as knife crime and climate change at schools' door (Brace, 2019). Young climate activists, including Greta Thunberg, have also expressed frustration when decision makers have attempted to push responsibility back onto youth climate activists. Some of the 'solutions' to strengthening climate change in the curriculum place the responsibility back on young people, rather than academics and academic developers currently working in curriculum design and delivery, to advocate for change.

Learning 'about' sustainability and climate change needs to be carried out alongside learning 'for', as sustainability is a form of professional practice as well as a body of knowledge to be acquired. This form of professional practice 'rests upon the belief that solving real-world problems requires us to build synergies between areas of knowledge previously construed as discrete' (Whalley et al. 2011, p. 385). To say that a person knows something in this sense means that their knowledge enables them to interact effectively with the environment. Learning that breaks down subjects into smaller components to be studied in isolation needs to be replaced with support for systemic learning, which generate understanding and intellectual links between phenomena and the larger context. Most current approaches in higher education are not preparing students sufficiently for the challenges and unintended consequences that often accompany proposed solutions to wicked problems (Tromp, 2018).

So what skills do geography students today need to be able to more effectively contribute in their professional careers to climate change challenges? Strong IT skills will be a key feature of the move to a low carbon economy with growing demand in areas such as carbon accounting, as

well as in supply chain management and data management (GLA, 2020). Strong digital literacy is also highlighted in other reviews of the skills, in particular innovation design software, 3D printing and coding (LSE, 2018). Skills in project management and communication are needed to successfully manage the transition process to low carbon organisational models (GLA, 2020). So-called 'soft skills' will become increasingly important in future as the level of complexity of job requirements increases. However, developing skills in problem solving, team working and critical thinking is often poorly integrated in our education system with the delivery of subject specific knowledge (IPPR, 2019). There should be more focus on teaching ways of thinking and in-depth engagement with stakeholders rather than zeroing-in on specific technical solutions (Kaufman et al., 2013). Writing in the aftermath of the 2008 financial crisis, Bangay and Blum note that higher education needs to move beyond adaptation (making educational buildings climate fit) to mitigation; the more challenging task of equipping learners with the knowledge, skills and attributes needed to tackle future challenges (Bangay and Blum, 2010). To build these skills in students, the curricula itself needs to embody these principles by being participatory, reflexive, inclusive, flexible, creative, experimental and authentic (McCune, 2020).

Authentic learning

Authentic learning centres on sustained engagement with 'real world', interdisciplinary problems, using active learning pedagogies such as group work, debates, pitching ideas, hackathons (e.g. FSC, 2012), scenarios and role plays, in a way that highlights the complexities of tackling wicked problems (Herrington & Herrington, 2006; Pitchforth et al., 2021). Authentic learning is closely associated with the constructivist philosophy of learning, which articulates how students personally develop their own understanding through engagement and interactions

with their peers, through direct experience, and through sharing and negotiating understanding with others. These processes tend to occur outside of traditional, didactic/dialogic lecture formats (e.g. Ramezanzadeh et al., 2017). Authentic assessments, tasks and activities in geography are designed to mimic the 'real-world' professional activities geographers are likely to encounter such as policy briefings or flood risk modelling (e.g. Robinson, 2009). Pawson and Poskitt (2019) highlight how geography students can develop critical, flexible and imaginative thinking that challenges the *status quo* when they are able to 'take ownership' of their learning through problem-based activities. They contrast the authenticity of lifelong learning and engagement with wicked problems this promotes, to the utilitarian acquisition of knowledge as a means to reach an end-point. Authenticity is also a characteristic of a teacher's identity (e.g. Kreber et al., 2010). Authentic teachers demonstrate 'care' or 'passion' for a subject and have an interest in motivating students to care as well. For example, this can be done by highlighting issues of personal importance, stepping back from the planned session to address issues happening in the world right now, engaging in debates with students and empowering students to be autonomous learners (Kreber et al., 2010).

Fieldwork is geography's 'signature pedagogy' (Schulman, 2005), and can provide a highly authentic learning and transformative, experiential learning experiences for students (France & Haigh, 2018; Hovorka & Wolf, 2009). It requires students to adapt to unforeseen challenges or unpredictable situations, developing skills in flexible thinking, on-the-ground decision making, and group working (France & Haigh, 2018; Glass, 2015). Fieldwork can provide direct insights into different lived experiences of climate change (e.g. city planners or farmers adapting to extreme weather events), and provide space for students to reflect on cultural differences (e.g.

Simm & Marvell, 2015). This can help students' conceptualisation of the super-wicked nature of climate change and develop inspiration for creative, solutions-focused thinking.

Methods

Our method comprised three stages. The first stage was a systematic review of papers presented at the RGS-IBG Annual International Conference about teaching and learning in higher education (2015-2019) (Table 1). We restricted our analysis to undergraduate programmes in the UK and Ireland for several reasons: i) around half of young people in the UK undertake graduate degrees, and so they are a major influence on skills and knowledge in the workforce and society; ii) the typical three-year structure of an undergraduate degree programme gives time in which to develop students' understanding and skills; iii) masters programmes are typically highly specialised compared to undergraduate programmes, making comparison between programmes more challenging; iv) undergraduate studies significantly shape students' decisions around further postgraduate study and employment.

The review sought innovative examples, case studies and any other research related to this study. The second stage was a survey aimed at programme leaders of undergraduate geography programmes in the UK and Ireland. We compiled a database of 98 geography degrees derived mainly from UCAS, including only single honours Geography, Human Geography and Physical Geography programmes delivered in the UK and Ireland. Programme leaders were emailed an online survey directly, where they could be identified. We also used Jisc mailing group postings, emails to heads of department and departmental managers, and our personal contacts to recruit

programme leaders. We received responses from 26 institutions, covering 47 programmes, three of which were affiliated to the Russell Group and the remaining 23 were post-'92 institutions. [*Table 1 near here*]

The third stage was 15 semi-structured interviews lasting c. 1 hour (using a prepared standardized interview schedule; see Supplementary Information 1) with respondents identified through the survey as carrying out innovative practices. This method has been described as an organized conversation that is guided by new information obtained as the interactive discussion unfolds (Ahlin, 2019). The interviews focused on approaches to teaching climate change and whether changes in student engagement with climate change through their taught programme and extracurricular activities had occurred. Interviews were carried out in April and May 2020, during the covid-19 pandemic crisis in Europe. This was reflected in the content of the interviews, particularly around technology, which tended to focus interviewees' experiences of transitioning to online teaching and the challenges of developing virtual field trips. Although the online survey was significantly disrupted by academic strikes in many UK universities and the subsequent covid-19 pandemic closures throughout the sector, colleagues were very keen to participate in interviews and share their experiences. We independently undertook thematic analysis of the interview transcripts to identify specific patterns and themes, resulting in six themes which form the basis of the results section below.

Results and discussion

1. Framing climate change and programme structure

Most interviewees did not report a clear framing, or positioning of climate change in their undergraduate geography curriculum. None of our interviewees mentioned the Sustainable

Development Goals, a broader sustainability framing of climate change teaching or specifically climate justice. Climate change material was framed in the context of broader societal issues in individual modules, for example food security and biodiversity or planetary boundaries (Röckstrom et al., 2009); there were occasional references to environmental or global citizenship. Our results do not show climate change being taught as an example of a super-wicked (or indeed wicked) problem either explicitly or using other related language despite widely being accepted as such in the literature: we found only one example in a single module. Overwhelmingly the examples given by interviewees only address Peter and Tarpey's (2019) first characteristic of wicked problems, that climate change is difficult to define and linked to other problems. This may hinder opportunities to engage students in powerful approaches to tackling wicked problems, applying problem solving and systems thinking (e.g. Kay, 2008, Tromp, 2018). Despite this lack of higher-level framing, the large majority of survey respondents highlighted the importance of students understanding how human activities were associated with climate change (Figure 1). The survey suggested that problem solving and research skills were relatively less important, but nonetheless remained of significance to most respondents. There were relatively few cases where modules were specifically designed around climate change as a central focus: teaching about the causes and effects of climate change was nearly always located throughout a number of modules in the curriculum. This embedded approach may help mitigate the concern raised by Robinson (2015) about the potential for disengaging students with climate change due to the 'sheer volume of coverage'. She argues that the low detail but extensive coverage of climate change in school may have already alienated first-year students from the topic, which points to the importance of embedding climate change into other geographical topics rather than isolating it in a climate-focused first-year module.

[*Figure 1 near here*]

Effective teaching about wicked problems requires both specialised and integrative thinking skills (Willamo et al. 2018). However, we found the general approach to climate change teaching reflected a dominance of the 'simple to complex' approach to curriculum design (Ornstein & Hunkins, 2009), with much of it focused on the science and problems of climate change. There was little material about solutions, and the limited time on teaching about solutions typically comprised a series of lectures. First year climate change teaching generally concentrated on the science that underpins environmental systems and long-term environmental change. Three respondents also pointed to the perceived unimportance of introductory modules: academics "don't want to waste their expertise on first-year" modules. In the second and third year, climate change was often placed in the context of environmental hazards, tourism, migration, international development and sustainable development. Final year teaching examined climate change in detail in specific fields of study, typically arctic environments and fluvial geomorphology, reflecting staff research expertise in these areas (Figure 2), but not necessarily the plight of highly-populous regions experiencing marked climate impacts (Gregory & Lewin, 2020). This structural approach risks the first year of a programme being relatively uninteresting and demotivating students (O'Neill, 2015) and students missing some of the major consequences of climate change. There were also missed opportunities to link the development of technical skills prominent in the first year of degree programmes (such as competence with statistical packages) to climate change challenges. Alternatives to a 'simple to complex' curriculum design include a socially critical approach, in which content is organised around societal themes and challenges students to consider alternative perspectives (Toohey, 1999; Tassone et al., 2017). It

contrasts with the idea that a curriculum replicates existing knowledge and understanding (Peach, 2010), which our results suggest dominate current climate change teaching. A socially critical approach could help develop students' integrative thinking skills and empower students to become active participants in addressing wicked problems.

[*Figure 2 near here*]

Best practice suggests that curriculum design happens most effectively at the programme level, rather than through individual modules (Price et al., 2008). Addressing the challenges of wicked problems requires the integration of different bodies of knowledge and diverse skills, which is unlikely to develop from a modularised curriculum without strong strategic decisions at the programme level. However, our research revealed that climate change teaching was not widely strategically considered at programme level, and that most academics outside of programme leadership roles were unaware of students' exposure to climate change material through the degree. One interviewee commented that they had designed "an amazing new module, that sets everyone up to understand climate change… but where do they go after that?". This was a programme that had a strong climate change offer for first and second year students, but only two or three climate-focused lectures spread across different modules in the third year. Another remarked that their programme had a "huge number of modules on offer… students pick and choose". This created difficulties for students trying to navigate a pathway through this choice in selecting climate-related modules. Modularisation clearly presented challenges for developing connectivity across the curriculum and breaking down 'compartmentalisation' of climate change teaching (e.g. Whalley et al., 2011). There was little evidence of deliberately scaffolding students' skills and knowledge (e.g. Walkington et al., 2011); students acquired skills and

knowledge in a largely ad-hoc manner governed by module availability and pre-requisite requirements, rather than cohesive curriculum design. There were instances of quite basic qualitative and social science research skills being taught on third year modules due to a lack of curriculum planning earlier in the degree. Our findings suggest geography programmes currently tend towards ‘collections of modules’ (O’Neill, 2015), lacking strategies for developing geographical skills to tackle wicked problems. More emphasis on holistic programme design approaches (e.g. Curriculum Design Intensives; Dempster et al., 2012) may help focus attention among geographers towards more strategic development of students’ climate change understanding and the accompanying development of transferable skills for addressing wicked problems.

Academic developers were acknowledged as an input to curriculum design, but their contributions were rarely mentioned positively in interviews. The survey showed academics’ research, their own views and the views of other academics were rated as more important factors in programme design than the RGS, teaching and learning specialists or employers (Figure 2). No interviewee championed their direct involvement in developing effective climate change teaching, or their role in supporting programme-level design choices about teaching or assessment; one respondent was clear they “hadn’t seen them do anything yet [about] climate change and sustainability” whilst another described the “forced infusion into their ideas" during programme development meetings.We also asked our interviewees about university teaching and learning strategies. None of our interviewees pointed to these as a driver. While some commented they had older strategies that made little mention of climate change, those with newer strategies thought they had little impact on geography teaching. The perception was these

strategies were about getting subjects that currently did not teach climate change to do something. As geography programmes have routinely already been teaching climate change for 15+ years, such institutional strategies did not require changes from programme teams.

Despite the limitations to current practice described above, academic developers have an increasingly powerful role in supporting pedagogical enhancements and policy responses (Sugrue et al., 2018). The position of academic developers as 'brokers' or 'bridge-builders' (Sugrue et al., 2018) in universities means that they can connect academics with institutional policies and strategies (e.g. sustainability, programme structures, assessment practices, civic engagement), and drive the pedagogical response to these in programme design. This is most likely to be valuable in institutions with a clear sustainability agenda or commitment to addressing climate change. However, they can also use their expertise in more pragmatic aspects of programme and assessment design, such as learning outcomes, assessment designs and teaching methods, which could address many of the shortcomings in curriculum design revealed in the interviews.

2. Implications of accreditation and subject benchmarks

Accreditation by a professional body is a key driver of curriculum change in many subject areas. Professional bodies can play an important role in setting a vision for degree programmes and provide effective mechanisms against which a degree programme can be benchmarked. The RGS offers an accreditation scheme, in which geography degree programmes are assessed using professional judgement against the UK Quality Assurance Agency (QAA) Subject Benchmark Statement (SBS) for Geography. An SBS 'describe[s] the nature of study and the academic

standards expected of graduates in specific subject areas… and what graduates might reasonably be expected to know, do and understand at the end of their studies...they are general guidance...not a national curriculum…[and] allow for flexibility and innovation' (QAA, 2020). SBSs are written by subject specialists, and the last major Review Group (in 2014) for the current SBS for Geography (QAA, 2019) had representation from one individual from the RGS, with the remaining 16 members of the review group comprising 12 academics, two QAA officers, an employer representative and a student reader. Programmes which have been accredited by the 'rigorous evaluation of their curriculum' therefore 'seek to deliver learning outcomes aligned with the attributes outlined in the [SBS]' (RGS, 2020).

Despite the clear potential for the Geography SBS to shape climate change teaching and approaches to other wicked problems, and the significant majority of programmes in our study being accredited by the RGS, we found that this had little influence on programme design or content in practice. The SBS was not seen as providing a framework for promoting innovative or joined-up climate change teaching. Climate change was only alluded to, rather than explicitly referred to in the current SBS for Geography (QAA, 2019): one participant noted that the word 'climate' only appeared five times (and only appears in the phrase 'climate change' twice). Further analysis of the SBS reveals these mentions of 'climate' to be once in the context of the 'climate system', twice as evidence of the concept of 'change' and interactions with ecosystems and landscapes, once as an example of 'human impacts on biophysical systems', and once in the context of improving societal wellbeing in the context of climate change. Climate change receives little explicit coverage in the SBS, and is not used to directly frame approaches to geographical knowledge which could provide a stronger steer towards creativity and innovation

in climate change teaching. The concept of 'wickedness' or 'wicked problems' is not referred to in the SBS at all, which again points towards a lack of contemporary thinking about the skills required to address global and geographical challenges.

Interviewees consistently said that RGS accreditation had not influenced the design of programmes, despite the importance of professional bodies for climate change teaching suggested by our survey (Figure 2) and the RGS claim for 'rigour' in the accreditation process. One programme leader said that after designing their curriculum, "we just thought we'll have a crack at the RGS thing… we didn't use [the SBS] as guidance at all". Other participants described the process as a "tick-box" exercise, and one suggested that their institution would "rather spend the marketing budget elsewhere". Others suggested that other accrediting bodies (e.g. the RTPI[1]) were, in contrast, widely recognised as valuable. A consequence of RGS accreditation was that first and second year core modules focused on delivering programme learning outcomes, whereas second and third year specialist modules tended to lack clear alignment with the overall programme. This contributed to the lack of direction and strategy in developing students' skills and knowledge to address wicked problems.

Our findings suggest there is greater potential for the RGS to contribute more fully to the development of the SBS, and set higher aspirations in climate change teaching in undergraduate geography programmes. The RGS could more strongly influence the SBS, and be more societally relevant, if it were to frame graduates' skills in addressing wicked problems, including climate change, as a distinguishing feature of a geography degree. The SBS could also be further

[1] The RPTI (Royal Town Planning Institute) accredits planning degrees in the UK.

strengthened by broadening employer engagement to include key policy-making bodies and environmental organisations in the UK (e.g. Defra, Natural England, Environment Agency, local authorities, and city councils) to more effectively recognise the importance of developing and implementing climate change (and other wicked problems) policies and mitigations as a geography-specific graduate skill. The RGS could play an important coordinating role here in bringing more diverse voices into the SBS development. There was some frustration among the interviewees that the RGS was not already providing a stronger steer to universities on the prominence and focus of climate change in undergraduate degrees, and we got no indications firmer action from the RGS would be viewed negatively.

In Ireland the higher education system has many common features with the UK policy landscape with the national regulator, the Higher Education Authority, putting significant emphasis on student progression, the student experience, transition from school to university, employability, widening participation and internationalisation. A key difference is the subject benchmark statement which does not have a parallel in the Irish context. The key policy documents, National Strategy for Higher Education to 2030 (DES, 2011) and Strategy 2019-2021 Leading Enhancement and Innovation in Teaching and Learning (National Forum, 2019), make no mention of climate change.

3. Climate change and authentic skills

Interviewees identified a range of general skills developed through learning about climate change that would support students progress through their degree, including scientific writing, use of academic journals, data evaluation and analysis, and critical analysis. These were similar to those

identified a decade ago by Whalley et al. (2011). Climate change was referred to as being a "hook" through which these fundamental skills could be developed. Specific technical skills (in particular using GIS to visualise change) were also developed through climate change teaching (Figure 1). Higher-level skills that are aligned with those for tackling wicked problems (e.g. IPPR, 2019) were also identified in some examples. These included advanced communication skills (e.g. infographics, big data and data visualisation design), and the rapid interpretation and sharing of information. Interviewees spoke of the importance of understanding the political nuances behind climate change reporting and the media. Technical skills were rarely mentioned by interviewees, although one explained their innovative practice which developed coding skills. Skills in self-reflection, including understanding the professional role of geographers in their future careers, and the responsibility to use and present data ethically, were also developed through climate change teaching. Overall the development of skills was given a lower priority than the acquisition of subject-specific knowledge about the causes of climate change (Figure 1).

4. Authentic learning

We found examples of authentic learning scattered throughout geography programmes. Although interviewees were aware of the value of authentic learning about climate change (e.g. Perkins et al., 2018), many reported a dominance of traditional, didactic approaches (lectures, seminars) to teaching climate change. Examples of authentic learning included collecting large datasets using low-cost sensors, discussing climate change with European officials, and one example of working on a live climate change project with the local city council. Tutors constructed and managed the degree of authenticity of learning according to students' level of study and the nature of the learning activity (e.g. Meyers & Nulty, 2009; Stein et al., 2004). This control over

the extent of 'realness' enables tutors to scaffold students' skills towards more unplanned, loosely constructed authentic experiences (e.g. live projects). It generates a positive creative tension which enhances learning, which on the one hand provides structured support and on the other takes students out of their comfort zone (McCune, 2020). It also manages some of the challenges of live projects, which our survey suggested were time-consuming to design and implement, and potentially posed a risk to the institutional reputation (Figure 3). Live projects were unusual, and there were few opportunities in the curriculum for students to apply their problem solving and analytical skills to climate change challenges. However, the survey revealed that lack of support from senior colleagues or the risk of low engagement from students was not seens as a barrier to implementing live projects, suggesting there is a good opportunity for their wider use in teaching (Figure 3).

(Insert Figure three near here)

Interviewees highlighted the importance of fieldwork as an authentic learning experience about climate change. Fieldwork was described as intellectually challenging and authentic, for example enabling students to question western world views by engaging with different cultures. Fieldwork also demonstrated the 'real-world' impacts of climate change, despite sometimes being carbon-intensive (e.g. Glass, 2015): "we recognise there are sustainability issues [but] the gain from doing those trips far exceeds the environmental damage that's done". Approaches to reducing the carbon impact of fieldwork included using carbon-offsetting schemes, or developing alternative low-carbon destinations. There was also concern about the ethical implications and colonial nature of "western, white, students and staff going to these places and studying them… we've wrangled with those ideas". One approach to these tensions is for the

students to undertake work that is genuinely useful to the community during their field trip, and we identified three examples of this: one collecting ecological data on turtle eggs; another collecting household data for hurricane preparedness; and another assisting with physical nature conservation tasks. An alternative approach to travel-intensive fieldwork includes using campus environments (e.g. Peacock et al., 2018), or using technology to avoid travelling. The covid-19 pandemic led several interviewees to reflect on the possibilities (but rarely their actual experiences) of using virtual reality and visualisation technologies to explore new environments or use video conferencing technology to do interviews, approaches which also minimise the environmental impact of fieldwork. It could also be possible to integrate authentic sustainable travel into the learning outcomes of the fieldtrip, such as using European rail travel as a way to understand sustainable transport networks. Experiences such as this could potentially be more authentic as the majority of graduates are likely to work in the UK or other western societies. Reinforcing climate change fieldwork as part of everyday experiences (e.g. personal carbon footprints; Hovorka & Wolf, 2009) minimises the environmental impact of fieldwork whilst enhancing its impact on environmental citizenship.

5. Authentic assessment

Interviewees described a range of approaches to authentic assessment, often linked to collecting primary data (e.g. using environmental sensors in urban environments). One interviewee explained how an authentic assessment used students' data analysis carried out in the UK to improve farming practices in a developing country. Students compared crop yields with other variables including soil type, altitude, farmer demographics, and different cultivars. Student co-production and analysis of scientific data highlights the potential of citizen science as a

pedagogical approach to engage students with climate change (e.g. Meyer et al., 2014), and also provides a way of engaging students with bigger philosophical questions, building environmental citizenship: "[it] links to the academic communities, and post-positivism, and who is a scientist and who isn't".

Many of the more authentic approaches to assessment focused on communicating scientific information to policy makers. POSTnotes[2] were often used as a model for policy-focused assessments. Producing policy documents encourages students to examine potential solutions to wicked problems and their impacts on stakeholders, rather than purely the scientific process underpinning a solution (e.g. Blaum et al., 2017). However, it is important to ensure that students are prepared to undertake more unusual assessment types through effective scaffolding (e.g. Shefer & Clowes, 2014; Smith et al., 2015). Many interviewees highlighted the dominance of 'traditional' assessments (e.g. essays, reports) in their programmes (but also efforts to reduce the number of exams, in part as an immediate consequence of the covid-19 pandemic). Some highlighted students' preference for familiar forms of assessment, especially in their third year when performance in each one can impact significantly on the degree classification. There were several programmes where students would encounter a novel assessment (e.g. a POSTnote) in their final year for the first time. A large number of optional modules meant it was difficult to ensure that the skills for more authentic assessment were scaffolded effectively: "it's not always possible...someone can always switch out…without having taken the second [year module]". The type of assignment that is viewed as aligning with employability varies. Research focused universities prepared students for careers in think thanks, consultancies and local and national

[2] POSTnotes are short communications for policy makers, written by subject experts and published by the Parliamentary Office for Science and Technology. See https://post.parliament.uk/briefing-type/postnote/.

government roles by setting assignments to write policy briefings, sometimes with direct links to existing formats such as POSTnotes mentioned above. In contrast, a GuildHE university where there was a strong focus on preparing students for careers in school teaching set students assignments developing learning materials aimed at school children, to better understand the relationship between tropical hurricanes, climate change and impact on communities.

6. Students' perspectives on climate change

In interviews, we asked lecturers to give their perspectives on students' views on climate change (Table 2). We did not survey any students directly, and as a result our insights are moderated by lecturers insights. They came with different personal experiences, ranging from three years working in higher education in the UK to over 20. They consistently reported an increase in student engagement (especially in the past 18 months) in climate change. This is in marked contrast to reports from 5-10 years ago, where commentators noted that students were 'oversaturated' with climate change and experiencing 'green fatigue' (Haslett et al, 2011; Robinson, 2015). Our findings show that universities are responding to the prominence of climate change among applicants by showcasing learning technologies and field trips with a strong climate focus at open days. One of our interviewees noted that students who attended that university selected it specifically because of the degree focus on human geography while another commented that students who came to their university were selecting a course with as strong focus on physical geography. That created some challenges for lecturers who were teaching students outside their expectations. The climate change content helped to engage students in physical geography assignments and vice versa. Overall the divide between human and physical geography was not a significant theme of our research.

A number of universities had recently declared or were about to declare a climate emergency, and students had been involved to varying degrees in those processes. One lecturer noted that a dissertation student was researching the approach the university had taken to engaging students in the institutional climate emergency declaration. While a significant minority of students regularly engaged in environmental activism, a much larger group adopted green behaviours. A number of modules used individual carbon footprinting tools as a way to engage students with personal carbon consumption, suggesting that the potential for climate change teaching to enhance individual action as noted by Robinson (2011) appears to be coming to fruition. An activist identity could be problematic, with some students whose main motivations were intellectual interest and a desire for a fulfilling career in the environment feeling excluded by activist colleagues. Some students were also disappointed that their lecturers did not adopt an activist identity - despite their strong personal beliefs in the importance of taking action on climate change.

[*Table 2 near here*]

In contrast to personal action, much less attention was given to encouraging students to think about what they could do as professional graduate geographers to mitigate climate change. This only appeared in programmes where some modules were taught jointly with planning students. The RTPI puts significant emphasis on student planners developing awareness of their professional role in addressing climate change challenges. This opened up a space in these modules where geographers also reflected on their specific contributions. Despite challenges an engaged student body can present, lecturers were uniformly positive about the implications of increased interest by students in climate change, and saw it as a good thing to help drive their

department and university into doing more. We found no indications that student attitudes and expectations are a limiting factor in the development of more solutions focused and authentic climate change content in the curriculum - in fact, quite the reverse: students are going into universities with expectations of wanting to play their part in solving climate change, yet developing solutions to such super-wicked problems through authentic experiences remains at the margins of most geography degree programmes.

Conclusions and way forward

Our findings demonstrate that climate change is not clearly framed as a wicked problem in UK and Ireland geography programmes. We suggest that there is significant potential for climate change to be taught more creatively and in ways that enhance the skills of graduates to better address climate-related challenges that exist now, and those currently unknown that will emerge in the future. Box 2 outlines seven principles of good practice in climate change that have emerged from our research. We urge leaders of geography programmes and all those engaged in teaching geography to reflect on these to stimulate debate among academic teams when developing new programmes and reviewing existing programmes. We believe they are equally applicable to human and physical geography; the principals implicitly argue for a more integrated approach to climate change teaching.

[*Insert Box 2 near here*]

Our results show that there is relatively little attention paid to programme-level design which results in innovative learning and teaching experiences about climate change not being effectively positioned in a wider, programme-level strategy. Students do not always benefit from opportunities to progressively develop the higher-level skills that are required to tackle wicked

problems, limiting their ability to succeed in more complex and authentic learning and assessment. Innovative and engaging modules must be placed within clear programme-level strategies to provide students with the skills and knowledge required to tackle both innovative learning and assessment, and in their subsequent careers, climate change challenges. It was notable from our interviews that few academics had a strong conceptual understanding of the structure of the degree programme to which they contributed, and were either uncertain about how climate change was framed in the programme, or aware that it lacked clear framing. All academics contributing to a programme should be playing a role in programme-level design, to ensure that structural choices about teaching climate change and other wicked problems are widely understood and agreed. More robust mapping out of skills development and clearer assessment scaffolding at the programme level could be delivered through more effective programme design approaches (e.g. Dempster et al., 2012) and the support of academic development teams. This does not mean to marginalise the importance of academics' teaching and subject expertise, but recognises the challenge in taking a holistic view of programme design. Academics can bring detailed subject knowledge, novel insights from their own research, external partnerships and knowledge of sector-wide good practice into strategic discussions about climate change teaching. Academic developers are equipped with the skills to ask the right questions of programme design teams, harnessing academic expertise to inspire and engage design teams to adopt creative, high-impact and innovative approaches to learning and teaching. The progress in access and inclusivity in UK higher education in recent years has demonstrated the importance of effective academic development in embedding new approaches to curriculum design; as yet their impact in climate change teaching is clearly under-developed.

Many institutions are keen to position themselves as civic universities with a focus on positively impacting their local communities on societal issues such as climate change. Integrating these communities more deeply as stakeholders in climate change education could generate more opportunities for students to develop higher-level skills in negotiation, communication and creativity. For example, local environmental charity work placements for students, student run allotments and local food markets, climate change exhibitions, and scientific public talks are some examples that foster skills development and co-curricular learning whilst enhancing universities' civic engagement missions. Harnessing this opportunity to embed climate change into institutional learning and teaching strategies could play an important role in focusing the work of academic development teams to support climate change teaching (e.g. Taylor, 2006). Currently teaching and learning strategies focus too heavily on making some progress in subjects where climate change is not taught at all, rather than pushing subjects like geography that already teach some climate change to go further. Strengthening teaching and learning strategies would give climate change a similar status to the work done by academic developers on other institutional priorities, such as research-informed teaching, and diversity and inclusion.

However, there is an inherent challenge in developing even more tightly structured curricula with rigid outcomes to teach students about wicked and super-wicked problems (Knight, 2001). Instead, a process approach to curriculum design can focus on the way in which knowledge is acquired and the position of these learning experiences within the programme-level structure (Knight, 2001). A process approach enables multiple authenticities to be acknowledged within the curriculum without privileging one over another. Student learning would be designed as a series of experiences through which they independently construct their own individual and

authentic understanding, rather than by prescribing authenticity as achieving a set of predefined outcomes. For example, some students could undertake projects with an NGO on zero plastic, while others on the module produce materials that support the city council on green infrastructure. It is the learning process and experiences that are important, not that some will have more technical knowledge about plastics or green infrastructure at the end of the module. This approach is aligned with teaching wicked problems, as it does not prescribe technical solutions, but a set of learning experiences to allow students to develop their own ideas.

Programme learning outcomes can then logically emerge from a curriculum design process that focuses first on learning experiences. There is a strong role for professional bodies in shaping the curricula in diverse subject areas, and programme teams give significant weight to their input. However, our study revealed the lack of impact of RGS accreditation on programme design and delivery. Several of the geography programmes were taught with shared modules with RTPI accredited planning degrees. The RTPI recently required planning schools to report on how climate change is taught on all their accredited degree programmes, in a mapping exercise that required programme teams to have a clear understanding of climate content across the degree. The RTPI engages with accredited universities outside the programme review cycle, coming to the university to talk to students about becoming a chartered planner after graduation. Accounts of this interaction strongly featured climate change in both the policy work of their professional body and the career pathways presented. This makes the relationship between the professional body and university more of a partnership, and moves beyond the transactional ‘fees for accreditation’ model current in geography.

Technology can play an important role in engaging students with wicked problems. Technology facilitates global collaborations and communications, exposing students to new perspectives on complex issues such as climate change. It enables the rapid acquisition and processing of large, complex datasets and communication of complex data and findings among diverse stakeholder groups. Developing digital skills in geography graduates should be a priority for geography programme leaders, not only because of their relevance to students employability (in c. 20 years, 90% of jobs are likely to involve routine work with digital technologies; Skills Funding Agency, 2016), but also because approaches to tackling wicked problems will be developed and played out in a digital society. Our findings suggest that there is untapped potential for using technology to teach wicked problems, with it currently being used for tightly defined, basic purposes. We found little evidence of creative approaches to technology in teaching, with an emphasis on 'how to do tasks using software X', rather than 'what technology can do to enable me to tackle wicked problem X'. This applies to the use of tools such as GIS and flood risk modelling. Such approaches should not be bound to individual software packages but would upskill graduates with the creative mindset to engage with as yet undeveloped technologies in their future careers or deploy current technology in novel ways. For example, 'hackathons' are increasingly engaging students, alumni and stakeholders to repurpose existing technologies and develop innovative solutions to wicked problems in an intense, collaborative and time-constrained environment (e.g. FSC, 2012; Climate-KIC, 2020; Climate Outreach, 2020). They draw on design thinking approaches where participants undertake structured brainstorming activities, sort through the ideas generated in a process of pattern finding and synthesis, then prototype their proposed solution (Briscoe and Mulligan, 2014). Hackathons are gaining traction in diverse disciplines (e.g. medical science, Lyndon et al., 2018; and art history, Gasser, 2018) and could

provide inspiration for more radical and contemporary digital pedagogies for teaching wicked problems in geography.

The concept of wicked problems was developed against a backdrop of changing values, protest movements and urban unrest. Our challenging times today seem to have much in common with this period in the late 1960s of rapid social change and emerging environmental consciousness. Our research makes a strong case for putting the concept of wicked problems centre stage and using it to reframe how climate change is taught, to best equip today's undergraduate geography students to face the global challenges ahead.

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Box 1: Characteristics of wicked and super-wicked problems. Based on Peters, 2017.

Wicked problems:

1. Wicked problems are difficult to define: there is no definite formulation
2. Wicked problems have no stopping rule
3. Solutions to wicked problems are not true or false, but good or bad
4. There is no immediate or ultimate test for solutions
5. All attempts to find solutions have effects that may not be reversible or forgettable.
6. These problems have no clear solution, and perhaps not even a set of possible solutions
7. Every wicked problem is essentially unique
8. Every wicked problem may be a symptom of another problem
9. There are multiple explanations for the wicked problem
10. The planner (or policy-maker) has no right to be wrong

Super-wicked problems have the following additional characteristics:

11. Time to find a solution is running out
12. There is no central authority, or only a weak central authority, to manage the problem and coordinate solutions
13. The same actors causing the problem are those best-placed to contribute to its resolution
14. They are inherently long-term and large-scale, so short-term amelioration is inadequate as a solution

Box 2: Seven principles for good climate change teaching

1. **Climate change should be framed as a super-wicked problem:** Programme teams should develop a clear intellectual position on climate change informed by the conceptual framing of climate change as a super-wicked problem. This should be articulated at the programme level to enable module content to be orientated around it.

2. **Teaching should be solutions-focused:** It should develop the skills required for students to design and implement innovative mitigations and solutions, not just teach solutions and mitigations that are currently used or offer purely scientific or cultural accounts of climate change.

3. **Students' skills to engage with climate change and wicked problems should be clearly scaffolded:** Material concerning climate change should be carefully integrated throughout levels of study and modules, such that the advanced skills to tackle wicked problems effectively are progressively developed during a programme.

4. **Assessment should be authentic:** Assessment strategies should focus on opportunities for students to apply their climate change knowledge and skills to contexts relevant to professional practices.

5. **Students' identity as a professional practitioner should be developed:** Students should have opportunities to develop an awareness of their responsibility as a geographer, to help take better professional decisions in the context of climate change.

6. **Teaching about climate change should be delivered using climate-aware methods:** Carbon intensive approaches to teaching (e.g. air travel) should be avoided where possible and replaced with practices that model climate-sensitive behaviours (e.g. rail travel, using local environments).

7. **Technology should meaningfully enrich climate change teaching:** Students should be given opportunities to develop an aptitude for using technology innovatively to critically explore data and communicate messages creatively.

Table 1:

	2019	2018	2017	2016	2015
Total number of research papers about teaching geography in higher education	**20**	**27**	**28**	**20**	**24**
Other session formats: keynotes, workshops, panels, discussions, posters	7	8	4	6	2
Papers that address authentic learning (excluding field work)	4	5	3	6	2
Papers on teaching climate change in higher education	2	4	0	3	3
Papers that address fieldwork in higher education	8	1	5	3	7
Papers that explicitly frame teaching with wicked problems	0	0	0	3	0

Table 2:

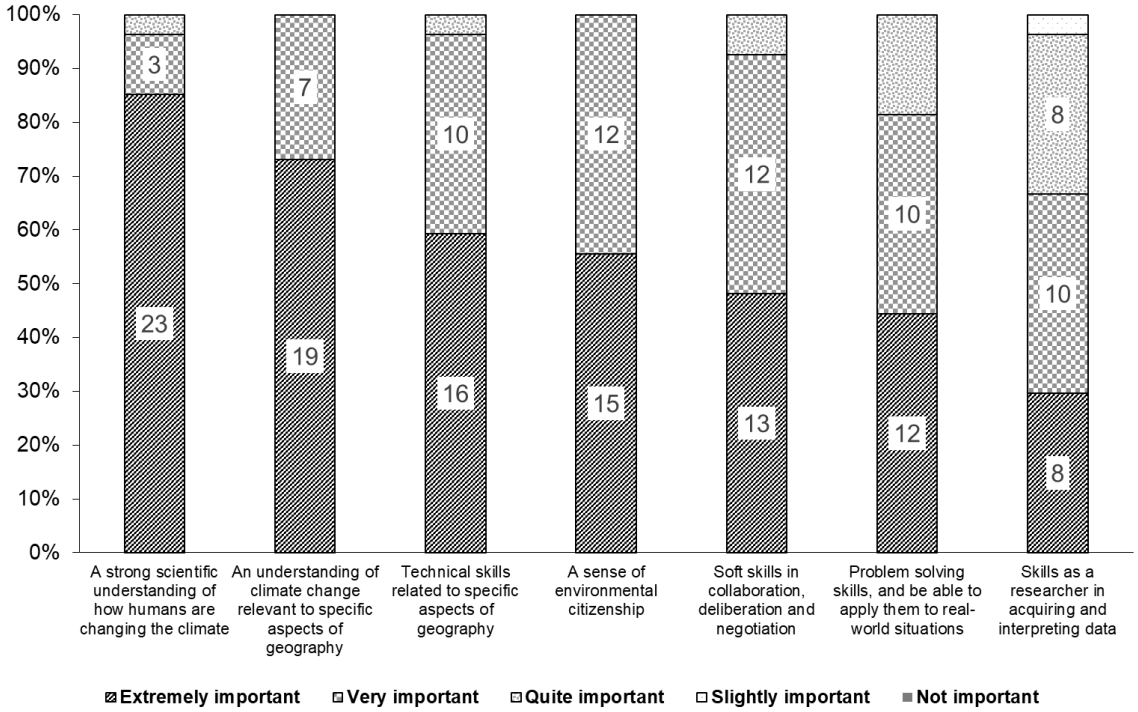
Student activism or behaviour	**Examples**
Student activism	
Attending public protests about climate change	Two universities in the south west reported half of their undergraduate geography class attended a public address by Greta Thunberg
Attending climate strikes	Some lecturers engaged with students on professional social media accounts and noted their active participation
Attending public lectures about climate change	Several universities reported strong geography student attendance at public lectures in the city aimed a wide audience
Volunteering with schools	Two universities reported their geography students volunteering to accompany lecturers on visits to engage school children with climate change
Activism on campus	Geography students taking a prominent role in campus based campaigns on single use plastics, more water fountains, fair trade and vegetarian/vegan food and divestment in fossil fuels
Promoting behaviour change among peers	Geography students prominent in campus wide roles to engage their peers through formal roles such as eco-reps
Food, nature and wellbeing on campus	Geography students practically supporting campus based allotments and voluntary projects to survey biodiversity on campus
Volunteering in the city	Geography students volunteering at food banks in the city. Students volunteering to help at science fairs talking to the public about climate change

Personal behaviour	
Changing consumption patterns	Students actively reducing their consumption of single use plastics
Changing attitudes to free gifts	Students not accepting free gifts e.g. reusable water bottles and coffee cups because they already have one and don't want to take more than they need
Changing attitude to flying	Some students flying less or not flying at all for personal and leisure trips
Changing attitudes to food	More students reducing meat consumption or becoming vegetarian or vegan and linking those choices to climate change
Directly related to geography degree	
Climate change a motivation to study geography	Lecturers report prominence of climate change in applicants' personal statements
Climate change affecting choice of university	Lecturers report it is regular topic of discussion by applicants at open days
Choice of dissertation	Many reported a rise in undergraduates selecting climate related dissertations, in some cases over half with a strong climate focus
Reluctance to fly on fieldtrips	Several interviewees reported a decline in take up of modules where the fieldtrip included a short-haul flight. Several reported student concern or even occasional refusal to attend long-haul fieldtrips

Table 1:Number of papers submitted to the RGS-IGB Annual Conference on topics of teaching and learning, 2015-2019.

Table 2: Examples of student activism and behaviours reported by interviewees.

Figure 1: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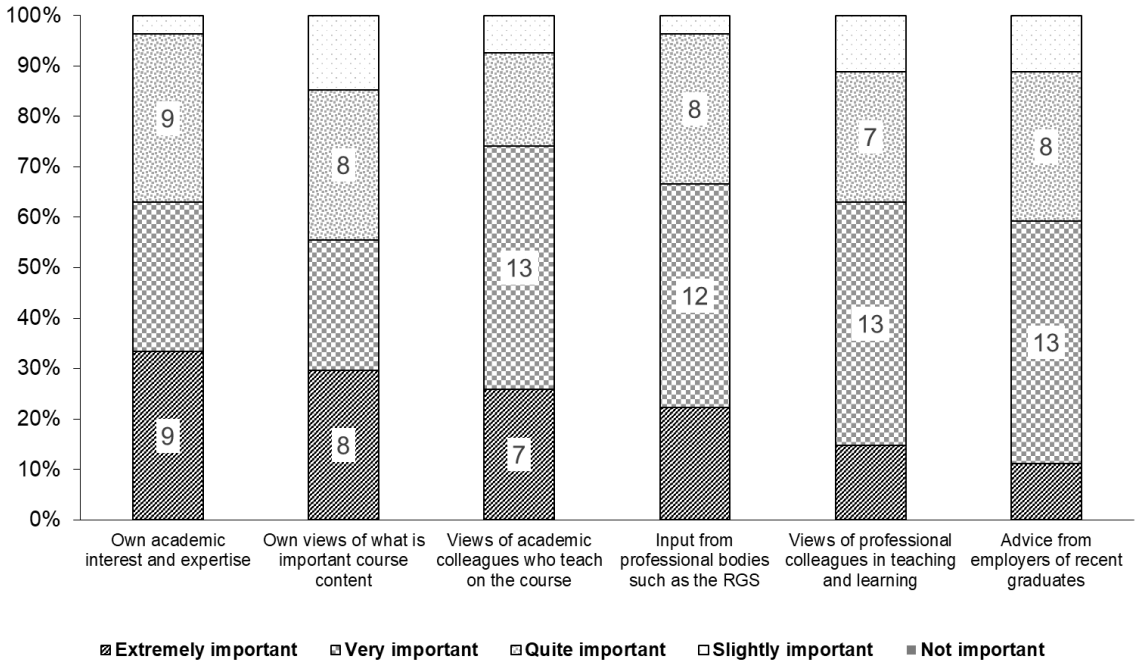
A strong scientific understanding of how humans are changing the climate
An understanding of climate change relevant to specific aspects of geography
Technical skills related to specific aspects of geography
A sense of environmental citizenship
Soft skills in collaboration, deliberation and negotiation
Problem solving skills, and be able to apply them to real-world situations
Skills as a researcher in acquiring and interpreting data
Extremely important
Very important
Quite important
Slightly important
Not important

Figure 2: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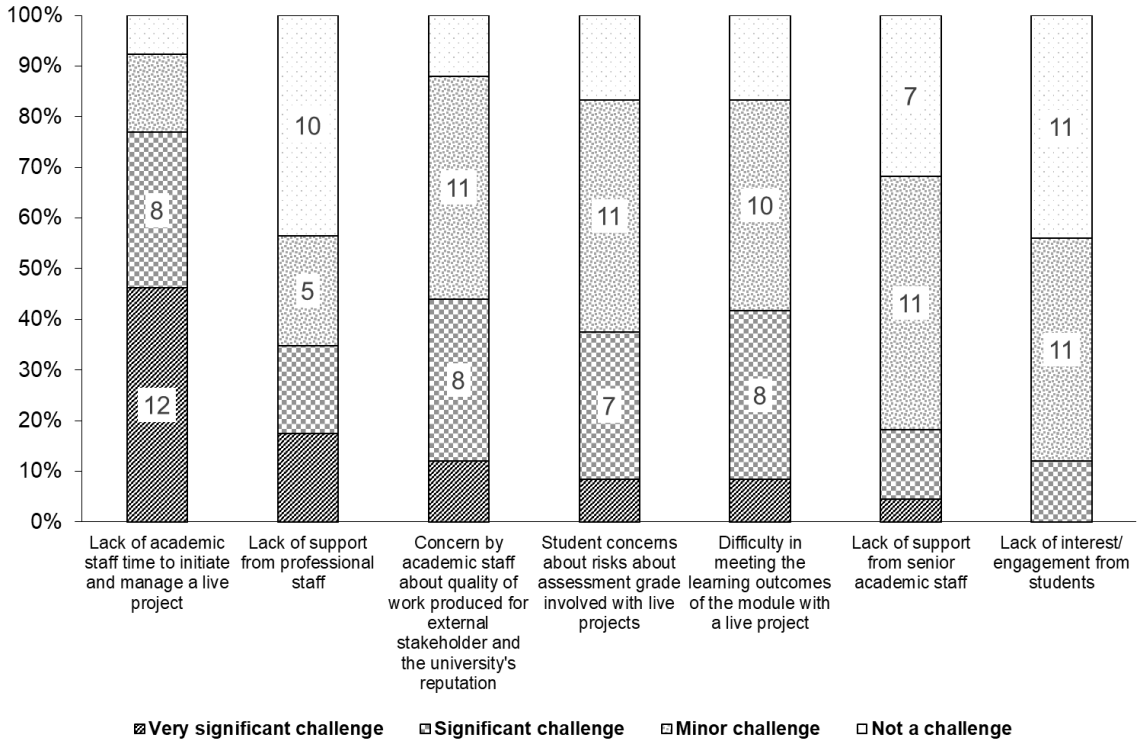
Own academic interest and expertise
Own views of what is important course content
Views of academic colleagues who teach on the course
Input from professional bodies such as the RGS
Views of professional colleagues in teaching and learning
Advice from employers of recent graduates
Extremely important
Very important
Quite important
Slightly important
Not important

Figure 3: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Lack of academic staff time to initiate and manage a live project
Lack of support from professional staff
Concern by academic staff about quality of work produced for external stakeholder and the university's reputation
Student concerns about risks about assessment grade involved with live projects
Difficulty in meeting the learning outcomes of the module with a live project
Lack of support from senior academic staff
Lack of interest/ engagement from students
Very significant challenge
Significant challenge
Minor challenge
Not a challenge

Figure 1: Responses to the survey question ‘What do you think are the most important things that undergraduate geography students should gain from the climate change content in their degree?’ Numbers on bars represent the count (*n*) of responses for the two highest frequencies.

Figure 2: Responses to the survey question ‘What do you think should be the most important factors that determine how climate change is taught on the undergraduate geography degree you are leader of?’ Numbers on bars represent the count (*n*) of responses for the two highest frequencies.

Figure 3: Responses to the survey question ‘What are the main challenges in embedding climate change-based live projects with external stakeholders on your geography undergraduate degree programme?’ Numbers on bars represent the count (*n*) of responses for the two highest frequencies.