Seamful learning and professional education

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ABSTRACT
Workplaces are complex, dynamic spaces. While some practices are routine and highly predictable, informed by disciplinary and practical knowledge, others are unpredictable and emergent. Outcomes-based education, characterised by standardised, objective measurement of performance under controlled conditions, might be appropriate for routinised practice, but cannot account for emergent forms of professional knowledge. Somewhere between developing pre-specified, discipline-based skills and knowledge, and adapting to situated, contextualised conditions, there must be a capacity for dynamically developing unpredictable practices. This, we argue, should be an important focus of professional education across academic and practice settings. We interviewed 14 teachers and professionals studying part-time, across a range of disciplines, including medicine, architecture, law and allied health professions, about the alignment of learning within the workplace and university assessment. Using a sociomaterial lens, we offer a seamful account of educational and professional settings, manifested through assessment, regulatory bodies, technology and materials. Each seam represents ways of patching contexts together (e.g. accreditation stitches requirements of professional practice into educational approaches). Exposing such seams can reveal limitations and possibilities of classrooms and workplaces as sites of professional learning, whereas hiding the complexity of professional practice may be counterproductive to developing students’ adaptive capacity to successfully negotiate practice settings.

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Introduction
Much professional education is designed via outcomes-based approaches that focus on the development of competencies. Rather than a list of content to be learned, or the development of ways of thinking, competency-based outcomes are concerned with what learners should be able to do at the end of a course or programme (Toohey 1999). They are seen as a systematic, precise and technical means of producing a guaranteed minimum level of practical, disciplinary knowledge, characterised by the standardised, objective measurement of performance under controlled conditions. The
assessment of competencies assumes that overall competence can be ‘subdivided into separate measurable, stable traits’ (Hodges 2013, 565). As van der Vleuten (1996, 42) noted, competence carries an implicit conception that professional behaviour is ‘caused by a set of latent factors: they are within the person and cannot be directly observed, but must be inferred from observed behaviour.’

Outcomes-based education is conceived of as linear, rather than complex and relational, as is evident in the principle of constructive alignment (Biggs 1996; Biggs and Tang 2011) which is prevalent across higher education (Gough 2013). Here, learning outcomes determine what must be demonstrated in the assessment, which, in turn, informs students’ learning activities. Learning is seen as predictable, and alignment involves putting appropriate steps in place to move from not knowing to knowing. The attraction of outcomes-based education is largely due to its promise of accountability (Toohey 1999) through pre-specification and measurement of relevant actions (and criteria for determining the quality of those actions).

In contrast, practice theory and sociomaterial perspectives (Fenwick, Edwards, and Sawchuck 2011) see learning as embedded in, and shaped by, situated relations between people, discourses and materials. These perspectives have helped researchers cast new light on otherwise mundane phenomena (Sedlacko 2017) by attending to ‘the physicality of human doing, the routine aspects of behaviour, the relevance of tacit knowledge, the significance of material artefacts for behaviour and the effects of explicit and implicit rules’ (Jonas, Littig, and Wroblewski 2017, xv). While these perspectives share with outcomes-based education a valuing of patterned, practical disciplinary knowledge, and the idea that ‘understanding is exemplified in action’ (Toohey 1999, 53), they differ radically in their conceptualisations of action, foregrounding the challenge of translating practices of learning, knowing and doing, across complex systems and working environments (Mulcahy 2013). They show that learning is not a commodity that can be mobilised or transferred from one setting to another, since new situations always require new learning, and the adaptation and re-contextualisation of previous knowledge (Hager and Hodkinson 2009).

Work on sustainable assessment (e.g. Boud and Soler 2016) has highlighted the importance of preparing students to continue learning beyond their undergraduate studies. The need to develop a capacity for ongoing learning is particularly relevant as higher education confronts the challenge of keeping pace with contemporary professional workplaces. Moving across contexts is made more difficult as developments in digital technologies continually transform the tools, resources and interactions of day-to-day practices, at a time of considerable political, social, and economic flux (van der Wal 2017). The challenge of transitioning between academic and practice contexts is exemplified by studies showing the anxiety and feelings of unpreparedness of healthcare graduates (e.g. Arrowsmith et al. 2016; Brennan et al. 2010; Duchscher 2009). Indeed, the metaphor of transition (from one place to another, or from one kind of person to another, or from one kind of knowledge to another) may be inappropriate. Rather than professional education acting as a bridge, for example, from classroom to workplace, student to practitioner, or theory to practice, perhaps higher education involves the ongoing negotiation of multiple, simultaneous contexts. As they learn, students frequently deal with academic and professional settings, identities, and knowledge at the same time. It is this other kind of constructive alignment – between academic and
practical knowledge, rather than between outcomes and activities – that we explore here. In this article, we examine the relationship between university curricula and forms of emergent learning required in workplace settings. In doing so, we consider possibilities for orienting professional education to account for not only routinised disciplinary knowledge (i.e. competencies) but also the development of an enhanced, ongoing capacity for graduates to adapt to new situations through the development of everyday, professional practices.

Methods
Between July 2018 and September 2019, we ran four focus groups, featuring 14 participants in total from across a variety of Schools at the University of Edinburgh. Our aim was to identify emergent forms of learning not captured by assessment. Data collection was conducted by TF, DH and GA, all experienced researchers in education. The local School of Education ethics committee granted ethical approval. Each focus group lasted about 90 minutes. Audio recordings were transcribed by a professional transcription service.

Conversations were structured around ways in which workplace learning related to, and departed from, the aims and scope of what is assessed at university. Involving participants from a range of professional domains allowed us to compare and contrast disciplinary perspectives on the ways that academic assessment converged and diverged with emergent learning required in practice. This helped us to understand the implications of different disciplinary structures on the alignment of academic and professional educational activity. Emphasis was placed on the material and social aspects of professional practice. Participants were chosen for their potential to be information-rich (Sandelowski 2000) in relation to our area of enquiry. They were practitioners, educators and students, often encompassing more than one of these roles (see Table 1). Even where a participant held only one or two of those roles at the time of data collection, all practitioners had previously undertaken undergraduate and postgraduate study, and all students had practice experience as professionals. Thus, everyone had multiple identities and domains of experience, and could take up different perspectives at different points during the conversation.

Table 1. Participant characteristics.

| Pseudonym | Current roles |
|-----------|---------------|
| Viv       | Programme Director (Dentistry) |
| Dan       | Doctor (Medicine) / PG Student (MD in Medical Education) |
| Chris     | Doctor (Medicine) / PG student (MD in Medical Education) |
| Mary      | Veterinarian / Director of Teaching |
| Lisa      | Clinical Psychologist / Director of Teaching |
| Tom       | Doctor (Medicine) / PG Student (Medical Law & Ethics) |
| Jane      | Doctor (Medicine) / PG Student (Clinical Education) |
| Ash       | Social worker / PG Student (Social Work) |
| Ed        | Educator / Researcher (Digital Education) |
| Kim       | Employability Consultant |
| Peter     | Educator (Geosciences) |
| Greg      | Programme Director (Architecture) |
| Sam       | PG Student (International Development) |
| Jo        | PG Student (Digital Education) |
Our analysis was underpinned by practice theory and sociomaterial perspectives, outlined in the Introduction, enabling understanding emergent forms of learning in complex, fluid settings, within which possible actions are shaped and constrained (Schatzki, Knorr-Cetina, and Von Savigny 2001; Fenwick, Edwards, and Sawchuck 2011). These perspectives trouble the individualist, cognitivist standpoints that have dominated educational approaches (Mulcahy 2014), instead encompassing the collective and relational practices through which professionals enact learning (Fenwick 2014). This orientation helped us to understand the ongoing negotiation and reconciliation of multiple contexts, and forms of academic and practical knowledge, as participants navigated complex environments.

As our sociomaterial analysis revealed the absence of clear boundaries between academic and professional work and learning, we borrowed Vertesi’s (2014) metaphor of seams to represent the messy, often hidden or unarticulated ways of patching together multiple infrastructures and systems. Vertesi (2014) developed her conception of seams from the work of computing design theorists Chalmers and Galani (2004), who proposed that, rather than aiming for seamlessness, in which the different working elements of a system are made invisible (Ratto 2007), exposing the seams between elements could encourage examinations of interdependence, and of ongoing processes of appropriation to suit particular situations. Literature on professional practice and education from sociomaterial and practice theory perspectives (e.g. Fenwick, Edwards, and Sawchuck 2011; Rooney et al. 2015) helped us to relocate Vertesi’s work from a remote context (a space station) to the professional education contexts of our participants.

For us, seams imply a less stable and clear-cut interface than boundaries. They are contingent on the work of people, in conjunction with materials and devices, to align and make sense of multiple contexts (Vertesi 2014). Accordingly, we came to consider the negotiation of academic and professional contexts as ‘less a question of boundary work as … a kind of ad hoc patchwork’ (269). However, as Vertesi observed, people still use seams to construct temporary boundaries via various exclusions and inclusions, achieved through technological and social means. This produces sub-spaces of localised and constrained activity (Vertesi 2014, 276). Below, we present an analysis of four important seams, around which our participants negotiated their learning and practice in academic and professional settings.

Results

Seam 1: between formal syllabus requirements and adaptive, everyday practices

In disciplines where academic and professional settings were tightly bound, such as in healthcare, the drive to objectively certify competence and the accomplishment of learning outcomes can be viewed as an attempt to stitch together settings by orientating academic efforts towards the learning of what is required in practice. However, this kind of heavily-structured tailoring was seen to have some important shortcomings. On the other hand, fields with much less structured career pathways (e.g. digital education) created different challenges for students and educators.
Healthcare-related subjects, in particular, had clear directives from external bodies about what should be learned to obtain a qualification. Professional entities influenced undergraduate and postgraduate curricula while simultaneously accrediting courses, setting and assessing professional exams, and awarding memberships. Viv gave an example from dentistry.

... the Royal College exam is a separate exam altogether and if they pass that, a combination of this [qualification], the Royal College and the portfolio, they can apply to the General Dental Council. ... the alignment of external bodies are really influencing how we write these programmes. (Viv, dentistry)

In contrast, for disciplines such as digital education and international development, in the absence of clear regulations or institutional guidance, students and teachers needed to fashion both career structures and professionally relevant practices. Sam, who, before studying international development at postgraduate level had studied artificial intelligence and computer science as an undergraduate, described how, in the absence of a clearly defined career structure, he needed to find his own pathway over time.

Particularly in digital, like, there’s no career path, there’s no kind of, like, body or anything like that. I mean, you can sign up for memberships for, for example, British Computer Society, things like that, you can do. But there’s very little accreditation, or anything. You really just have to prove yourself on the job. (Sam, international development)

Similarly, Ed described his previous experience of teaching in international development, where students needed to develop skills and capacities that were ill-defined and malleable.

[In] the development space ... you’re walking into insecure positions ... the education that they received had no preparation for those aspects of management of how you would work in the space ... self-promotion becomes a large part of the equation, how you make yourself viable to your network ... And how you assemble a team around a task, because most of the money floating through the development space is not through stable positions, they’re coming through bids, open tenders and things of that nature. So most of the work they prepare for ... has nothing to do with their subject matter or expertise. (Ed, digital education)

There was little consistency within extant professional practice to use as a reference point for the assignments Ed set for his students, and his focus on authentic tasks was around encouraging the development of practices that worked for the individual, rather than tying them to any particular ‘subject matter or expertise’. However, the university’s academic processes provided their own, often considerable, constraints, even where the value of flexible and innovative activities was recognised. Ed commented on how standardised assessment policies were making such approaches more difficult, and Peter discussed how ‘streamlining’ and standardising across courses led to reduction in flexibility and novelty within his assessments.

It’s assessed in a very different way to the usual courses because it’s project-based learning ... The course won an innovative assessment teaching award last year ... [but] we had the exam board and the recommendation was that we need to streamline some of our assessments, which we’ve taken on board because there are four or five different assessments and it is getting a bit unwieldy. (Peter, Geosciences)
Peter also noted challenges in using non-academic industry professionals (as a way of making assessments more ‘authentic’), because of their unfamiliarity with the ways of academic assessment.

We did think about getting the clients to assess them, but we just found we couldn’t standardise it across the course, because some of these schools and clients are just basically desperate for any help and they’ll get a bit of student work that they’ll think is amazing just because it’s something. (Peter, Geosciences)

In contrast, Ash pointed to a developing partnership in social work between local authorities and universities.

We got to a point where the local authorities were saying, social workers coming out of universities aren’t good enough. And the universities were saying, basically, ‘you lot don’t talk to us, you never send us anyone, how are we meant to know what you want from a social worker.’ (Ash, social work)

In this case, the combination of academic and professional input could help with setting expectations, but did not necessarily clarify the place for everyday workplace practices within the curriculum, since assessment was still heavily focused around academic knowledge, assessed through essays. Overall, participants made clear that, beyond final products and performances, the conditions and processes of doing the work required for assessment were important to authenticity. Participant educators who held multiple roles, in particular, were very conscious of the practical challenges for newly qualified practitioners, and the requirements of their professions for ongoing learning. They saw it as part of their role to be aware of those elements of preparation for practice situated outside of the assessment structure. Dan gave an example from medical education.

… there’s a lot of things that you do as a junior, like writing notes, making referrals, looking after a small number of patients who are really quite sick. All the prescribing stuff that we do that gets compressed into some end modules like where [another doctor] teaches them how to make a referrals phone call. And yet all of that becomes quite a large percentage of their job when they qualify and is only implicitly taught through … enthusiastic people making a decision that they’re going to teach it. (Dan, medical education)

Thus, even in the tightly-regulated world of healthcare, teachers patched what they recognised as important elements of practice onto the academic curriculum.

**Seam 2: between containment and complexity**

Professions with more tightly structured career paths featured the replication of common procedures (e.g. ‘competencies’). This was particularly pronounced in medical education. However, approaches to teaching, learning and assessing competencies could highlight ways in which student performances in academic contexts were of a different nature from professional ones. For Chris, concurrently studying and practising medical education, many forms of assessment appeared to remove situated aspects of performance in favour of the abstract, procedural, or objective. For example, conveying the speed of clinical practice in both written and practical exams such as Multiple Choice Questions (MCQs) and Objective Structured Clinical Examinations (OSCEs) was problematic.
A lot of your assessment in undergraduate practice is written exams or OSCEs where all the kind of contextual things which make speedy decisions more important are kind of stripped out. So you have on average, what is it, 60 seconds or 90 seconds for an MCQ question and in real life, that’s not really comparable to anything you’re doing. And also, if you’re sort of focusing on an emergency station in an assessment in undergraduate life, exams, you know that it’s going to last 14 minutes or eight minutes or something, whereas in real practice it takes as much time as it takes you to do it. And it’s not so obviously signposted. (Chris, medical education)

Chris characterised two different ‘lives’ (undergraduate life vs. real life), showing how academic and professional settings diverge in their temporality. Simulated exams and activities are given a set time in which all tasks, including socially-oriented ones, must be satisfactorily completed. Some participants saw this as conceptually problematic, since clinical care is patient-dependent and clinical temporality is, therefore, emergent, depending on the relations between patient, carer, colleagues, environment and situation. Exams like OSCEs can evaluate the behavioural elements of skills, but neglect the longer-term implications of, for example, having rushed through a patient history, even if the necessary information has been elicited. In MCQ exams, assessed knowledge was seen as overly simplistic, static and abstracted from clinical reality.

We focus on the knowledge and the answer, and all our exams are on the diagnosis being correct for these single-diagnosis things, when actually all of our patients have multiple diagnoses and they’re complex, and we don’t know what’s going on with half of them. (Chris, medical education)

As Chris said, ‘it’s very difficult to get the complexity of decisions into textbook format,’ in part because complex, unpredictable and interdependent factors could modulate what would conventionally be seen as the ‘correct’ procedure. These points of dissonance between what is required in academic settings and what is required to be effective in practice could manifest in divergent educational aims.

When I talk to students now, they almost have two lines of things that they’re trying to do. One, is learn stuff to pass their exam, and one is learn stuff to be a first year junior doctor. … And they’re completely different things in their mind. (Jane, medical education)

Examinations were seen by our medical education participants as unrealistic in various ways: there was no requirement to filter out ‘noise,’ quickly synthesise relevant information, or produce holistic understandings of situations to inform decisions and actions. Our participants lamented a focus on discrete and compartmentalised tasks, rather than multifaceted ones like managing a ward round. As Dan put it, ‘the real life [situation] is this, like, noise and chaos and multiple tasking.’ Consider Dan’s description of a medical simulation.

On a simulated ward round … it takes them ten times as long … Prioritisation, it’s just completely off, you know, we set the task with a patient who clearly needs something done now, but because they’re kind of maybe out of sight or they don’t know who to call … it just doesn’t get done. And we’ve got, you know, a patient who … a manikin who’s died during the ward round and … at the end it comes to the debrief and [we ask], ‘so the patient who died …’ and they go, ‘a patient died?’ And they’ve got absolutely no idea of what’s happened around them. (Dan, medical education)
Such a lack of noticing is suggestive of what we might call a *classroom gaze*, where students see what they have learned to prioritise in the academic context, shaped, in part, by the ways they are taught and assessed.

**Seam 3: between abstract and embodied knowledge**

Participants’ responses in all focus groups showed that materials were essential elements of professional practices, and of what it means to be a practitioner. Chris, for example, identified an entanglement of materiality within practice-based knowledge:

> It may feel like what you’re doing is a physical process of putting a stethoscope on, but there’s some underlying knowledge there that you couldn’t ignore it, you had to learn it somehow. (Chris, medical education)

However, in our conversations, materials were typically backgrounded, or reduced to a mediating role, rather than being an essential part of learning. In many cases, material elements of practice only became foregrounded in moments of rupture, where the seamless interface between infrastructures broke down.

> A lot of it’s quite physical … you come in, and the situation is, you don’t know how to log into the computer, so you learn how to log into the computer, but your confidence is a bit shaken, and then actually, there’s no chair to sit on, for example. And you could say, okay, your job is to do this, this and this. No one says there’s no computer for you to use. The nurse is at the computer, and she just gives you a death stare. Now, what do you do? … PS, you haven’t pee’d and you’ve not eaten … (Jane, medical education)

Jane’s example conveys the importance of coping with, and adapting to, a range of physical encounters and conditions, and also shows how interactions with the material are enmeshed with the social. Her experiences suggest that practitioners need to be able to succeed in complex, social and embodied conditions that assessors or curriculum designers cannot ‘replicate on paper’. Moreover, success might be seen not only as the satisfactory performance of tasks, but as learning to manage bodily activities, social dynamics, physical spaces, and technical systems.

Jane suggested that embodied experience, ‘copying,’ and being monitored and supervised by more senior colleagues, was probably necessary to developing the capacity to perform in practice conditions. Whether these approaches would help junior colleagues to succeed in only that setting, or to develop a general capacity for professional practice is not clear. However, the perceived need for such approaches reinforces the suggestion that assessment of individuals in isolation of complexity gives a narrow view of the kinds of learning that are valued. For Jane, the difference between what students know about, and what they can cope with in the physical and social reality of qualified practice, is bridged by role modelling, support and scaffolding, focused on learning to work with systems and prioritise tasks. Dan argued that immersion within practice environments was conducive to learning to operate within the complex dynamics of professional life. His concern about the divergence between university assessment and learning on the hospital ward relates strongly to a disappearance of sociomaterial elements within the curriculum.

> I think you learn it if you’re there. So I think if you go in and you spend time on the wards and you see that stuff, or you spend time with the patients or spend time in the clinic that
you see it. But actually, the way that we test people is all based on that knowledge stuff and I think we’ve almost devalued spending time on the wards. (Dan, medical education)

However, while others also suggested that spending time in practice settings is how one is primarily exposed to, and learns about, the sociomaterial complexities of clinical practice, they acknowledged that there is still a role for educational practice outside of the workplace in supporting the negotiation of professional settings. Two prominent ways of scaffolding this transition were simulation and applied assignments. While there are important differences in focus and function, both could represent activities that relate to practice contexts, while foregrounding particular aspects of practice and bracketing off others. For example, Peter described a written assignment through which students could become accustomed to communication requirements of professional practice.

We try and get them to write in the style that it could be basically a report if they’re working for consultancy or something like that, which some of them struggle with … because they’re really not used to it. (Peter, geosciences)

In contrast, Ash argued that written work was an inauthentic way of assessing social work practice because it is disconnected from ‘actual ability’ as a practitioner.

Whatever you’ve done, however small, if you can write it up really well, you will pass. You could be the best social worker in the world, if you can’t write that academic essay well, you won’t pass. There’s no way of assessing you, or your actual ability as a social worker. (Ash, social work)

The balance between abstract, scaffolded learning and exposure to the complexities of practice was a key challenge in medical education. Tom conveyed, in emotive terms, the experience of confronting the physical reality of clinical practice, having learned and been assessed in academic settings.

That is a very painful experience … I still remember the first few days … I was really apprehensive, when I heard that I needed to go and take blood. It’s like, oh my God. Now what am I doing? I hoped that it would be easy. (Tom, medicine / medical law and ethics)

**Seam 4: between technology use and professionalism**

The pervasiveness of digital technologies within both workplace and university practices was an important analytical theme. Students, practitioners and educators all spoke of improvisations and uses of technologies as inadvertent learning tools, and how this was caught up in learning and practising as a professional.

I saw a patient yesterday who had a condition I’ve never heard of. And no amount of MRCP or undergraduate exam is ever going to make me remember that condition because it’s so rare. So I consulted Professor Google on my phone and get it up, and say to the patient, is this what you’ve got? Yeah. That’s really interesting, I’ve never heard of that before. So, I guess, life in the fast lane … in emergency medicine, this free open-access medical education has exploded and there’s hundreds of sites with podcasts and blogs, and actually … it’s okay not to know what you’re doing. (Dan, medical education)

Dan’s closing phrase suggests an outsourcing of knowledge to external materials. Yet the requirement to find, filter and make sense of a huge range of potential information as part
of the finely-tuned practice of a patient encounter seems to involve a different kind of knowing in which technologies are clearly entangled in pervasive demands of communication and information literacy:

You do end up with the phone calls and sometimes the emails and other electronic referral methods to get advice, which is itself a quite difficult skill. (Chris, medical education)

Our participants described complex forms of skill or knowledge involved in dealing with available or imposed technologies. These were not just important to completing tasks but to maintaining professionalism. In Dan’s example above, the use of Google can be seen as a seam between inner and outer clinical worlds, as well as between dynamic social and cultural norms. Specifically, the ways in which professional knowledge and technological devices were entangled, along with the implications for status and identity as a professional, were in ongoing renegotiation (Lupton 2014). More broadly, the availability of acceptable strategies, in response to uncertainty, was intimately connected to engagement with materials, including technology. Dan also highlighted a tension between technologically entangled practices of professions like medicine and nursing, and the more formalised representation of competence in academic curricula.

You’ll watch practising this very polished examination-taking, whereas actually now if you hear someone’s got a murmur, you don’t have to know exactly quite which high pitch it is and where it is. I hear a murmur, I get an echo [echocardiogram], like an ultrasound of the heart … that’s modern practice. And you kind of need to know a little bit about which one it might be, but in reality most people will hear, they’ll go, okay, that person needs an echo because they’ve got symptoms. (Dan, medical education)

In architecture, Greg discussed how the infrastructure required for students to learn to use a particular intelligent modelling system was too expensive for academic settings to procure. Universities are limited in the extent to which they can realistically teach and assess this practical knowledge, despite recognition that it is caught up in requirements for professionalism beyond graduation.

The logistics of building are immense these days. The classic architect … tells somebody what to do … [now] it’s not just telling, it’s working in partnership. There’s information modelling systems, and it’s quite immense. We don’t teach that to students [but the] profession is becoming highly focused around digital things … (Greg, architecture)

**Discussion**

For our participants, an important aim of professional education was to enable graduates to embody professionalism and operate reliably, independently, proficiently, and safely. They recognised that this required going beyond competence, to the development of what might be called *adaptive capacity*. Where competence is a clearly-bound, individualised, prescriptive and demonstrable accomplishment of a performance standard, adaptive capacity is an *always-developing* potential to integrate into, and shape, teams, systems and settings. It is distinguished from notions of adaptive expertise (e.g. Hatano and Inagak 1986) by its emphasis on collective and relational practice. In adaptive capacity, relational agency is prioritised over performances. It is what allows learners to negotiate new sociomaterial situations, by being accomplished not only in predictable, regular
patterns of practice but also in developing emergent practices as required. In our study, drawing on practice theory and sociomaterial approaches helped us to see the relational qualities of the practice requirements articulated by our participants.

Rather than trying to achieve all practice requirements within a defined curriculum, participants saw an important role for academic programmes in preparing students to continue learning beyond graduation. As Greg said,

It’s fairly obvious that you can’t just learn everything in your first period at university then walk out. (Greg, architecture)

Indeed, in line with research into sustainable assessment (Boud and Soler 2016), our participants’ experiences exposed limitations in viewing education as the acquisition of predetermined and abstract forms of knowledge, exemplified in competency-based approaches. While academic settings play an important role in helping learners build a foundation of disciplinary knowledge, university curricula are often underpinned by principles of constructive alignment, in which teaching and assessment activities are structured in relation to pre-defined aims, and learners are ‘entrapped’ in a ‘web of consistency, optimising the likelihood that they will engage the appropriate learning activities’ (Biggs and Tang 2011, 99). Yet Gough (2013, 1223) warns that constructively aligned curricula will be based on notions of an ‘isolated simple system’. In consequence, what is learned is measured in terms of expected behaviour, rather than in relation to the emergent practices required of unpredictable and complex situations.

Of course, an inability to predict learning outcomes raises challenges for accountability. Accreditors, educators, and, indeed, students, may value outcomes-focused curricula for their clarity of aims and structure, while also recognising the significant limitations of attempting to pre-specify knowledge intended for deployment in complex and dynamic settings. We suggest that routinised disciplinary knowledge (e.g. competencies) is still a crucial aspect of academic professional education, and should contribute to professional accountability. Rather than accepting competencies as guarantees of safe or successful performance in complex practice, however, they might be understood as a necessary basis from which learners must diverge, in ways that are attuned to their varied practice contexts. Accountability, in other words, should encompass the contextualised adaptation of routinised knowledge.

We also acknowledge that not all learning outcomes are expressed in the reductive form of competencies (e.g. Digital Education, Geosciences, and Architecture all feature outcomes around developing critical or reflective awareness). However, the presence of highly prescriptive learning outcomes within at least some of our participants’ programmes may be the result of an impoverished theorisation of curriculum development, leading to ambiguity around what competence means in practice (Govaerts and van der Vleuten 2013; Hodges 2013). Consider Ash’s distinction in our interviews between academic essay-writing as an inauthentic assessment and ‘actual ability’ as a social worker. While such essays do not entail in situ practice, they may involve legitimate forms of disciplinary knowledge, problem-solving and contextualisation (Villarroel et al. 2017), and their authenticity is a product of both the assessment design (i.e. the question, criteria, etc.) and the students’ efforts to make it relevant and meaningful. In other words, authenticity comes from students and teachers collaboratively patching together contexts.
Ajjawi et al. (2019, 3), suggest ‘that authenticity by its very nature is in the eye of the beholder and that alignment as constructed by the student contributes to perceptions of authenticity.’ In other words, it is, in part, up to students to orient the assessment, within its design parameters, such that it is authentically relevant to their practice. Through this shift, which is easier in some assessment contexts and designs than others, authenticity becomes more than ‘an attribute of tasks … but a quality of educational processes that engages students in becoming more authentic’ (Ajjawi, Boud, and Marshall 2020, 68). This is a valuable reinterpretation of Biggs’ constructive alignment principle: responsibility is shared between teachers and students to align goals, activities and assessments. Part of the role of teachers and curriculum designers, then, is to help students to make assessments relevant. This is not just about extracting value from a task, but also about actively navigating multiple, relational and complex systems (Hager and Beckett 2019). As Hager and Beckett argue, it is collective activity (in this case, of students, teachers and others) that generates the learning of individuals. Sociomaterial and practice perspectives can inform assessment practices by providing alternatives to taking ‘the individual student as the unit of analysis, and [regarding] all knowledge of others – student peers and their interactions, for example – as irrelevant’ (Boud et al. 2018, 1109).

In professional education, then, we would extend the criteria for alignment to the reconciliation of multiple contexts. This kind of constructive alignment is more likely where students are involved in decisions, not only about content, but also about the criteria by which their work is judged, since that encourages reflection about what should be valued across settings (Carless 2007; Fawns and O’Shea 2019). We argue that to meaningfully engage students in this process requires their ability to appreciate and interact with seams between academic and practice settings, such as those presented in this paper. This, we would argue, is seamful design, in which curriculum designers, teachers, and students work together to expose, reflect on, and, potentially, shape the ways in which academic and practice contexts are combined.

Seamful design and education

In using seamfulness as an analytic concept, Vertesi (2014) recommended thinking through the constraints of infrastructures, while observing how people, rather than producing stable and coherent systems, craft ‘fleeting moments of alignment suited to particular tasks with materials ready-to-hand’ (268). Dan’s use of ‘Professor Google’ is one such example, in which the wider infrastructure of the Internet is patched into the immediate practice setting to accomplish an emergent task. Google does not become part of a stable system, yet this practice resonates beyond the moment, contributing to repertoires both of possibilities for future practice, and of experiences which Dan and colleagues can reflect on and discuss. On the other hand, Vertesi suggested that failures to knot systems together successfully can illuminate the otherwise obscured infrastructural elements and relations essential to the task at hand. Jane’s lack of a ‘chair to sit on’ or an accessible computer constitute more than a problem to be solved by finding resources. These challenges are entangled in the wider infrastructural provision of space and resources, social hierarchies, the preparation of professionals and the working environment for the incorporation of new, junior colleagues, etc. In these
contrasting examples, we can see that individual, collective, and systemic work is necessary in producing fluent and coherent activity.

Here, then, is a moral dimension to considering seams. Where the work of seamlessness ‘actively disguises the moments of transition and boundary crossing … in order to present a solid and seemingly coherent interface’ (Ratto 2007, 21), seamfulness shows the instability and multiplicity of systems in complex settings. It highlights aspects of inconsistency and non-coherence and, frequently, ‘the fleeting, local, or ephemeral nature of actors’ infrastructural patchwork’ (Vertesi 2014, 278). Seamfulness is, therefore, a potentially useful concept with which to examine professional education, where efforts are made to minimise or streamline crossings of academic and professional boundaries in order to reduce discomfort (Duchscher 2009), maximise efficacy (Frank et al. 2010), bridge the practice-theory ‘gap’ (Gallagher 2004), etc. While such efforts are understandable, Ratto (2007) has argued that seamlessness creates ethical challenges in encouraging a lack of engagement with, and agency within, social and material relations. Looking for, and acknowledging and exposing, seams can help students (and teachers) to move beyond a classroom gaze, allowing greater understandings of heterogeneity, possible actions, and changes in context over time.

For us, a seamful design approach to curricula in professional education would involve students and teachers looking together ‘under the hood’ of their learning activities, exposing, critiquing, and reconstructing the seams between academic and professional settings. This, in turn, involves seeing students as active collaborators in their education, and being open about the processes and systems that hold together the multiple contexts involved in developing professional practices and identities. For this, educators must first have insight into their own teaching methods, governance processes, systems and environments, and how these reflect the complex interrelation of academic and practice requirements. Academic settings, in particular, may play an important role in this latter kind of reflexive exploration by creating space and scaffolding analysis, allowing a shift in the classroom gaze from the abstract to the concrete. This is a considerable challenge, requiring, at course, programme and institutional level, ‘the resistance of overtures towards efficiency, effectiveness, and seamless education’ in order to appropriately develop the evaluative judgement of students and teachers (Fawns, Aitken, and Jones 2021, 77). Aijawi et al. (2019, 11) suggest that teachers can learn from assessment by reflecting on the ‘alignments and misalignments between university practices and the necessary “situated” enactments in the workplace.’ This reflection should then support the dynamic and collective processes of constructive alignment, as students and teachers understand how each environment, and its related forms of knowledge, are at play in a particular learning or assessment task.

It is, nonetheless, crucial to acknowledge that authenticity in assessment is not an all-or-nothing, binary concept (Dawson, Carless, and Lee 2021). It is often necessary and desirable, on sound educational grounds, for students and teachers to construct ‘interaction spaces’ (Vertesi 2014) – temporary boundaries that make it possible to foreground certain key elements and render others less visible. Similarly, Rooney et al. (2015) discuss how the selective focusing in educational simulations enables students to ‘learn to attune and pay attention to practice in ways that are not possible when fully involved in the action’ (281). There are also examples in our own data: OSCEs (which constrain the variability, temporality and materiality of clinical encounters), the criteria for Ash’s
essays (which exclude embodied knowledge and certain material practices), and Chris’ single-diagnosis exam questions (which constrain complexity and exclude sociomaterial relations). While such practices have utility in modulating learning complexity, if these boundaries are not co-constructed with students and relevant professional colleagues, then opportunities for learning from, and about, educational seams may be lost, along with adaptive capacity for negotiating multiple systems in the future. Rooney et al.’s (2015) related concept of ‘agility’ describes practitioners who not only react appropriately to activity ‘as it unfolds’ but are ‘open to, and able to seek out, opportunities to learn (and relearn)’ (270). It is this seeking out of learning opportunities beyond the formal design of the task (e.g. simulation, MCQ exam, essay) that underpins our understanding of seamful education.

**Conclusion**

Our analysis of focus groups with students, educators and practitioners, most of whom hold multiple roles and identities, highlighted ways in which academic and professional settings are patched together by ad-hoc, localised, sociomaterial activity. Yet, while workplaces are complex, dynamic spaces where ways of working are emergent, curriculum structures within educational settings are currently dominated by approaches that privilege predetermined, discipline-bound skills and knowledge at the expense of engagement with situated and contextualised practices. We propose that the inter-relations between these kinds of learning have been neglected, and could form a promising focus for curriculum development. Helping students to develop the capacity for learning things that have not yet been captured in formalised bodies of knowledge should equip them to adaptively respond to the unknown, individual and collective challenges of the future.

To this end, we have proposed exposing and examining the seams between systems as a potentially productive approach to understanding how practitioners negotiate multiple and complex contexts – what Rooney et al. (2015) characterise as the ‘patterned yet unpredictable, routine yet also changing practices of work’ (274). In our study, the participants revealed seams between formal syllabus requirements and everyday practices; containment and complexity; abstract and embodied knowledge; and technology use and professionalism. These elements are patched together by students, teachers, curriculum designers, and accreditation bodies, primarily through forms of assessment, policies, technology and materials, and the seams between them revealed limitations and possibilities of classrooms and workplaces as sites of professional learning.

The flexibility of curricula was often seen by our participants as constrained by regulatory bodies (exam boards, accrediting professional units, etc.). On the other hand, some professions were less regulated, and had less structured career paths, which made it challenging to see what kind of practice would be relevant to their professional future. Assessments with sufficient opportunity for students to make them relevant to their practice, both in terms of content and criteria, can simultaneously allow engagement in authentic tasks, and support the development of an appreciation of how professional and academic settings are patched together, and of how people combine with each other and material resources to get their work done. The value of a seamful design perspective is in finding, exposing, critiquing, and shaping ways in which connections between academic and
professional infrastructures are encountered by professional education students, and providing opportunities for them to learn to do this for themselves.

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