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Common Language of Sustainability for Built Environment Professionals—The Quintuple Helix Model for Higher Education

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Abstract: One of the repeating themes around the provision of the knowledge and skills needed for delivering sustainable communities is the idea of a "common language" for all built environment professionals. This suggestion has been repeated regularly with each new political and professional review within and between different sectors responsible for the delivery of sustainable communities. There have been multiple efforts to address academic limitations, industry fragmentation and promote more interdisciplinary working and sector collaboration. This research explored the role of skills for sustainable communities, particularly within the higher education (HE) sector, and the responses to support the development of a "common language of sustainability" that can be shared between different sectors, professional disciplines and stakeholders. As an interdisciplinary group of academics and practitioners working with the HE sector in the North East of England, we evaluate the progression of sector collaboration to develop a quintuple helix model for HE. We use this as a suitable framework for systematically "mapping" out the mixed sector (academic, public, business, community and environmental organisations) inputs and influences into a representative sample of HE degree modules that are delivered from foundation and undergraduate to postgraduate levels, including examples of part-time and distance-learning modules. We developed a cascade of models which demonstrate increasing levels of collaboration and their potential positive impact on the effectiveness of education on sustainable communities. The methodological assessments of modules were followed by semi-structured group reflective analysis undertaken through a series of online workshops (recorded during the Covid19 lockdown) to set out a collective understanding of the generic skills needed for the delivery of sustainable communities. These generic skills for sustainable communities are presented as a pedagogical progression model of teaching activities and learning outcomes applied to the levels within HE. We propose sustainability education principles and progressions with the hope that they can have an impact on the design or review of current degree modules and programmes. The paper informs future sustainability research to be grounded in holism and systems thinking; better understanding of values, ethics, influencing and political impact; and procedural authenticity.

1. Introduction

Changing educational practice in the delivery of further education (FE) and higher education (HE) programmes from various disciplines within the construction industry has always been challenging. When, in the North American context, Boyer and Mitgang [1] suggested that there should be a unified profession between teaching and practice, with the academic connecting with the real world, and more radically, using a connected curriculum that brings knowledge from outside architecture and professional disciplines into play, they were subject to a lot of undue criticism. The educational paradigm which they argued strongly in favour of suffered criticism and was described as a "form of institutional narcissism" and proposing "a tepid prescription for reconciliation and civility" that was unique to architecture [2].

Yet one wonders how collaboration and interdisciplinary working can be so offensive when it comes to the design and delivery of built environment-related programmes. Whenever the idea was simply to make the architecture and built environment (ABE) professions more collaborative in their underlying shared values and in the use of a common language.

Similar messages in the UK were repeated by Latham [3] in suggesting that the fragmented professions responsible for sustainable communities, design and the built environment should move from an operational position of confrontation to one of collaboration and shared standards. Yet much fragmentation between professions and activities remained, with too little investment in research, development, training and applied learning [4], with the cyclical nature of the industry meaning that the lack of investment in and need for better professional skills is still being repeated [5], and in some cases being enshrined in public sector procurement, contracts [6] and strategies [7].

As the built environment professionals charged with delivering sustainable development are seen to be lagging significantly behind other sectors in the national economy [8] there is the need for new models for education, training and the delivery of skills [9] that have a shared understanding of how important collaboration is to the delivery of sustainable communities [10].

Academic teams from different universities have attempted to introduce collaborative approaches to delivering education on sustainable communities [11–14]. Inviting industry professionals to share their expertise and professional experiences with the students is probably one of the simplest examples of academia collaborating with the industry. This paper argues that the academic institutions delivering education for sustainable communities to the students on ABE courses must attempt to gain much greater engagement with and active participation of a wide range of stakeholders including professional bodies (viz., Institution of Civil Engineers (ICE), Institute of Structural Engineers (IStructE), Royal Institution of Chartered Surveyors (RICS), Royal Town Planning Institute (RTPI), Royal Institute of British Architects (RIBA), Chartered Institute of Building (CIOB), etc.), regional and central government representatives, charitable organisations (such as Ministry of Building Innovation + Education (MOBIE)) involved in sustainable communities and the general populace who care deeply for the health of socio-economic and environmental systems. The authors have developed a cascade of models which demonstrate increasing levels of collaboration and their potential positive impact on the effectiveness of education on sustainable communities.

2. Knowledge Transfer to Exchange

The symbiotic functioning of academia and industry leads to the development and enrichment of the sea of knowledge that encapsulates several domains including those from the physical sciences. This vast body of knowledge permeates through to various strata of formal education including HE. Individuals graduating from academic institutions which engage in this rich, collaborative relationship with the industry have been known to possess a good mix of sound theoretical grounding and the

acumen to solve problems which are of particular interest to the industry [15]. Academia-industry collaboration helps academia keep its research and educational practices relevant to the needs of the present and future. This collaboration helps industry in gaining access to graduates who are better prepared and able to meet its technical and commercial needs. Despite the virtuous nature of academia-industry collaboration, competing interests and other factors hinder the extents to which the educational institutions interact with the business world.

Academia-industry relationship, as practiced world-wide, is a spectrum. Figure 1 represents a significant part of this spectrum where academic institutions engage in intellectual pursuits in the form of structured and non-structured collaborative research and the fruits of this intellectual endeavour are passed on to various players within the business world, so it helps them become more profitable and efficient in their functioning. This is the traditional entrepreneurial model [16] of "Knowledge Transfer" between these sectors that has developed in the UK in part response to the Lambert review of business and university collaboration [17] and is indicative of contractual research-based relationships in receipt of central government agency funding.

Figure 1. Knowledge transfer.

There are limits to the extent of knowledge that can be generated when academia conducts its intellectual pursuits, largely, in insolation from the industry. An improvement over the fore mentioned Knowledge Transfer model is the "Knowledge Exchange" model which was introduced in the UK from 2017 onwards (Figure 2), where the identification and formulation of research problems and the means to resolving these problems is done collaboratively by the research teams at academic institutions and practitioners working in commercial organisations. Where there is an important semantic distinction between the "transfer" and the "exchange" of knowledge, the new framework stressed the later with consideration of knowledge being more a two-way flow between partners with different metrics aimed at achieving more real-world impact through this sort of collaboration and with the addition of the scope to consider the charity/community or third sector as a suitable collaborative partner. The Knowledge Exchange framework can be understood as the UK government efforts at broadening the scope of applied knowledge [18] and it is particularly relevant to sustainable communities, in that non-financial social or environmental benefits can be considered alongside commercial outcomes. In effect, the subtle shift in emphasis in central government policy and programmes is having the effect of widening engagement between HE and other sectors beyond private business [19] as part of a growing knowledge economy.
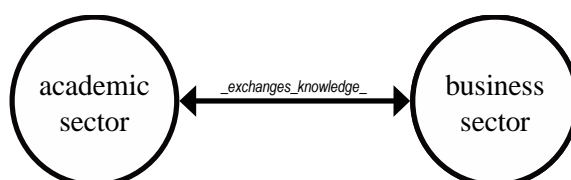

Figure 2. Knowledge exchange between collaborative partners.

3. Triple to Quadruple Helix

The World Bank describes a knowledge-based economy as one in which the sustained use and creation of knowledge are at the core of the nation's economic systems and their development [20]. Countries such as the UK have seen an accelerated change in their transition from being resource-based

to knowledge-based economies during the second half of the 20th century. It is argued that the national governments leading these knowledge-based economies have begun monetizing knowledge as innovation and knowledge are increasingly seen to be the driving forces behind economic development, job creation and improved social standards [21,22]. These socio-politico-economic changes have created new expectations from the academic institutions, particularly those operating within the HE sector. As a consequence, individual academics and institutions are now required to engage in research activity that is relevant to and undertaken in collaboration with business sector (or) industry. This co-creative and collaborative interaction between the public sector, academia and industry is conceptualized as "Triple Helix" (Figure 3). It is similar to the tradition Knowledge Transfer and Exchange models but with the public sector with an explicit role in the setting of policy and as the significant funding body. As a model, it defines the role of government and the public sector in a policy definition and strategic funding or enabling role and recognises the widening context of contractual arrangements for research and partner working between different sectors.

The various "helix" models define bidirectional flows of knowledge over different timescales between the multiple stakeholders. Review suggests that research aligned to the Triple Helix model has clustered around entrepreneurship, business innovation, industrial policy, and regional development [23], with common areas of shared research and knowledge management between universities, industry and government. In so doing, it is reinforcing the idea that the academic sector does have a clear regional association and deep long-term shared research interests with layers of government while at the same time being specifically interested in impactful outputs from any university research. The Triple Helix model describes a form of regional research and innovation policy that is in a constant state of transition. Leydesdorff [24] made use of this model to describe different or unequal forms of overlapping interests in regional research and innovation policy landscape. Hence, the idea of the Triple Helix, is mostly about finding a descriptive model of how the regional dynamics actually operates between the multiple sectors.
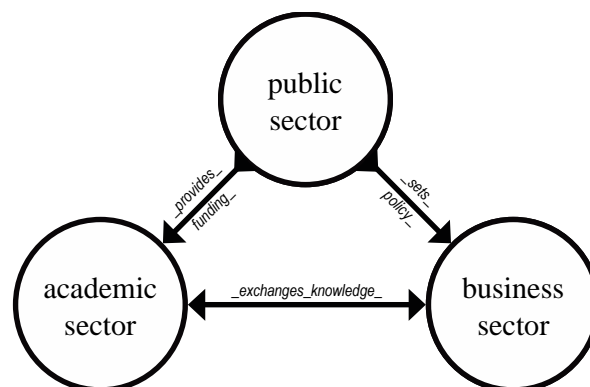

Figure 3. Emergence of the "triple helix" collaborative model adapted from Leydesdorff [24].

The Helix has evolved as a descriptive model, most recently, in understanding the community sector and its particular role as "client" to the output from any collaborative innovation partnerships. Arnkil et al. [25] added additional categories of stakeholders and actors to describe the "Quadruple Helix" (Figure 4), most commonly placing citizens (or the third sector) into the model, albeit as a framework this is not as widely recognised as the preceding Triple Helix. Often the community or citizens are placed centrally in a model that seeks to produce directly relevant products, services and other outputs. In practice, the factors central to any descriptive model of innovation within society have been described as "happy accidents" [26] that emerge from collaborative, co-evolution and co-production at a local level. Indeed, this progression in open innovation towards the helix model(s); of whatever level; has been identified and mapped in different cultural and national contexts [27] in attempts to find common ways for describing collaborative practice between different sectors.
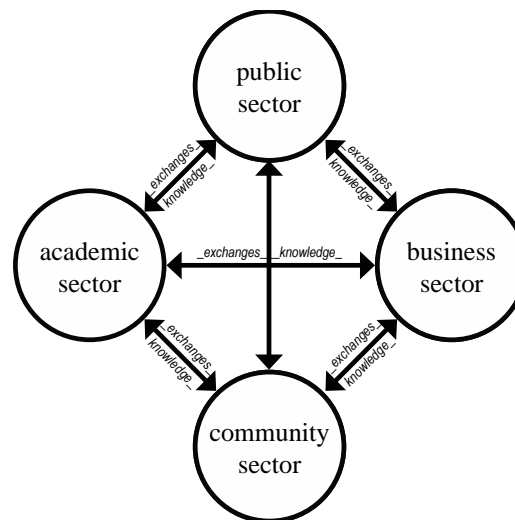
Figure 4. "Quadruple helix" stakeholder model adapted from Arnkil et al. [25].

4. Helix Plus Environment

We are beginning to get some references in literature and policy to the "helix" collaborative model as more dynamic and having a filter through the context of the natural environment and the requirements for sustainable communities. Central to the consideration of the environmental context, including locality specific environmental priorities, is the idea of a geographical or spatial cluster of organisations from different sectors that operate within a shared natural environment and often with a corresponding set of shared environmental concerns.

In effect, the current means of delivering sustainable development and environmental education is aligned somewhere beyond the triple helix and tending towards the added integration of community engagement; including a mix of "client" stakeholders; and the aspects of the natural environment, described as the "Quintuple helix" (Figure 5) innovation system [28]. The Quintuple Helix reflects the governmental focus on sustainable smart growth [29] being the current focus for collaboration between the sectors, as much as a result of the global financial crisis from 2008 onwards.
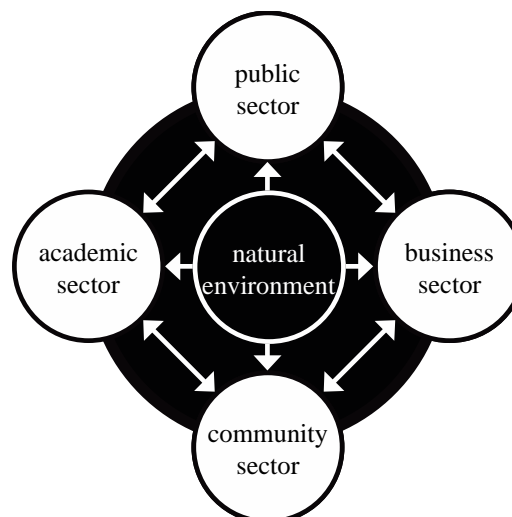

Figure 5. "Quadruple helix" plus environment, adapted from Gouvea et al. [30].

We have considered this Quintuple Helix as one of the most effective frameworks for describing current practice and one that allows for the consideration of the environmental and societal factors central to sustainable communities. Gouvea et al's [30] diagrammatic representation has been adapted

(Figure 6) to clearly differentiate a nested model with the Triple Helix as the traditional knowledge core comprising the academic, public and business sectors but set within the social context, which is itself set within the environmental context.
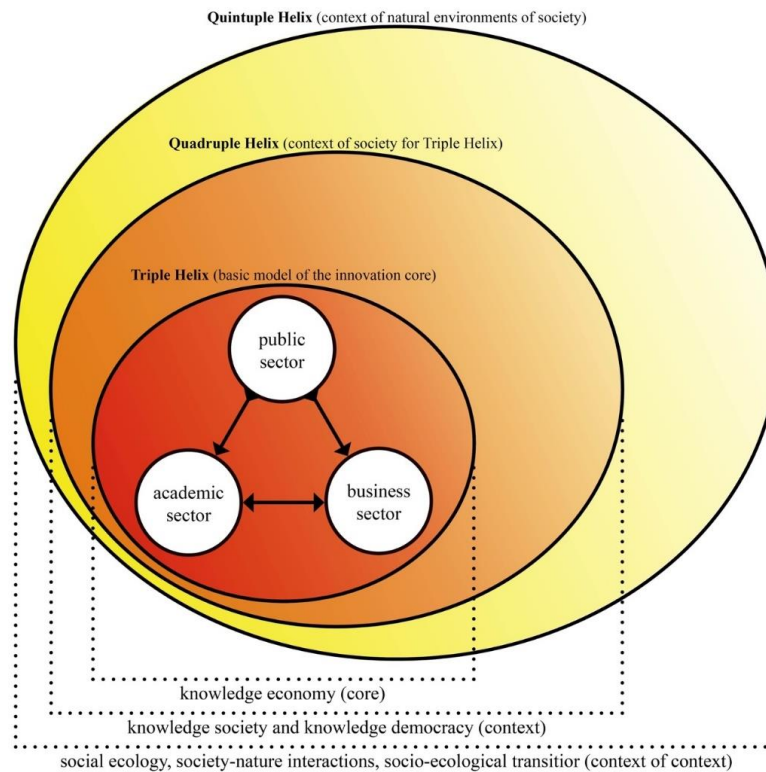
Figure 6. "Quintuple helix" adapted from Gouvea et al. [30].

5. Methods in "Mapping" Sustainability Modules

This section sets out the professional review and semi-structured process for "mapping" the various sustainable community modules against the Helix plus environment model.

In practice this has involved setting out all of the "individual" stakeholders and influencers within each of the sectors and their input into the specific module. We collectively followed a standard method for mapping the different sector involvement (Figure 7) for each of the individual modules under consideration, based on access to module/programme materials, together with staff and student records. At each step in the process, the module leaders identified the key organisations and/or individuals involved as follows:

(1) Professional institutions involved in moderation and validation of the degree programme within which the selected module sits;
(2) Student profile by current work sector based on University records, with specific identification of the professional roles of part-time students (in this instance, the student sectors are highlighted in black);
(3) Academic staff profile engaged with module design and delivery;
(4) External support, visiting tutors, lecturers and project collaborators indemnified within module handbook and/or delivery programme;
(5) Additional internal markers, assessors and moderators; and
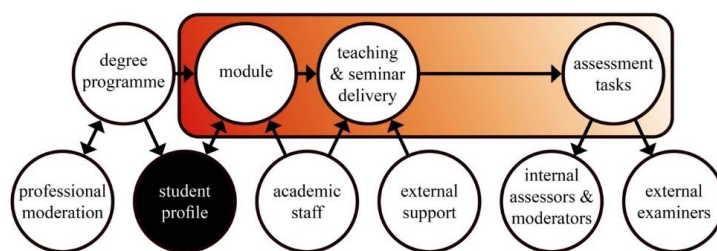(6) External examiners, both academic and professional.

Figure 7. Process for mapping sector involvement at each stage of module design and delivery.

The criteria for the selection of suitable programmes and modules from the north eastern Universities are that they are aligned to a Built Environment discipline, individually include a focus on sustainability, and collectively include a full range of levels, professional institutions and forms of delivery. In practice, there were multiple options for modules that met these criteria and we followed a pragmatic strategy of selecting a sample size that was able to be representative of the different levels of programme delivery, from foundation to postgraduate levels and where we had direct access to module materials. Table 1 sets out the 7 sample modules from three Universities selected for mapping against the Quintuple Helix model.

Table 1. Scope of modules "mapped" against the helix model of collaboration.

Module	Degree Programme, University	Student Level/Numbers	Professional Accreditation	Descriptor
Sustainable Development (Figure 8)	Architecture and Built Environment, Northumbria University	Foundation Level 3	Feeding into courses accredited by RIBA [1] and RICS [2]	Common foundation module for entry into Surveying and Architecture degree programmes.
Design of Sustainable Engineering Systems (Figure 9)	BEng Civil Engineering, and BEng Civil and Structural Engineering, Newcastle University	Under-graduate Level 4/5	Accredited by, ICE [3], IStructE [4], CIHT [5], IHE [6].	Suite of compulsory modules delivered across the three years of the UG programme.
Strategies into Action: Urban Design (Figure 10)	BA Urban Planning, Newcastle University	Under-graduate Level 6	Accredited by RTPI [7]	Optional final undergraduate year module for town planners.
Building Pathology (Figure 11)	MSc Quantity Surveying, Northumbria University	Post-graduate Level 7	Accredited by RICS [2]	Distance learning module provided through Pearson International.
Health, Safety, Welfare and the Environment (Figure 12)	Chartered Membership Programme, Private	Under-graduate Level 6/7	Accredited by CIOB [8]	Remote learning, chartered membership provided through professional providers.
Urban Planning and Development (Figure 13)	MSc Real Estate, Northumbria University	Post graduate Level 7	Accredited by RICS [2]	Year-long professional postgraduate course with mix of built environment and non-cognate first-degree students.
Future Homes (Figure 14)	MSc Advanced Home Futures; Teesside University	Post graduate Level 7	MOBIE [9]	Collaborative programme developed between industry, community/charity and academic sectors.

[1] The Royal Institute of British Architects; [2] The Royal Institution of Chartered Surveyors; [3] Institute of Civil Engineers; [4] The Institution of Structural Engineers; [5] The Chartered Institution of Highways and Transportation; [6] Institute of Highway Engineers; [7] The Royal Town Planning Institute; [8] The Chartered Institution of Building; and [9] Ministry of Building Innovation and Education.

The following sections have a short descriptive narrative on the module content and assessment tasks to accompany the diagrammatic mapping. In each case, the mapping has been through several iterations and subject to verification with the individual module leader.

5.1. Foundation Level Modules

The sustainable development module (mapped in Figure 8) forms part of a foundation programme within the School of Architecture and Built Environment (Northumbria University) and is aimed at students seeking entry onto a range of degree courses within the school. Typically, these include Quantity Surveying, Building Surveying, Real Estate, Architecture and Interior Architecture, albeit historically the module was also delivered jointly to both ABE and Geography students and had a significant number of students progressing onto degree programmes in physical and human geography. It has also been the case that students would use the foundation year as the basis for entry into programmes within other universities. While the programme is open to everyone, the majority of students are recent UK school leavers, albeit occasional mature students do bring their own work experience to the programme. In this context, most of the variety in the sectors inputting into the module has been dependent on the academic staff activity, experience and their own personal external contacts.
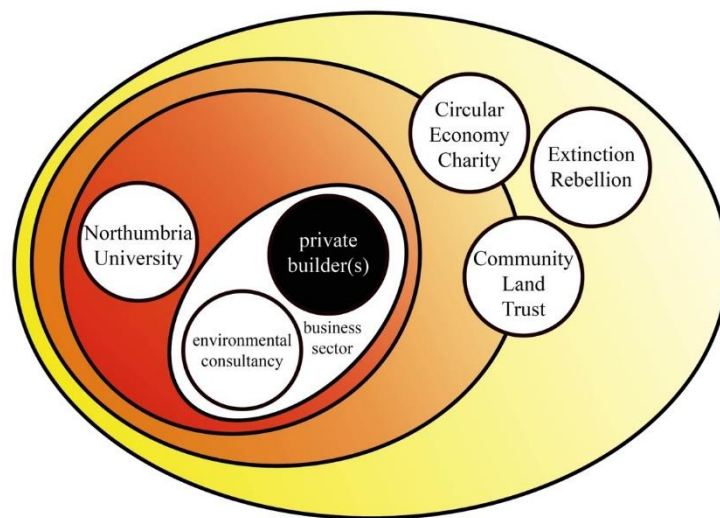

Figure 8. Mapping of Sustainable Development for Architecture and Built Environment Foundation Level 3 Module.

The content of the programme is a mix of introductory lectures to provide some theoretical grounding to the history and the science of climate change and sustainability, together with blended learning through seminars and workshops intended to provide practical tools in assessing sustainable communities. The actual structure of delivery closely and sequentially follows that of a suitable sustainability assessment framework. Assessment is based on a collaborative sustainability strategy for a local development site produced in small groups that are emulating a small consultancy team, with an individual element exploring one aspect of the strategy in more detail. This individual element would be a choice of an energy strategy developing some spreadsheet modelling, a resource strategy exploring systems and materials within the circular economy, or a site layout as an architectural concept design response. More recently the individual elements also have the choice of an implementation or influencing strategy which is concerned with persuasion, marketing and changing personal or household behaviours [31].

Given the increasing importance of the "climate emergency", the module has incorporated materials and input from outside of the dominant Triple Helix model, particularly for contacts outside of the knowledge core and within the charitable, community and environmental sectors (Figure 8).

5.2. Undergraduate Modules

Design for Sustainable Engineering Systems (Figure 9) is a module that places sustainability as a compulsory element of two separate degree programmes (Newcastle University) offered for

second or final year students. It is accredited by, and thus closely associated in terms of design with, four separate professional institutions, namely ICE, IStructE, the Chartered Institution of Highways and Transportation (CIHT), and the Institute of Highway Engineers (IHE). It is moderated by a collective of these professional bodies called the Joint Board of Moderators (JBM).
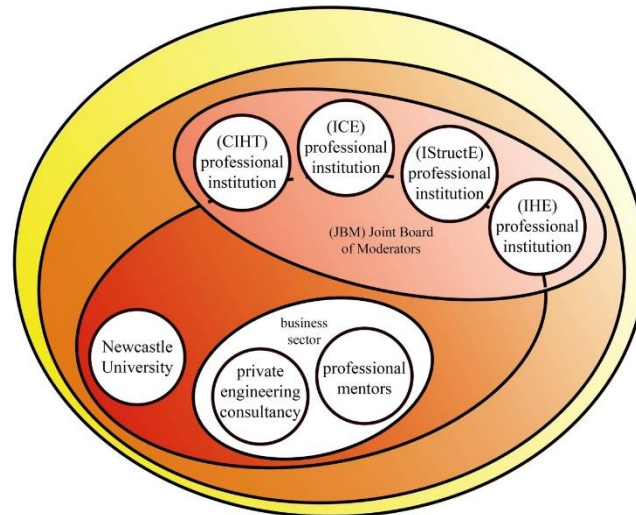

Figure 9. Mapping of Design of Sustainable Engineering Systems Undergraduate Level 5/6 Module.

Within the mapping (Figure 9) of the sectors with an explicit input into the module and the delivery of learning, it is evident that the different professional institutions dominate, at the expense of opportunities for community or environmental sectors.

The teaching and learning and assessment methods adopted in this module follow Problem- and Project- Based Learning (PBL) approaches [32]. The teaching of the underpinning concepts and other relevant material is done through a combination of classroom-based lectures by university staff and external speakers, and technical events hosted by civil engineering professional bodies. Students extend their learning by undertaking self-directed research and peer-assisted learning.

The Urban Design module (Figure 10) is part of the undergraduate planning degree (Newcastle University) and had been part of a wider range of options in a module entitled "strategies into action" that had an explicit focus on practical problem solving and decision-making around a range of land-use planning policy, development management and community consultation activities that would often be undertaken by graduates within their planning career. The urban design choice evolved into a separate optional module to widen the choice for students and to provide a sort of "taster" for urban design as a discipline. As such, it is one of the few module options offered to students that is both designed and lead by a practitioner (private/business sector). The nature of the student intake, with a mix of UK and overseas students who are both full-time and part-time, provides a wider mix of sector experiences. Particularly with students making the connection between the project-based design project assessment and their year-out placement or other paid or voluntary work experiences.

In the module, sustainable communities are integrated into a simple project management system; in this instance, the RIBA "Plan of Works" [33] up to concept design stage; which has the potential to address and explore the implications of delivering sustainable communities at different stages of decision-making and to varying levels of detail and sophistication. It is a useful exercise in the use of a practical project management tool that is up to date and used within industry.

The Urban Design module also varies from other programme modules in the use of a real-world design problems and the allocation of hypothetical but sector-specific "clients" for each of the student groups. Hence, in addition to dealing with project group dynamics; ranging for time management through to decision-making and conflict resolution; there is significant role-play around the specific needs of the development "client" (ethical investor, social housing-provider, community enterprise,

private company, or some joint venture between these choices) with involvement of interested stakeholders from business, local government and the community sectors.
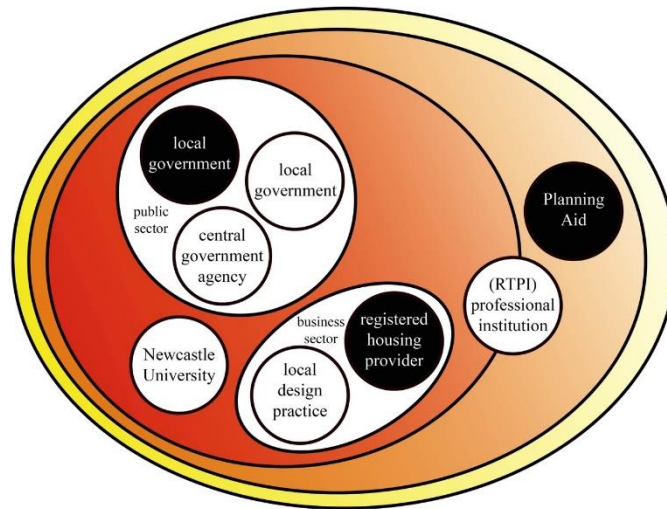

Figure 10. Mapping of Strategies into Action—Urban Design Undergraduate Level 6 Module.

5.3. Postgraduate Modules

Building Pathology for Practitioners (Figure 11) is offered as part of a two-year distance learning course leading to a master's degree in Building Surveying (Northumbria University). The module follows on from an introduction to Sustainable Technologies with a technical overview of different technical systems for delivering sustainable buildings. The key change from other modules linked to sustainable communities is the focus on problem solving and finding suitable sustainable solutions within a range of existing residential and commercial buildings. The form of delivery as distance learning is designed to be flexible and suitable for current practitioners, and hence the "mapping" of the sectors within the module (Figure 11) has significantly more involvement of student experiences in public, private and community (social housing) sectors. However, in practice there are significant limitations around authentic learning through larger group projects, where these are at the cost of flexibility in accessing learning materials through the online platform at a convenient time for the individual student.
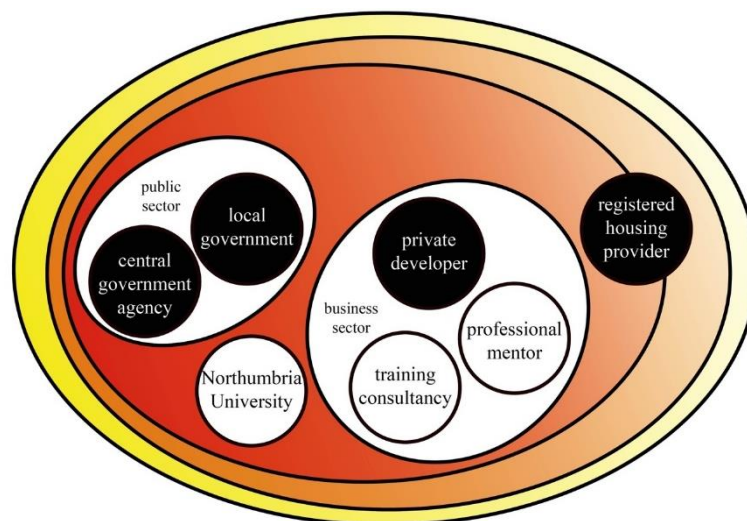

Figure 11. Mapping of Building Pathology Postgraduate Level 7 Module.

The CIOB "Chartered Membership Programme" is a vocational route towards professional qualification for practitioners without a Level 6 academic qualification (Figure 12). The programme comprises four separate modules; Construction Technology; Management; Contracts and Commercial Practice; and Health, Safety (Welfare) and the Environment.
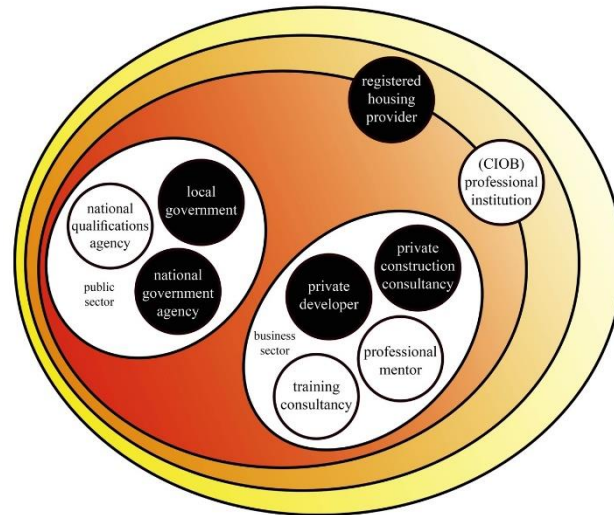

Figure 12. Mapping of Health, Safety, Welfare and the Environment Module for the CIOB Chartered Membership Programme.

This course is delivered through directed learning; a mix of remote delivery with professional guidance/mentoring with a certified private training provider (independent providers, Universities, Colleges or directly with the CIOB Academy); working towards an "open book" examination process regarding a practical construction project or problem. Leading to the use of title Chartered Construction Manager or Charter Builder MCIOB, comparable to QCF Level 6 (Bachelor Honour's Degree) and also partly meeting QCF Level 7 as validated by NARIC [34] The course also has the option for classroom style delivery, albeit the geographical spread of the professional students has the effect of limiting this option. The dominant characteristics of the course is the interconnected nature of the different modules, the "blended" methods of delivery, and the student profile which effectively has the majority of students within fulltime employment within the ABE industry. The "mapping" of the individual student sector experiences (Figure 12) show module input from a broad variety of sectors, scales of operation, as well as variety in organizations within each sector.

The Urban and Regional Planning module is a compulsory element for the post-graduate Real Estate programme (Northumbria University). The student cohort includes a mix of non-cognate disciplines as well as those from ABE backgrounds, and as such maintains a professional focus on the private and public sector roles in commercial development in order to ensure all of the core competencies required by the professional institution (RICS) are covered. This commercial focus is reflected in the mapping (Figure 13) with the majority of inputs being provided by external/guest lecturers and project related problem solving. The relationship with sustainable communities is one of a "golden thread" running through and linking each aspect of strategic planning, development control and the role of multiple stakeholders within this process. The major limitation of wider sector involvement; particularly community and environmental organisations; is that of time as the mandated elements required by the validating institution take precedent over optional inputs.
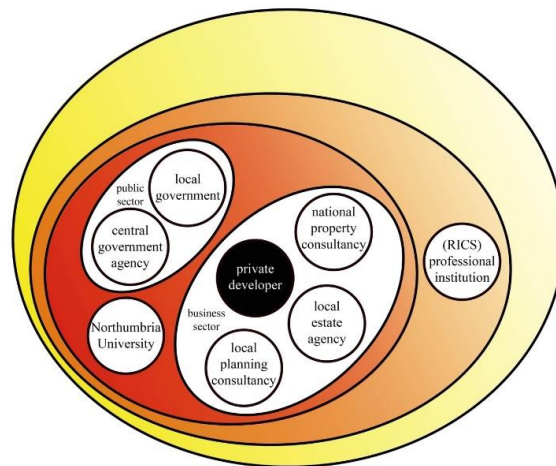
Figure 13. Mapping of postgraduate Urban and Regional Planning Level 7 Module.

The Future Homes module is part of a distinctive post-graduate programme designed by the MOBIE educational charity and academic partners (Teesside University, Middlesbrough, UK). It is distinct in the scope of thinking around collaboration and interdisciplinary as a means of disrupting current practice sin the housebuilding industry. The programme has a mix of full and part-time students but all with professional and academic experience in sustainable design and ABE disciplines, and this breadth of sector experience for the students themselves evident in the mapping (Figure 14). Assessments comprises a mix of group projects and individual work but both being closely aligned to contemporary industry challenges. In many cases, delivery of module content and the setting of assessments has deliberately been driven by stakeholders outside of the academic sector and as such the number and diversity of organisations involved extends well beyond the traditional knowledge core.
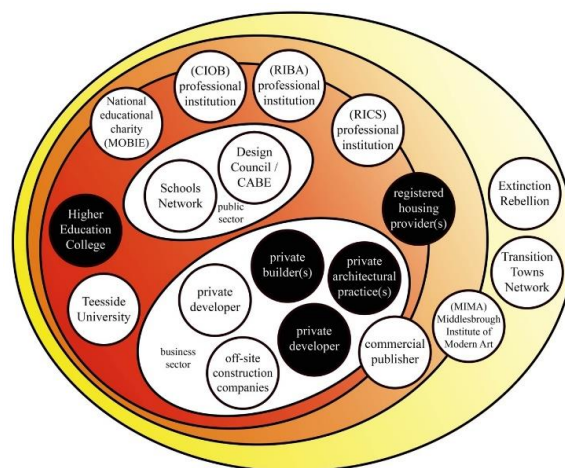

Figure 14. Mapping of Future Homes Postgraduate Level 7 Module.

The overview provided from the scope of these selected modules, being methodologically recorded, validated and mapped, is the basis for some sort of "meta-reflection" in the form of a semi-structured professional reflective analysis using the diagrammatic analysis in the following discussion section.

6. Reflective Practice and Discussion

The choice of critical reflection [35] for analysis was made to draw some conclusions from the mix of perspectives, held by the authors, on the design and delivery of sustainability education. Schon's "the reflective loop" [36] was considered a rigorous professional process in contemporary CPD and professional review processes, hence, it was felt that a reflective discussion held by the authors

would serve as a potent medium for drawing insights on this research. Yet drawing wider conclusions from any individual case study (or selected sample) remains problematic [37] in any approach to professional reflective practice. Hence, the discussion and reflection on outputs and outcomes are preliminary given the novelty of the various programmes and modules.

6.1. Collective Professional Reflective Analysis

As part of a collective professional reflective analysis exercise, the scope of professionals involved in programme or module management were asked to address the common characteristics of effective learning within the various professional training programmes and how these begin to develop the "generic skills" identified within the Egan Review into Skills for Sustainable Communities [38]. These "generic skills", in an adapted and simplified form, were the basis for a semi-structured review of the module "mapping" exercise. Our professional responses were organised around these three broad areas or open questions (with the emphasis highlighting the terms used within the Egan Review), namely:

(1) How is the programme and module grounded in systems/sustainability theory and how is this reflected within the staff and student profiles, including some understanding of the non-economic motivations of each group that contribute to clear *leadership* and *inclusive visioning* around required outcomes?

(2) What is the potential for impact arising from the programmes or modules from links to real-world problems and practical tasks that reflect activities undertaken within industry to support *breakthrough thinking*, practical problem solving through *analysis* and design/peer review *evaluation* processes?

(3) How authentic are the processes and tasks associated with the programme or module, specifically considering the development of practical skills regarding *project/financial management*, *stakeholder management*, effective *communication* and *conflict resolution* within collaborative and *partnership working* activities?

The authorial team met via Zoom Video conferencing, during May and June 2020 in two separate groups, to discuss the above and reflect upon our respective individual professional practices as academics delivering Sustainable Development Education to construction professionals at different stages in their professional education. The two meetings were chaired by the principal author of this paper who recorded the meetings with the permission of the participants. The transcripts of these recordings, as noted by Zoom, were edited and reviewed to provide the excerpts included within the paper. Each of the participants drew examples from their own research, Sustainable Development Education related teaching practice, industrial engagement, and interactions with Built Environment professional bodies. The following summary is indicative of the common themes from the reflections gathered over the course of the two workshops/meetings. We have included selected quotations from the workshop transcripts to support the key findings.

6.2. Learning to Think Sustainably

It is paramount that the modules and degree programmes attempting to impart Sustainable Development Education incorporate some of the key aspects of United Nations Sustainable Development Goals which require interdisciplinary approaches for their delivery. Academic teams involved in Sustainable Development Education must operate in a "holistic framework" rather than engage in either pure science/technology-based or social-realist, ideological approaches as this could hinder the broadening of the students' mindset and knowledge base. Learning theory [39] itself developed from historical theoretical models that explicitly link theory and practice; and blurs any distinction between "hard" (scientific) and "soft" (social/qualitative) knowledge. In this pragmatic context, there is weight in decision-making to heuristic knowledge, or knowledge gained through "learning by doing" as it presents a useful cycle of practical or practice-based learning and in so doing, hinting at the importance and/or relevance of lifelong learning and continuing professional

development for ABE professions. The Sustainable Development Education related modules must expose students to design projects, problems and tools in a manner that the students are encouraged to find solutions outside the "eco chambers" and "hierarchies" of the professional domain of their choosing. The scope of the projects set for students in Sustainable Development Education modules must be broad enough that they invite a wide range of perspectives to be employed in finding solutions to these projects or problems. Within the specific programmes and modules, there are multiple opportunities for incorporating this practical learning or reflective cycle with the inclusion of a reflective task, in so doing, demonstrating that it is a continuous "reflective" process. The broad professional scope of activities has to be explicit, rigorous, systematic and structured.

> *"I mean . . . it doesn't really matter what framework you use (provided) you've got a holistic framework and you see it's not just about the energy . . . you know it's the interconnections which needs to be explored and that's about more than having a grounding in pure science or being a positivist or some kind of social realist perspective . . . you need to have a social context to it. You need to address issues which are beyond the physical sciences at a very basic level, and the social impact is one of them".*

Learning or problem-solving tasks have to be set within an explicit epistemological position or world view that is both systems-based but also informed by personal reflection regarding cognitive bias arising out of any individual professional domain. In other words, academic teams have to think holistically and address the socio-economic implications that are impacted on by physical/technical responses. They have to encourage and prepare their students to develop similar holistic thinking and problem-solving. Encouraging students on engineering-centric degree programmes to interact with students on social sciences-centric programmes and vice-versa would serve well in any attempts of realizing holism in Sustainable Development Education. In addition, the nature of grounding in the complexity of natural and organizational systems is stronger when there is a mixed student profiles, bringing together part-time students with experiences of business.

> *"I just think it's a bit of a paradox between the motivations (of the professional bodies and the university sectors) . . . certain professions like to differentiate their courses from other professional courses, (while) industry and government policies are arguing that there's got to be common ground for some or all of the professions. When this doesn't work in practice . . . there is just another government endorsed Commission dealing with high fragmentation in the industry. Environment and industry are dealt with as all working in little silos. So, what's the motivation for people to think sustainably outside the box . . . to think about an entire project or think about systems or the implication of sustainable systems".*

Conversations around "Values" and "Ethics" that govern some of the decisions made as part of the planning and execution of infrastructure schemes and housing development schemes must be strongly encouraged. Actively discouraging a siloed approach and promoting Critical Systems thinking is important in sustainability modules irrespective of the specialism and stage of the degree programme. Designing the taught elements and assessment methods in such a way that they allow the student groups to appreciate the complex nature of sustainability problems and the interconnectedness of the contributing factors is absolutely essential for successful Sustainable Development Education.

> *"Critical reflection should happen in every institution. Not critical reflection of sustainability as a concept, but . . . about how they operate as businesses, rather than responsible professional body membership institutions" . . . "maybe the discussion is actually about . . . power and control systems and who has the top seat, the power and control in the hierarchy of the professions. Who has control over the mandate? . . . So even if you've got a professional who thinks and works holistically (if they haven't the decision-making power) they still fall back on professional contracts and small tasks within a bigger project process".*

It seems evident in all of the modules validated by professional institutions, that it was inaction or disinterest on the part of these institutions to support and promote collaborative working that was one major barrier to thinking sustainably. If the need to differentiate the professions from each other was less evident, then practitioners would be open to thinking and acting with regard to the complex socio-economic and organizational systems within which we operate.

6.3. Creative Impacts and Breakthrough Thinking

The triad of academia, industry and professional/accrediting bodies must work collaboratively in the design, delivery and review/accreditation of undergraduate and postgraduate programmes if *Breakthrough Thinking* were to be become a reality. Innovative thinking requires a certain level of freedom from the rigidity of the development of domain-specific skills. As is the case with the Triple Helix, this little triangle must come together to share knowledge and promote interdisciplinarity and innovation. HE institutions must use the disruptions caused by incidents such as the Covid-19 pandemic as opportunities for learning as they cut across all spheres of life and require collective, and yet innovative approaches to finding solutions. By setting broad, open-ended questions as part of the formative and summative assessments, academic teams teaching on sustainability modules, are encouraging critical thinking. The involvement of industry partners in Sustainable Development Education modules, tempers any idealism and helps students appreciate the skills required in managing projects effectively, meeting time pressures and resolving conflicts in a constructive manner.

> *"It's all about leadership and effective leadership. We've gotten our leadership got wrong. This is not only for our technical people . . . you really have to take the time to do things as in the real world, address an agenda. The point about lack of leadership, or leadership being an issue is endemic across the board. If you try to talk to (managers) outside of their discipline, they have no views and yet they're supposed to be managing hundreds".*

Aspects of creativity are also reflected in entrepreneurial and leadership behaviours, in having a go, being honest and humble in an awareness of team or personal limitations, asking for support, promoting cooperation can be designed and embedded into specific programmes with collaborative, problem-solving tasks.

> *"So the collaboration, which we are asking students to practice doesn't happen out there in the real world. So that's the reality but we can only change one bit at a time, and we are doing it. And we think we believe that this collaboration . . . a deep critical collaboration where you're able to ask broad questions is helpful. That's how something like sustainability can be taught. And we all agree on that hundreds".*

> *"You're touching on politics there. Because are we teaching professionals to deliver policy, or are we teaching professionals to shape and manipulate and develop policy or innovate, or be disruptive?"*

There is a consistency with the empowerment role of the educator [40], with the expectation that the graduates act as a change-agents, where in practice, individuals have to be empowered to initiate, influence and undertake change within any organisational or institutional context. To be disruptive and active in changing organizational processes, creative thinking from leadership, or enabled by leadership is critical. In this context, one of the repeating themes is around personal motivation and how this begins to relate to a shared sense of purpose and common values.

6.4. Authentic Processes

One of the repeating themes from the professional reflection was that of developing more authentic projects, tasks and assessment activities. Authentic or "real-world" problems begin to develop the ways of thinking needed to deliver sustainable communities, namely, to think clearly, decisively, strategically, creatively and flexibly. The use of real-world problems, even if simplified, as part of the summative

assessment is crucial in sustainability-related modules or degree programmes. Students must address problems which already exist in the real world (the community and environmental sectors within the "Quintuple helix") and they ought to find solutions to these in partnership with their peers working in small groups. Students must each assume a role of a professional of certain specialism and engage with their peers as if they were solving a problem of similar nature outside the academic setting.

> *"Even if you have a group of mature students with direct construction industry work experience; because of the limitations of the academic processes; your module cannot be fully authentic. It is going to be a 'make believe' (or simulated) problem. But the question is what do we do to bring it close to reality? . . . You're looking at ideas simulating a real-world problem, probably in a group, with tasks around how you run a project, work within timescales and collaborate".*

The solving of real-world problems requires collaborative working of professionals representing various economic and socio-political institutions. By encouraging students to role-play, the sustainability modules are staying true to the spirit of authenticity. Unconscious Bias is a barrier to authenticity. All stakeholders involved in Sustainable Development Education must undergo a reflective process which helps them recognize their biases and provides tools to overcoming the shackles of these biases.

6.5. Updating Sustainable Development Learning into Practice

In this adapted "Egan-esq" list of professional attributes, there does appear to be several inherent contradictions between being decisive and clear, versus being flexible and open to change. Much of this apparent contradiction can be put down to semantics and interpretation [31], in addition to the generic behaviours requiring support from examples. In the UK, the Academy for Sustainable Communities was meant to be one of the new government-supported organisations (a.k.a. quango) charged with the development and clarification of these attributes and the delivery of skills to support sustainable communities as set out in the Egan report [38]. Just before their abolition as part of the "bonfire of the quangos" enacted by a change in national government in the UK, the ASC [41] highlighted the skills gap for both "generic" and technically qualified staff, making it clear that was at that point a gap between theory and practice.

Our response has been to link the Egan generic skills to pedagogical theory and map out the progression of learning from foundation (level 3) to post-graduate (level 7), with L3 being at the centre of the wheel and progressing to L7 at the outer wheel in Figure 15.
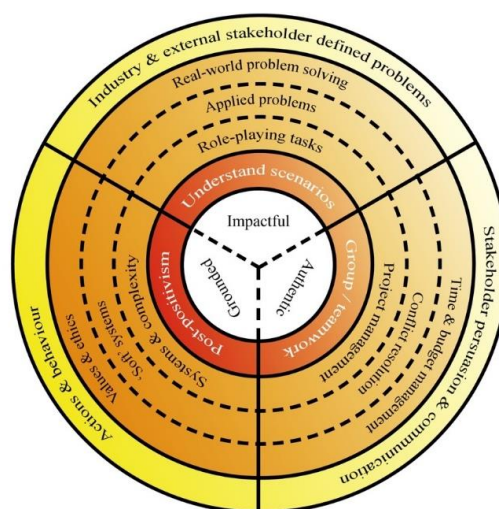

Figure 15. Summary of sustainability education principles and progression.

This visually summarises and tabulates (Table 2) the findings from the mapping and reflective analysis tasks into a practical set of learning outcomes for programme and specific modules.

This suggests targeted advice about setting programme/module objectives and learning outcomes that can have an impact on skills for delivering sustainable communities irrespective of the professional discipline or stakeholder sector role. While this summary is initially based on a small but representative range of modules at different levels of university teaching, it is presented as a framework to compare against learning objectives in wider degree programmes and modules which have a focus on sustainable development. Looking at the alignment between wider sustainable development programmes and this framework is suggested as an additional area of research.

Table 2. Learning activities and outcomes for sustainability education.

Foundation Degree	Undergraduate Degree	Post-Graduate Degree
(Level 3)	(Levels 4–6)	(Level 7)
Theoretical Grounding		
Students understand the scientific basis and degree of risk/uncertainty for climate change.	Students explore the implications of systems and complexity theory, especially the importance of "soft" socio-economic systems on the physical and natural environment. Connections are made between personal values and professional ethics within these "soft" systems.	Students produce creative and disruptive solutions capable of influencing and changing organizational actions and individual/household behaviours.
Impactful Learning		
Students become aware of the political context and scenarios for sustainability.	Students undertake a variety of different role-playing tasks, moving from simplified/thematic issues to more applied problems, to complex real-world issues.	Students have the ability to respond creatively to contemporary issues and problems as defined by industry or other external stakeholders.
Authentic Processes		
Students are introduced to multi-disciplinary groups and team working.	Students collectively experience project management challenges ranging from team roles, responsibilities, decision-making and conflict resolution. Constraints of timescales and budgets are introduced to tasks.	Students communicate and share project outcomes and review the levels of persuasion around key deliverables.

7. Conclusions

In 1887, Zamenhof [42] published a book under the pseudonym "Dr Esperanto", in response to the prevalent internationalism movement and the origins of many of our modern "so-called" professions. This was a literal suggested and entitled "common language", intended to be used by different professions to support international and interdisciplinary collaboration. At the time, it was the start of a conversation about the best mechanisms for supporting professional (and international) collaboration around some common purpose and shared values relating to scientific development and progress. The irony is that with the contemporary challenges of the climate emergency and the promotion of sustainable communities, the lack of integration between hard and soft systems, limited interdisciplinary collaboration and fragmentation between professional roles all combine to make a "common language" between the sectors more important than ever. Education on sustainable communities will have an important role in addressing these shortcomings, albeit only if future built environment professionals have a theoretical grounding in sustainability and learnt how to make an impact through authentic real-world experiences that are supported by shared values.

This paper highlights the significance of collaboration and interdisciplinary working in sustainable design education. While recognizing the challenges associated with changing educational practices in the delivery of ABE programmes, a strong case has been made for a common language educational framework that is built around holistic thinking, critical reflection, effective leadership and authenticity. Based on the collective experiences of delivering sustainability concepts on modules offered at all

levels of HE system in the UK, including Foundation degree to Post Graduate level programmes, a Quintuple Helix Model for collaborative sustainable design education has been presented. This model draws contributions from interdisciplinary institutions and systems, and engages with complex issues associated with social ecology, society–nature interactions, and socio-ecological transitions. We believe that our Quintuple Model helps create and sustain a common language for built environment professionals working towards sustainable development.

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