

Educational technology as social tradition: cultural transmission of remote teaching techniques during the Covid-19 pandemic

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Abstract

The Covid-19 pandemic seriously tested Higher Education Institutions preparedness for Emergency Remote Education. Amidst the call for a 'pivot online' educators quickly realised that simply switching to online distance learning was a forlorn hope. What followed was an undignified stumble into remote teaching. Social theories of innovation suggest that rapid technological change is simply a matter of choice and organisations can make rapid and strategic changes when required. I argue that talk of pivots and innovation is misleading and deflects enquiries from an important reason for academic resilience: teaching as tradition. By using a sociocultural evolutionary lens to analyse 102 courses in a business school, I demonstrate the persistence and resilience of teaching traditions. Using a phylogenetic analysis of the evolution of these courses prior to, during and after the lockdowns of 2020 and 2021, I show how digital drift, punctuated by unstructured change, allowed the school to survive the dissolution of the campus and to iteratively add to teaching capability, without undermining the importance of tradition. I argue that viewing teaching as a tradition and applying the methodology of cultural evolution is a more productive analytical instrument in understanding adaptation than is innovation. I explain how these results can inform resilience building in Higher Education by supporting the persistence of tradition and descent with modification.

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Introduction

The Covid-19 pandemic has had an unprecedented impact on Higher Education (HE), forcing academics to quickly adapt to remote teaching. The shift to remote delivery highlighted the importance of educational technology in facilitating distance learning and maintaining educational continuity. However, the adoption of these remote teaching techniques was not simply a matter of technological implementation. Rather, it represented the transmission of a social tradition, as educators had to navigate the cultural and pedagogical nuances of remote instruction. This dissertation examines the cultural transmission of remote teaching techniques during the Covid-19 pandemic, exploring how educators have adapted to a new reality and how these adaptations were shaped by existing traditions. Rather than describe the so-called *pivot online* as a deliberate and innovative response to a crisis, I will draw on cultural evolutionary frameworks to determine the extent to which changes were based on improvisation, imitation, and the prominence of tradition.

In March 2020 the full significance of the Covid-19 pandemic hit academia. Petar Jandrić, Editor in Chief for the academic journal, *Post-Digital Science and Education*, described this a 'unique time in human history' (Jandrić 2020, p.1069) and called for testimonials to capture the event from an HE perspective. The 'viral' response to the call (*loc. cit.*) was just the beginning of the sense-making and cataloguing of the academic response to the crisis. By 2021, with the pandemic still dominating teaching, the field of Emergency Remote Education (ERE) was re-invigorated.

I hear the call, like so many others, to document the extraordinary events of the acute crisis stage of the pandemic. The sense-making so far has been based on the subjective experiences of academics and students (Bond et al. 2021). While this is an understandable and necessary step to deeper insights, it has inevitably created narratives and counter-narratives about the value of digital education and technology. I found myself at the centre of the storm. As a digital educator tasked with the launch of the school's first digital programme, I was one of a handful of academics with a working knowledge of remote education.

While the school leadership set down the guidelines and standards for remote teaching, our small band set about creating guides, teach-yourself videos, and teach-the-teacher courses. I worked 90-hour weeks for months on end, contributing to what would become a framework of resources for other academics to use (see Honeychurch and Offord 2021), as well as holding training workshops and one-to-one support. I became aware of the 'pivot online' and felt, at the time, that the term was misleading. Additionally,

the crisis seemed to invigorate the smouldering debate about online and traditional teaching. This dissertation is an opportunity to discover the nature of change in Higher Education. I have no doubt that this truth, whatever it may be, will be less clear cut and more nuanced than the pivot online. As an educator working in the digital margins of a highly traditional university (I often say my university is *pre-digital*), I wanted to make sense of the sudden change and the role digital education was expected to play. I also want to set the record straight on what kind of change is realistic under crisis conditions.

My own view as a digital educator is obviously biased. I believe online education offers an opportunity to many who would otherwise be unable to access education. As someone who did not attend university to study a bachelor's degree and studied at Masters, Doctoral and another Masters level, entirely at distance, I clearly understand online education, probably better than the campus. By engaging in this study I will learn more about my own biases and also learn to understand the traditional academic. I am looking forward to empathising more with the campus-focused academic and learning from it. From both sides of this argument, there is a focus on technology.

Isolating the role of technology is a naïve and limiting view which ignores the complex entanglement of factors in education (Fawns 2022). The shift to remote teaching was framed as 'abnormal' (Boys 2022, p.1) while ignoring the preceding decades of digital drift, gradually substituting the face-to-face experience with educational technology (Tesar 2020). While this, no doubt, fuelled the optimism of the *pivot online*, the transition was anything but seamless. Not diminishing the genuine toil and anguish of the pandemic in HE, I posit that the crisis was simply a chapter in the cultural evolution of teaching traditions; traditions which are resistant to change and yet, inevitably, take up an ever-increasing post-digital nature.

I will consider and compare two very different narratives surrounding remote teaching in 2020 – 2021. A review of the literature begins with social theories of innovation, the origin of hubristic narratives around seamless diffusion of new technology. I argue that this simplistic view of innovation stems from early sociological theory, which remains very influential. This is compared with a more rigorous and understated view of innovation, drawn from Cultural Evolution theories. I argue that these theories are developed from strenuous mathematical, experimental and field testing, and are a more dependable lens through which to view change. From this broad field, I will go on to focus on models of cultural transmission which incorporate the view of technology as tradition. Such theories are well placed to counter the tendency to see technology as innovation or for rapid and purposeful adaptation. Traditions are viewed as channels for learning, they are persistent and evolve according to the rule of *descent with modification* (Jordan 2016, p.9). To conclude the literature review, I will compare these theories with the emerging narrative of experience based on academics'

responses to Covid-19. Here, I compare the *pivot* imagery with the reality of ERE and the consequences of disruption in HE. From this point I will develop research questions focussed on exploring the consequences of viewing teaching as a tradition, rather than a technique. I will, therefore, ask whether Higher Education Institutions (HEIs) are responsive at all, how they can adapt to major changes and how HEIs should learn from this experience.

The research was conducted at Adam Smith Business School (ASBS), University of Glasgow. As a part of the Russell Group of research focused universities, Glasgow focuses on research-led teaching. Around 6000 students were studying in the academic year 2020 – 2021, split evenly between undergraduates and postgraduates (ASBS 2021). As the student numbers indicate, programmes deal with large student cohorts and course sizes of up to 600 students. The school manages these numbers using the 'Oxford' tutorial system whereby, lectures are based on large group teaching but supported by tutorials taught in much smaller numbers (usually up to 25 students). Students experienced a campus-based and traditional learning environment, where teaching took place via lectures and self-study, albeit tutorials allow for more interactive sessions.

Prior to the pandemic, fully online courses were rare with online educators very much in a marginal role (as described for the HE sector, as a whole, by Hodges et al. 2020). One digital programme had been developed at postgraduate level, which had not yet been launched in academic year 19/20. Although, a few staff had experience of Online Distance Learning (ODL), the vast majority did not. At the beginning of the crisis, the school developed an online framework which could be used as a self-study resource centre for academics to develop online skills (for a full description see Honeychurch and Offord 2021). This included a series of guidelines to convert courses using an overall strategy of asynchronous teaching to account for time zones and other inequalities commonly thought to be worsened by rapid remote teaching (see Oliveira et al. 2021). The school's approach, therefore, differed from that reported as the most common response to Covid-19. According to Bond et al. (2021) most HEIs adopted a system of synchronous videoconferencing. This was known to create inequalities in learning (*Ibid.*, Boys 2022, Raaper and Brown 2020, Oliveira et al. 2021). The example set by ASBS affords an opportunity to observe academics consciously trying to adopt an unfamiliar and difficult task under considerable time pressure. It is therefore a good test of the likely adaptations to new realities, under crisis conditions.

Having set out the direction for this research, I will outline a pragmatic research philosophy, based on 'what works' rather than a definitive appreciation of reality and how we may know it. From this I consider the role of information as cultural artefacts and the building blocks of traditions. Taking account of modern complexity and cultural transmission, I will advocate the paradigm of Computational Social Science (CSS) from which I explain how modern computation can generate high resolution analysis of

change in HE. Specifically, I will explain how cultural phylogenetic analysis can be used to explore the evolution of 102 business courses at graduate and postgraduate level in a business school over five years (including the period of remote teaching).

In the results section I will present the data in the form of different types of evolutionary trees. My research indicates that, indeed, the responses to the crisis took a limited number of forms. Evidently, a great deal of imitation is at the core of a highly resilient yet conservative range of adaptations. The crisis year punctuates an equilibrium of gentle digital drift and generated a great deal of change, although this was not a deliberate *pivot*. These findings are discussed in terms of likely strategies HEIs can use in future catastrophes. While, I find no evidence of genuine innovations, deliberate and agile pivots, or 'great leaps', the data suggest that the inertia of teaching traditions may be the source of a deeply organic resilience and rich tradition of teaching.

Literature Review

Social Theories of Innovation

Overview

The popularity of the term, *innovation*, renders it almost unusable as an academic concept, due to the sheer volume of writing on the subject and lack of consensus about what innovation is. The Cambridge Dictionary defines innovation as:

"(the use of) a new idea or method"

Cambridge Dictionary (2022)

Innovation was an important field discussed by founding figures such as Marx, Durkheim, Spencer and Weber (Blute 2022). However, the now neglected sociologist, Gabriel Tarde may have articulated the most accurate picture of innovation via his theory of imitation, according to Emeritus Professor of Sociology, Marion Blute (*Ibid.*, 2022). Both Spencer and Durkheim were organicists and mechanists. They believed in a mechanistic cause-and-effect model of social forces which shape society, in much the same vein as the compelling scientific and positivist turn of the 19th Century. But they also believed that social organisations could be compared with living organisms and had a 'life of their own'. These ideas remain in the 21st Century and are especially influential in positivist sociology today (Blute 2022). Spencer's phrase, 'survival of the fittest' became a rallying call for politicians and businesspeople, despite it being reductionist, overly simplistic, linear and progressive (Mesoudi 2016, p. 37; Laland and Brown 2011, p.29).

Kevin McCaffree describes social change, in terms of early social theory, as responses to logistical pressures (McCaffree 2022, p.93). Responses can be 'Durkheimian', 'Spencerian', 'Marxian' or 'Weberian' (*loc. cit.*). Of the four responses, Weberian and Spencerian draw on innovation, whilst Durkheim and Marx both articulated narratives concerning the competition for existing resources (*Ibid.*, p.96). Weber's work integrated the earlier sociological texts and thus incorporated Spencer's ideas about innovation (*loc. cit.*). Thus, Herbert Spencer emerges as a founder of sociological thought who explicitly considered the role of innovation in social change. However, his theories have been criticised for their 'progressive' narrative which echoed the cultural biases of the time (Mesoudi 2016, p.37).

19th Century sociologist, Gabriel Tarde concerned himself more with a micro-level view of innovation and differed significantly, in this respect, from the now-established sociological founders (Blute 2022). Tarde was interested in

the role of imitation, which aligns him more closely to Darwinism (although he refuted this) (*Ibid.*). Marion Blute argues that Tarde's writing was "unrivalled among 19th Century social theorists" (2022, p. 4). Specifically, Tarde included historicity in his theories (unlike Durkheim) and developed a theory of social learning and imitation which is comparable with Darwin's *descent with modification* (*Ibid.*). Tarde's theories were full of promise but Durkheim's theories of 'social facts' proved to be more popular and Tarde's diffusion of innovation theories slipped into obscurity (Blute 2022). As a result, social theorists inherited progressive and deterministic theories which conveniently propped up cultural mores but failed to capture the complexity and nuance of social learning, innovation and change (Mesoudi 2016, p. 38). In the following sections, I describe two theories of innovation which remain true to early mechanistic approaches: creative destruction and Roger's Diffusion of Innovation.

Creative destruction

The influential theory, *creative destruction*, focuses on institutional aspects of innovation but ignores the impact of systems, networks, and relations (see Pel et al. 2020). Schumpeter determined that capitalist societies were driven by consumer goods. The competition between firms caused perpetual *mutation* in those goods as rival firms sought to drive businesses into obsolescence (Bailey et al. 2018). According to advocates of creative destruction, a perpetual state of change continuously dominates markets (Gaffard 2008). Schumpeter's description of creative destruction avoids the teleological mistake of assuming innovation is adaptive. Firms simply innovate to achieve market share, a Durkheimian analysis. Creative destruction describes firms as essentially change engines which drive capitalist society (O'Hara 1994). By modern standards the model is somewhat descriptive and is not empirically derived for all its intuitive appeal. Schumpeter's theories of innovation failed to account for how new innovations are percolated through a sector, thereby ignoring relational, network and systemic constraints (see Pel et al. 2020).

Diffusion of innovation theory (DIT)

Another influential theory of innovation is the Diffusion of Innovation Theory (DIT) made famous by Everet Rogers (Rogers 2003). Unlike creative destruction, DIT posits a process-based model. Adopters of innovations go through five stages, beginning with awareness and moving through appraisal and adoption (Frei-Landau et al. 2022). DIT also characterises the population of adopters as five separate categories: innovators, early adopters, early and late majority and, finally the laggards. This adoptive trait is claimed to be normally distributed with the categories neatly dividing the curve such that innovators and early adopters take the first 16% while laggards occupy the final 16%. Early and late majorities are split evenly

between these more extreme groups (Rogers 2003, p. 283). Figure 1 (below) breaks down the key points.

The individual innovation process:



Population level distribution:

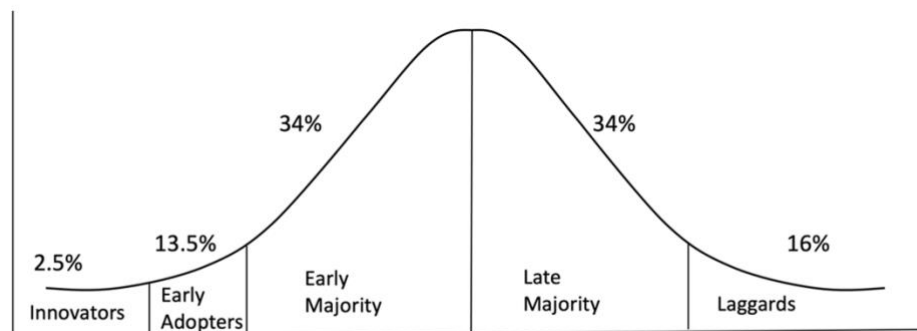


Figure 1 - Roger's diffusion of innovation theory (2003)

DIT proposes a five-stage process for adopting innovation from knowledge through to implementing and confirming use of the innovation. At any point, rejection (non-adoption) may occur. The model also divides the population into five categories based on their acceptance of innovation. These categories are posited to be normally distributed as shown by the gauss curve.

DIT offers a process for individual adoption and a diffusion model to spread innovation through a network. As such the model focuses largely on relational and network aspects of innovation (e.g. Pel et al. 2020). A shortfall of this approach is the simplistic and linear predictions it makes (MacVaugh and Shiovone 2010). The overall approach is Spencerian as it relies on the selection of the fittest innovations. In reality new technology does not always neatly replace old. This is known as the 'sailing ship effect' after observers noted that many companies persisted with sailing vessels even after steam and diesel propulsion proved itself to be much faster and more profitable. Indeed, the arrival of competition forced designers of sailing vessels into increased innovation (*Ibid.*). The rather neat adoption distribution (Figure 1) is not empirically supported and indeed, an adoption trait (if such a thing exists) would be a complex integration of psychological and external factors (*op cit.*).

Innovation in Higher Education

While DIT is useful for understanding innovation in general terms, the role of tradition is critical in HE and the context for innovation is all-important (Pel et al. 2020). In Higher Education, criticism has been levelled at educators that they lack a culture of innovation (Kopcha et al. 2016). Non-adoption is closely associated with a cultural concept: *traditional* teaching (Kopcha et al. 2016). Traditional teaching is influenced by the imagined academic, an expert in her field who dispenses knowledge to students (*Ibid*). Kopcha et al. (2016) place the traditional academic *persona* at the heart of non-adoption.

Westera (2004) offers critical insight into innovation in education. This begins with the revelation that education itself has been somewhat immune to innovation over the course of history. Developing from the apprenticeship model of learning, the classroom (as technology) transformed education in the Middle Ages, unlocking the ability to *teach en masse*. This was the last innovative transformation of education which continues to be based on classroom-based pedagogies (*Ibid.*). A more detailed analysis is offered by Frank Smith's *Book of Learning and Forgetting* (1998).

Westera (2004) argues that despite the gradual ingress of technology, education has demonstrated considerable inertia such that problem-based and resource-based teaching techniques (which are more student-centered), remain marginal. Westera's explanation for this inertia is that academics are both the product and guardians of this same system (2004) and, therefore, less likely to participate in its creative destruction. He argues that teaching in HE is not considered as a profession, but a craft (guided by tradition), therefore resistant to innovation (Westera 2004). However, Westera (2004) admits that substitution of traditional with modern technology is inevitable. Gradually, elements of education have been replaced by convenient technologies with little critical thought and in a strategy vacuum (Westera 2004; Tesar 2020), resulting in unexpected consequences as the inevitable tension between instrumentalism and alienation has played out.

Sociocultural Evolutionary Theories of Innovation

The academic analysis of education in the Anglo-American tradition is an interdisciplinary venture, comprising mostly of sociology, psychology and philosophy (Kvernbekk 2021, p.13; Biesta 2011). This tradition is the point of departure of this study, as I argue that a contribution can be made from an evolutionary perspective, that is missing from past attempts to understand educational innovation. Within the social tradition, I have argued that innovation has been approached with an optimistic outlook, assuming complete agency and prescience. These theories lack empirical support, fail to incorporate real world complexity and, therefore, make exaggerated claims.

Cultural evolution, having survived similar critiques in the past, has built deliberately on mathematical models, recently graduating to experimentation and field testing. Furthermore, many theory fragments from social research (e.g. strategic inertia, technological substitution, essentialism etc.) can be integrated under the banner of *social learning*, a major plank of the evolutionary approach (Laland and Brown 2011, p. 218). Social learning has been neglected as a factor in innovation along with other aspects of Tarde's sociological framework of the 19th Century (Blute 2022).

Within this paradigm we can consider many of the threads discussed in earlier sections of this dissertation under a single approach to innovation under crisis. To do so, I will briefly explain the evolutionary approach in general. I will then move on to counter the flawed premise of prescient innovation and then introduce the key topic of tradition. Tradition as an alternative to innovation, I will argue, is a useful framework for considering adaptations to the remote teaching crisis. After re-visiting the diffusion of innovation in a more rigorous way, I will discuss the cultural landscape of inertia, punctuated with sudden and indiscriminate change.

Introduction to cultural evolution

Darwinian sociocultural evolution is the theory that culture evolves in a similar (but not identical) manner to biological evolution (Mesoudi 2011, p.25). Culture, as information, is therefore created, adapted, and spread. Since Darwin's *Origin of the Species* of 1859 (Darwin 2011), there have been many attempts to apply an evolutionary framework to social theories. Many of these have been misguided or harmful, such as the so-called *progressive* theories of the 19th Century or controversial such as socio-biology or memetics (Mesoudi 2016, p. 25). The story of cultural evolution has been a roller coaster of fame and infamy (*Ibid.*), but towards the end of the 20th Century a scientific and empirical framework emerged. In this dissertation, I will refer to this framework as sociocultural evolution or cultural evolution for

brevity (Mesoudi 2016, Blute 2010). Cultural evolution holds intriguing clues to many aspects of culture, including innovation.

Innovation is blind

Unlike other social theories of innovation, cultural evolution emphasises the role of social learning and transmission. This process is not necessarily intentional or conscious, but can occur through various mechanisms such as imitation, teaching, and emulation. Caldwell et al. (2018) assume innovation to be 'blind to the motivations and intentions of its creator' as a practical assumption in their review of cultural evolution experiments (p.8). This fits the evolutionary principles of VISTA (variation, inheritance, selection, time and adaption) (see Mesoudi 2016). Therefore, variation becomes the first step in the innovation process and this step is unguided (Blute 2010, p.34). Teleological errors cannot apply to evolutionary definitions of innovation.

Additionally, cultural evolutionists attempt to model systems of transmission which account for the complexity of real-world innovation, including the material realities. These models of innovation do not rely on individual agency working in a material vacuum, i.e. through social constructivism (Blute 2010, p.139 – 161). Innovation is considered as blind variation or mutation. It is on this variation that cultural evolution acts through sociomaterial conduits.

Tradition trumps innovation

There are limits to innovation. These limits exist because of Darwin's law of *descent with modification*. Naturally, any innovation depends on existing knowledge or technology and must be based largely on existing forms (Laland 2017, p.102; Blute 2010, p. 53). Consequently, forms may vary within limits prescribed by their historicity, while selection of new forms is likely to be influenced by necessity (*Ibid.*). Consequently, some sociocultural researchers ground their research in traditions (e.g. Morin 2015, Jordan 2015). Traditions are carefully repeated but not immune to variation, indeed flexible imitation plays a key role (Morin 2015, p.99). Flexible imitation (*loc cit.* Morin 2015, p.99) is, therefore, a candidate for the genesis of ideas: new approaches that are based largely on previous ones.

Good news travels fast

Sociocultural evolutionists believe humans have evolved to learn a repertoire of actions which are selected according to context (phenotypic plasticity) (Blute 2010, p.141). Observed behaviour can be imitated, but usually based on existing traditions and flexibly adapted to new conditions (Morin 2015, p.122). Existing traditions have considerable inertia, so new ones must be attractive (*op cit.* Morin 2015, p.124). Successful diffusion also requires that selective forces *match* available innovations (Blute 2010, p.142). Finally,

cultural practices can simply drift, that is experience change over time without any adaptive outcome (op cit.).

Slow, slow, quick

Any model of diffusion must consider the pace of change. While traditions researchers take a parsimonious view of evolutionary change (Morin 2015, p.124), intuitively I suspect that bursts of rapid change are also possible. Mesoudi (2016) compares this with the biological observations of *punctuated equilibrium* from the fossil record. Researchers noted that organisms remained largely unchanged for extensive periods but events such as the 'Cambrian Explosion' were characterised by fast change and rapid speciation with new animals exploiting new evolutionary niches (p.117).

Cultural evolution could follow a similar trajectory and Mesoudi outlines recent research into language evolution which, does indeed, show the same profile of *punctuated equilibrium*, leading to the creation of new languages (p.117 -118). If traditions such as teaching can also experience rapid bursts of change, the Covid-19 pandemic could feasibly become a speciation event for new teaching traditions. Like the Cambrian Explosion, change is unlikely to be deliberate, but random and unstructured.

Can cultural evolution really work in a similar way to biological evolution?

Stephen Jay Gould, the evolutionary biologist most associated with punctuated equilibria (Gould and Eldredge 1972) disputed the similarity between cultural and biological evolution. His argument for this was based on the principle of *blending and particulate* evolution (Mesoudi 2016, p.100). Biologists had long believed that biological evolution comprised distinct packages of information, hence the branches of the evolutionary tree diverged into new species. Reticulation or blending of branches was not originally considered a part of biological evolution, yet in culture, blending was far more common. This was held to be a defining factor which made biological and cultural evolution distinct. This difference between particulate transmission and blending was one of the reasons that Richard Dawkin's *meme* failed to achieve academic endorsement, since the *meme* was very much based on a genetic description of transmission (as well as a lack of empirical support) (Laland and Brown 2011, p. 141).

More recently biologists have noticed an increasing array of examples of blended evolution in animals, especially invertebrates (Mesoudi 2016, p.101). Equally, cultural evolutionists have found that the horizontal transmission of ideas (ethnogenesis) is not as prevalent as originally thought (Tehrani and Collard 2002). The amount of branching in cultural examples of evolution puzzled researchers until anthropologist, William Durham identified several Transmission Isolating Mechanisms or TRIMs (Durham 1992). TRIMs differ according to context, but it appears there are powerful forces to insulate traditions from exposure to alternative cultural practices, (while still allowing

more horizontal flow of ideas than is normally found in biological evolution). This is especially true in the evolution of modern technology which appears to share ideas more freely than in other cultural areas (although this is yet to be fully verified by research) (Mesoudi 2016, p. 102). Since this study is aimed at this area specifically, it will be able to contribute to this research gap.

Summary of innovation as described in sociocultural evolutionary theory

Innovation is considered in a pragmatic way, as simple mutation. There is a background of constant small-scale change, or drift. Traditions are largely based on pre-existing forms (historicity) while the selection and ultimate success of any innovation will be determined by the conditions of competition. Traditions have inertia, whilst innovations do not, attractive changes survive. Attractiveness may not be based on any sense of adaptation but rather on conformity with the majority, ease of use or other factors. The Covid-19 pandemic may have triggered rapid change, but this change would be random, rather than deliberate, and change over longer periods is likely to be conservative.

Emergency Remote Education (ERE) during Covid-19: What if the new-normal is just the old-normal?

ERE Overview

In October 2020, an influential article by Emily Nordmann and colleagues described the shift to remote teaching as a 'temporary pivot' (p.1), providing useful guidance based on the 'pedagogy of online learning' (*loc. cit.*). Hopeful as this advice was, the disruptions lasted much longer than expected and knowledge of digital pedagogies turned out to be far lower than was generally expected (Tesar 2020). Ultimately, HEIs hurriedly adopted ERE instead (Oliveira et al. 2021). A *pivot online* as a deliberate and innovative change did not happen. The aim of this research is to discover whether the pandemic, nevertheless, triggered a significant change in teaching traditions in a specific HE context. This section will consider innovation and adaptation during the crisis. I will describe the general response as outlined by Bond et al. 2021, authors of a systematic review of Covid-19 teaching up to 2021, and other influential commentators.

ERE is a field concerned with maintaining education in nations affected by war or natural disasters (Oliveira et al 2021). The field is a part of the wider Educations in Emergencies (EiE) project, supported by UNESCO (*Ibid.*). Central to the purpose of ERE is the evidence that disruptions to education result in longer term educational deficits, fuelling later crises in an ever-decreasing spiral (UNESCO 2003). ERE researchers have endeavoured to find out how education can continue when schools and universities are temporarily out of action. Despite exploration of innovative ideas, such as temporary learning spaces, researchers report that responses are typically conservative, often relying solely on synchronous videoconferencing (Bond et al. 2021). Such was the state of the field prior to Covid-19 when researchers reported the lack of preparedness for the H1-N1 virus, should it become a pandemic (Oliveira et al. 2021).

ERE as a response to Covid-19

Johnson et al. (2020) report that in the first phase of the crisis, nearly all administrative and academic staff successfully transitioned to remote delivery (897 participants were surveyed over 47 US states). Over half of faculty reported that they were using 'new teaching methods'. The wording, 'teaching methods' implies faculty viewed this from a pedagogical perspective, since the researchers did not use the words 'new technologies'. However, the researchers later define these methods as using the institution's Learning Management System (LMS) to post learning material and synchronous or asynchronous video (mostly synchronous). This aligns closely with a later systematic review of the burgeoning ERE/Covid-19

literature by Bond et al. (2021). Only 16% of faculty in Johnson et al.'s study reported making changes such as making adaptations for students studying online (2020). However, in this study participants often reported a need for further support in sharing emergency plans, making technical advice available and supporting students (*Ibid.*).

Early modifications closely resembled ERE while aiming to 'pivot online' (Johnson et al. 2020). It doesn't appear from the literature that this was intentional, it appears that institutions were earnestly trying to shift to online teaching, without realising the challenges involved (*Ibid.*). Early reporters such as Johnson et al. (2020) and Nordmann et al. (2020) recognised that the institutions had fallen into ERE by default, something both papers point out is unsustainable in the long term. However, Bond et al. (2021) discovered this situation did not change greatly as the pandemic continued.

Rof et al. (2022) take an alternative view: digitalisation of HEIs was already in progress but the Covid-19 pandemic accelerated this process. The authors argue that digital transformation, impacted by Covid-19, has raised expectations of digitalised HEIs with the potential obsolescence of more traditional universities (*Ibid.*). According to this paper, ERE has impacted universities by setting an expectation for more personalised learning and the use of technology to provide flexibility in a more customer-student focussed way. This approach takes it as self-evident that HEIs should continue to transform, rather than 'new normal' narratives (e.g. Nordmann et al. 2020, Nordmann et al. 2022).

Reviews demonstrate a confused response to Covid-19. While many institutions thought they were 'pivoting online' they defaulted to a set of strategies reminiscent of ERE. The well-researched drift into digital (Tesar 2020; Rof et al. 2022) made this not only convenient but realistically, the only option.

Whether, or not, a backlash in the form of a romantic return to the campus or an acceleration into deeper digital is likely, remains to be seen. Rof *et al.* (2022) describe the pandemic as an extension of digital drift which resonates with evolutionary perspectives of continuous, modest and random variation, punctuated by rapid unstructured change. Rapid change events leave the landscape irrevocably changed (Mesoudi 2016, p.117) which supports the concept of a 'new normal'. However continual change (i.e. digital drift) also seems to be part of any normality, prior or after the pandemic.

The cost of change

There have been a great number of reviews of the crisis in HE. These papers describe the challenges and trauma of 2020 - 2021. They also describe a lack of support for staff adaption (Johnson et al. 2021; VanLeeuwen et al. 2021; Oliveira et al. 2021), unequal access to digital technology (Raaper and Brown 2020; Meletiou-Mavrotheris et al. 2022,

Czerniewicz et al. 2020), lack of student support (Raaper and Brown 2020; Meletiou-Mavrotheris et al. 2022, Oliveira et al. 2021), shock (Rof et al. 2022; Stewart 2021), lack of digital mindset (Rof et al. 2022), dataveillance (Usher et al. 2021) and issues with assessment (Oliveira et al. 2021).

Collectively, the literature paints a picture of a degraded learning and teaching environment. Yet, researchers report that, for the most part, courses were successfully converted to a remote format (Oliveira et al. 2021; Johnson et al. 2021). VanLeeuwen et al. (2021) title their paper "Never-ending repetitiveness, sadness, loss and 'juggling with a blindfold on'...during the Covid-19 pandemic", giving a sense of the trauma exacerbated by a lack of institutional support which is echoed in many other papers (for example, Johnson et al. 2021; Oliveira et al. 2021). Oliveira et al. 2021 report that the switch to remote technology was successful, while personal adaptation to these changes were negative. Similarly, Johnson et al. 2021 report successful transitions to remote teaching but that, as a strategy ERE is not sustainable (agreeing with Nordmann et al. 2021) and requires a greater level of support to faculty in terms of training and how to support students.

Digital drift, strategy and adaption

Rof et al. (2022) and Tesar (2020) point out that HEIs have been drifting into increased reliance on digital technology in an unstructured way for some time before COVID-19. HEIs were widely, uncritically and thoughtlessly rolling face to face content over to digital formats without considering underlying pedagogy or strategic thinking (Tesar 2020). An instrumentalist and essentialist approach to technology had been noted for some time in Higher Education (e.g. Hamilton and Friesen 2013) but Tesar (2020) notes that this 'policy push' (p.556) was somewhat unfocused and superficial, resulting in poorly designed and supported translation into online offerings. This does, indeed, reflect rather accurately what happened during the initial phases of COVID-19 as described in the section above.

Research

Hodges and Fowler (2020) argue the importance of reflection on the latest period of ERE for precisely these reasons (Hodges and Fowler 2020; Hodges et al. 2020). Other researchers have pointed out the need for resilience more generally in Higher Education as well as for rebuilding HEIs in the wake of Covid-19 (Nandy et al. 2021).

The comprehensive and systematic review of ERE thus far by Bond et al. (2021) demonstrates a clear strategy of synchronous videoconferencing combined with using the LMS as a repository for asynchronous learning materials. However, there is a clear difference in the lack of consideration for material affordances such as temporary learning spaces. Literature on Covid-19/ERE in HE, is largely cross-sectional and subjective (Bond et al.

2021), as can be expected at this stage. Over time, more longitudinal and nuanced research will be required (Ibid.)

Research questions

The switch to remote teaching was initially labelled as the 'pivot online', however it became clear that the situation was far less controlled than that. Ultimately, hindsight revealed a largely unplanned and unstructured shift towards emergency remote education (Oliveira et al. 2021). Given the long term aims of ERE are to maintain the continuity of education in any crisis, it is therefore useful to draw on the Covid-19 experience to develop contingency plans for any future disruptions. To do so, it is useful to understand what the nature of innovation in a crisis really is. It is clearly counter-productive to develop ambitious and innovative responses if academics are unable to adopt them.

Sociocultural evolutionary approaches predict that teaching methods, as traditions, have inertia (Jordan 2015, p.66) but are comprised numerous cultural traits (*loc cit.* p.68). Traditions evolve through the random variation of these traits which are either selected or not, while maintaining the original form to a large extent; *descent with modification* (Blute 2010 p.53). The evolution of new forms branches from previous ones following the process known as an evolutionary tree, a term popularised by Darwin in the *Origin of the Species* (Jordan 2015, p. 78). Cultural phylogenetics is the technique of analysing the evolutionary trees for cultural objects such as teaching traditions (*Ibid.*).

Phylogenetic analysis of Covid-19 teaching traditions can determine the realistic changes made under crisis conditions, creating probable future responses to crises. Clusters of adaptations noted over the period of remote teaching are likely to be repeated, rather than 'out of the box' innovations. Thus, the crisis can be used to teach us how HEIs will likely react in future dilemmas and what directions can be encouraged and supported. The following research questions are adopted:

- Can HEIs respond innovatively to a crisis (are they sufficiently resilient)?
- What sorts of pedagogical responses are likely to be adopted?
- How can a contingency plan support academics to create in-house responses which are adaptive?

Methodology

Theoretical framework

Philosophical underpinnings

Bond et al. (2021) point to the current state of research into ERE caused by the covid-19 pandemic. In their systematic review they found most of the research to be based on subjective first impressions reporting (op cit.). This, of course, reflects the necessities of any early exploratory work. To balance the situation, Bond et al. (2021) call for theory-based and objective research.

However, the ERE problem (adaptive response to educational emergencies) is practically oriented. Following the work of Peirce and Dewey, a more flexible philosophy, that of pragmatism, has been developed to focus on 'what works' (Cohen et al. 2018, p. 36 - 37). This approach encourages researchers to avoid a dogmatic adherence to one philosophy. Pragmatism is based on the logician Charles Peirce's assertions that knowledge is for action and that knowledge is created through the agreement of competent researchers over a period, also referred to by Immanuel Kant as *inter-subjective validity* (Benthall 2016).

Research paradigm

Innovation and adaption is an information game. Very simply and literally, innovation is new information and its cultural transmission is a form of information processing. Computational Social Science (CSS) is described as an information-processing paradigm (Cioffi-Revilla 2017, p.2); its onto-epistemological roots are in objectivism and realism, tempered by the intersubjective validity of pragmatism (Benthall 2016). CSS is an instrument-enabled science (Cioffi-Revilla 2017, p.3) in that it uses the processing power of modern computation to analyse large datasets and thereby gain new insights that hitherto were unavailable. CSS also promises to make valuable headway with an ongoing problem with replicating research in quantitative social sciences to the extent that in the future quantitative social scientists may also need to be computational statisticians (Benthall 2016). CSS is heavily influenced by Herbert Simon's Theory of Artifacts which informs Complexity Theory (Cioffi-Revilla 2017, p.10). Complexity Theory breaks with more objectivist ideas of linear predictability of social systems, casting organisations as Complex Adaptive Systems (CAS) (Cohen et al. 2018, p. 27). CSS incorporates any computational research methodologies such as data mining, textual analysis, network analysis and social simulations. These techniques are amenable to using naturally occurring data such as data-

traces, or existing documents (Cioffi-Revilla 2017, p4.). These methods are useful for both theory building and policy making (*Ibid.*) which is valuable in ERE to add the depth required to reflect properly on the pandemic (Bond et al. 2021) and to ensure that HEIs are better prepared in the future (Oliveira et al. 2021).

Research Methods

In this section the research methods are detailed and discussed including any ethical considerations. The project uses phylogenetic analysis to explore the trends in adapting teaching traditions to remote teaching.

Phylogenetic reconstruction is based on the concept of *descent with modification*, popularised by Darwin (Jordan 2015 p.78). The branching of new teaching traditions away from ancestral forms is a novel but effective way to visualise change. Cultural evolution can be achieved through phylogenesis (newer forms inherit traits from earlier ones) or ethnogenesis (new forms inherit traits from contemporary traditions, also known as reticulation) (*Ibid.*). Phylogenetic trees are a visually impactful way to show the amount of evolutionary change of taxa (business courses in this case) (Huson et al. 2010 p. 52). Phylogenetic networks are a different form of graph which depict both vertical (phylogenesis) and horizontal (ethnogenesis) relationships as opposed to phylogenetic trees, which depict phylogenesis only (*loc cit.*).

Although phylogenetic methods are well established in computational biology, their introduction to social sciences is more recent and largely focused on anthropology (e.g. Tehrani et al. 2016) and archaeology (e.g. Jordan 2015). Jamshid Tehrani and colleagues were able to use several cutting edge computational phylogenetic methods to determine the evolution of the Little Red Riding Hood fairy tale across the globe from oral to written versions. Like biological research, Tehrani et al. were assessing the likelihood of various hypotheses on the complex evolution of this childrens' story (2016). However, I will be exploring the phylogenesis of HE courses with existing knowledge of their timeline. A simple exploratory method will suffice for this task. A diagram of the research framework is at Figure 2 (below).

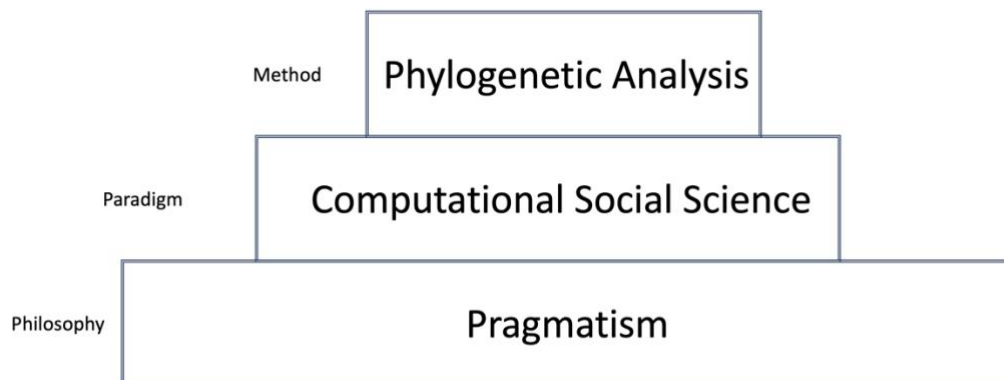


Figure 2: The research framework

Dataset building

At Adam Smith Business School (ASBS) courses are approved using a documented change process. Any further changes are also approved and documented in the same way. Additionally, each year new instances of each course are hosted on Moodle, the University Learning Management System (LMS). Each “Moodle”, as it is known, is a digital record of that instance of the course. Courses being shaped by teaching traditions will naturally exhibit the characteristics of these traditions. For example, prior to 2020 almost all courses were based on face-to-face lectures since the school ran no digital programmes at that time. I confirmed this by exploring Moodles for any courses prior to 2020 for lecture timetables or teaching plans. I can assert that these courses were campus-based and assign this characteristic accordingly. However, as suggested by Tesar (2020) ASBS courses were not immune to a degree of digital drift. Hence, I also observed that some courses started to use electronic submission of assessments, whilst others retained physical essay scripts for marking. Those courses have the characteristic of electronic submission which I can give a code or character. After 2020, several new developments become visible, for example asynchronous learning materials and so on.

By assigning a group of characters and listing each instance of each course I can derive a character matrix in the same manner as Tehrani et al. (2016) for fairy tales and Jordan (2015, p.80) for hunter-gatherer technologies. An example of a character matrix is given at Table 1, based on a hypothetical course at ASBS.

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3145_18	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
3145_19	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0
3145_20	1	0	0	1	0	0	1	0	1	1	1	1	1	1	0	0
3145_21	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1
3145_22	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0

1	Asynchronous video	[0] absent [1] present
2	Synchronous video	[0] absent [1] present
3	Serious games	[0] absent [1] present
4	Online resources	[0] absent [1] present
5	Campus Lectures	[0] absent [1] present
6	Email	[0] alternative / chat [1] primarily email
7	Classroom Response Systems	[0] absent [1] present
8	Online quizzes	[0] absent [1] present
9	Online formative assessment	[0] absent [1] present
10	Online summative assessment	[0] absent [1] present
11	Lecture slides	[0] absent [1] present
12	Lecture recording	[0] absent [1] present
13	Course built online	[0] no [1] yes
14	Active learning	[0] no [1] yes
15	Blended online	[0] no [1] yes
16	Online social spaces	[0] no [1] yes

Table 1 – Example of character matrix for a hypothetical course
The matrix is based on a hypothetical course (code 3145). The code is randomly assigned to the course so that practitioners at ASBS cannot recognise the course in question. There are five instances of the course from 2018 to 2022, over which period the course evolves. States for each character are recorded against the character number based on absence (0) or presence (1). The character code can be translated using the second table.

The 102 courses captured using this process, took 50 hours to collect and input into the character matrix, as each course required in depth analysis. For each course, in each year, Moodle was interrogated to search for teaching plans, discussion fora, presentation slides, quizzes etc. Additionally, data were wrangled to ensure they were arranged in a ‘tidy’ format, that is an arrangement that R’s package *tidyr* requires to deploy powerful data management tools (Wickham *et al.* 2023). In addition to the time constraints of this hefty data management task, it was clear after around 10 courses, that a few patterns of change were repeating through the dataset. These patterns remained stable, with no new combinations emerging as the dataset grew to 102 courses. The dataset had achieved theoretical saturation, that is further data collection was considered unnecessary.

Analysis

The dataset can be seen at appendix two. Each course comprised of up to five instances between 2018 and 2023. However, not all courses ran continuously over this period, so instances with between three to five years of data were included. The dataset comprised of 435 observations, which is a very large dataset for phylogenetic analysis. For example, Jordan’s network analysis of platform building in Northwest Siberia drew on traditions from 31 locations (Jordan 2015, p. 159) and the study of Little Red Riding Hood used 24 stories (Tehrani 2016). A distance table was created and used to generate phylogenetic trees using the statistical programming language R (R Core Team 2021) in conjunction with the appropriate phylogenetic packages: *ape* (Paradis and Schliep 2019); *phangorn* (Schliep 2011); *phangorn* for phylogenetic networks (Schliep *et al.* 2017) and *ggtree* (Guangchuang 2022). Finally, R Studio (RStudio Team 2015) was used as the programming environment. The code used for the analysis can be found at appendix three.

Phylogenetic Trees

Phylogentic trees are less computationally demanding than networks and can be quickly created to determine the amount of evolutionary change in the business school. For example, while the *ggtrees* package (Guangchuang 2022) will generate phylogenetic trees immediately for the full dataset, the NeighborNet programme (Schliep *et al.* 2017) had to run overnight to calculate 10 course networks on a standard desktop computer. Trees also produce some useful complementary visualisations.

Trees were generated by applying the UPGMA algorithm to the distance table explained above. UPGMA stands for *unweighted paired group method using arithmetic averages* (Huson 2010, p.52). The method works by merging the two closest clusters until only one cluster remains (a full mathematical model is at Huson 2010, p.53). This is explained in more detail at appendix one. The method is very similar to hierarchical clustering used in

other sciences. An unrooted tree with equal angles between clusters was used with ggtree package (Guangchuang 2022) as this created a more tree-like visualisation. An example from the hypothetical course 3145, is given at Figure 3 (below).

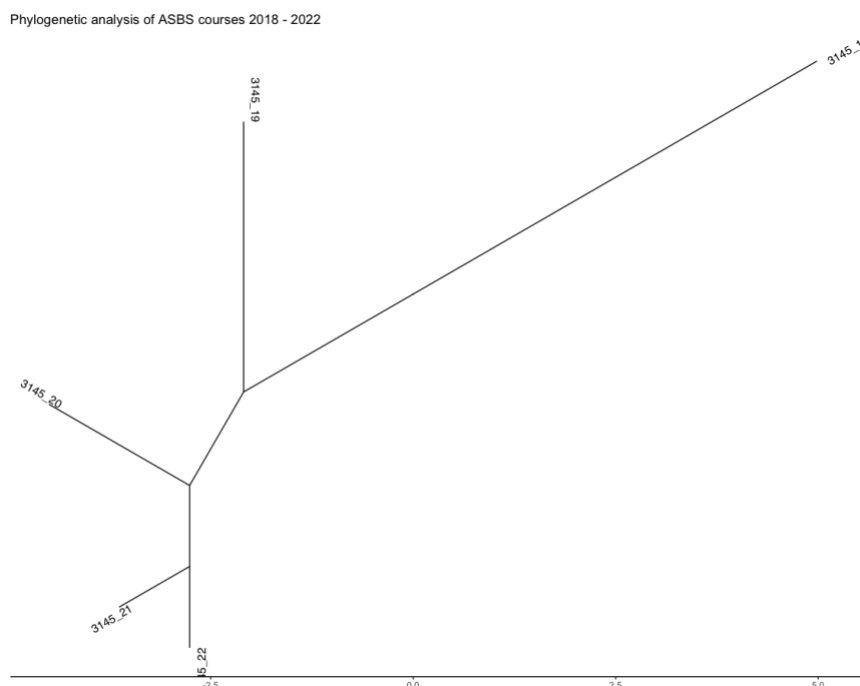


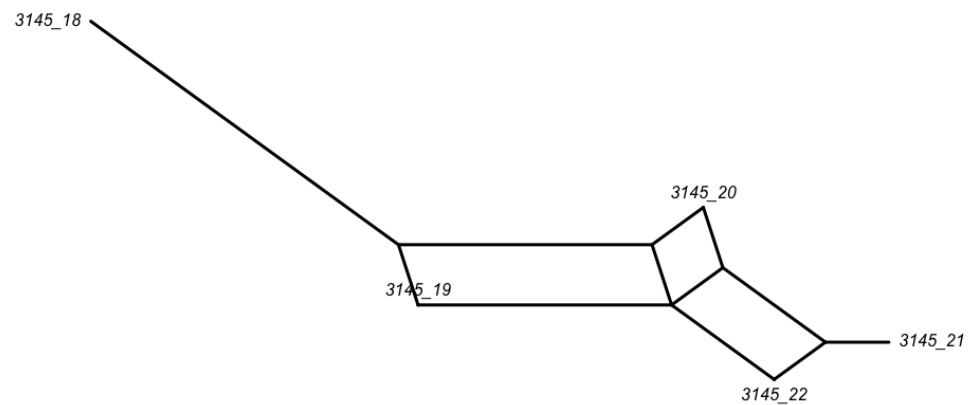
Figure 3 – UPGMA Tree based on hypothetical course 3145. The tree is rendered as an unrooted tree using the layout ‘equal angle’ in the ggrees package on R. The x axis is used to measure evolutionary distance.

The tree at Figure 3 shows the greatest evolutionary change between 2018 and 2019, despite the pandemic being a year later. This would suggest the course was substantially reviewed prior to the pandemic and then changed further because of it. Evolutionary distances gradually decline over the five-year period, demonstrating that the course was settling down over time with more modest changes taking place later. The last two instances (2021 and 2022) are very similar. Although the trees are easier to generate and tell a story, they lack the information regarding the hybridity and improvisation of this course, which is shown using the splits technique, shown at figure 4 (see next section).

Phylogenetic Networks

Instances (more accurately taxa (Jordan 2015, p.81)) can be clustered into similar groups based on similarities in character states. These partitioned groups form ‘splits’. The more characters are shared within a certain group, the stronger the split (*Ibid.*) The method for determining the splits is known as the NeighborNet algorithm (Bryant and Moulton 2004, Huson et al. 2010, p.254).

Phylogenetic analysis is based on random graph theory, specifically Directed Acyclic Graphs (DAG). The mathematical models described by Huson *et al.* (2010) are described in more detail at appendix one. An example, based on the same data described previously as hypothetical course 3145, is given at Figure 4 (below).



*Figure 4 – Phylogenetic Network for hypothetical course 3145
The length of lines between instances shows the evolutionary distance. Box shapes between instances show evidence of ethnogenesis or horizontal transmission*

As the hypothetical course is only one in number, the resulting network is very simple and demonstrates how the technique works easily. In this case the greatest distance is between 2018 and 2019, agreeing with the visualisation at Figure 3. There is a large distance between 2019 and 2020, which we know was caused by the change to remote teaching. Beyond this point, the distances become shorter suggesting courses after 2020 experienced less change. The 2022 course is closer to 2020 than 2021 which suggests that new course techniques were tried in 2021 but abandoned in 2022.

The number of box shapes and connections between later courses shows a greater amount of horizontal transfer between courses. The shape of the network begins to resemble a mosaic in the later courses, suggesting ideas were being trialled and shared between courses. It is important to note that all phylogenetic trees and networks are hypothetical. They serve as a method to visualise and explore the cultural development of traditions.

Sample size

The nature of this research is exploratory. The analysis of phylogenetic networks employs several statistical tests to ascertain the likelihood that certain characteristics are shared between taxa (see Huson 2010). But, unlike the cultural and biological examples given earlier, the order of developments are already known with certainty. The thesis of this research is that teaching is best viewed as a tradition resistant to large changes but subject to evolutionary drift. This can be achieved through visualisation of the data to explore the nature of change. However, I do need to be certain that the results are valid, in that they represent the population.

The business school course catalogue contains 420 courses available in 2023. 46 courses are dissertations, which are not subject to teaching in the strictest sense. 16 courses ran over too few years (one or two) and 33 courses are copies of others or are online courses in the first place. In total 348 courses may be used in this study. This is a very large data collection task. Since it typically takes around 30 minutes to collect data from one taxa, the total data collection task would take around 174 hours. There is also the issue that at a certain point, no new significant information may emerge from the data.

In qualitative research, this is known as theoretical saturation where further data collection generates no further insights (Low 2019). In quantitative sciences the concept of theoretical saturation is closest to the notion of statistical significance (Sullivan and Fein 2012). Sullivan and Fein point out the tendency to focus unduly on the p value and ignore the effect size, adding more data to achieve a satisfactory p value (known as p-hacking) is widely held as bad science (*Ibid.* 2012). Whilst I am not generating statistics based on p-values, I adopt the same stance and stopped collecting data when no further insights were likely. In practice this occurred at around 10 courses, but 102 courses were collected in total, to generate a large and rich dataset.

While analysing the dataset, I discovered that my desktop PC was unable to conduct the phylogenetic network analysis for such a large dataset. It was computationally far beyond the machine's capacity. I worked around this limitation by dividing the dataset into smaller groups and building networks for these groups. The analysis demonstrated both ethnogenetic and phylogenetic transmission and, since evolution of individual courses was independent, this did not dilute the analysis. This does demonstrate the limitation of powerful computational techniques. Future research in this field will need to take account of this limitation by using smaller datasets or gaining access to high performance computers.

Ethics

Although the research is not participatory there remains a requirement for careful ethical consideration. Although ethical approval is often considered to be solely about those directly involved in the study, the primary ethical concern is with the valid, reliable and worthwhile production of knowledge (Cohen et al. 2018, p. 510). Additionally, there is an issue with informed consent. Since the project will, in a sense, audit courses against a standard there is a possibility that it will be seen as critical of course design during the shift to online teaching. This raises the question of to what extent do course convenors own the content of their courses or is it the property of the HEI who may choose to audit courses for accreditation or other purposes? Ethical approval was gained both from the University of Edinburgh and from the Head of Adam Smith Business School to ensure both the quality of the proposed research, and to ensure the correct permissions are obtained. No personal data were extracted from the documents.

Results

Summary of the dataset

The dataset comprised 102 taxa with each instance listed in rows. The Hamming distances of evolutionary change (see appendix one) generated a table with 93961 entries, recording the number of substitutions required between courses. From the raw data the number of substitutions per course per year were calculated to summarise the evolutionary change from one year to the next. As some courses were not run on all years, this task could only be conducted on 78 courses.

Evolutionary change

The mean number of substitutions was 2.16 over the period, indicating the average number of changes per course per year. Figure 5 (below) shows the substitutions over the period. There are only four categories since substitutions can only be measured *between* years.

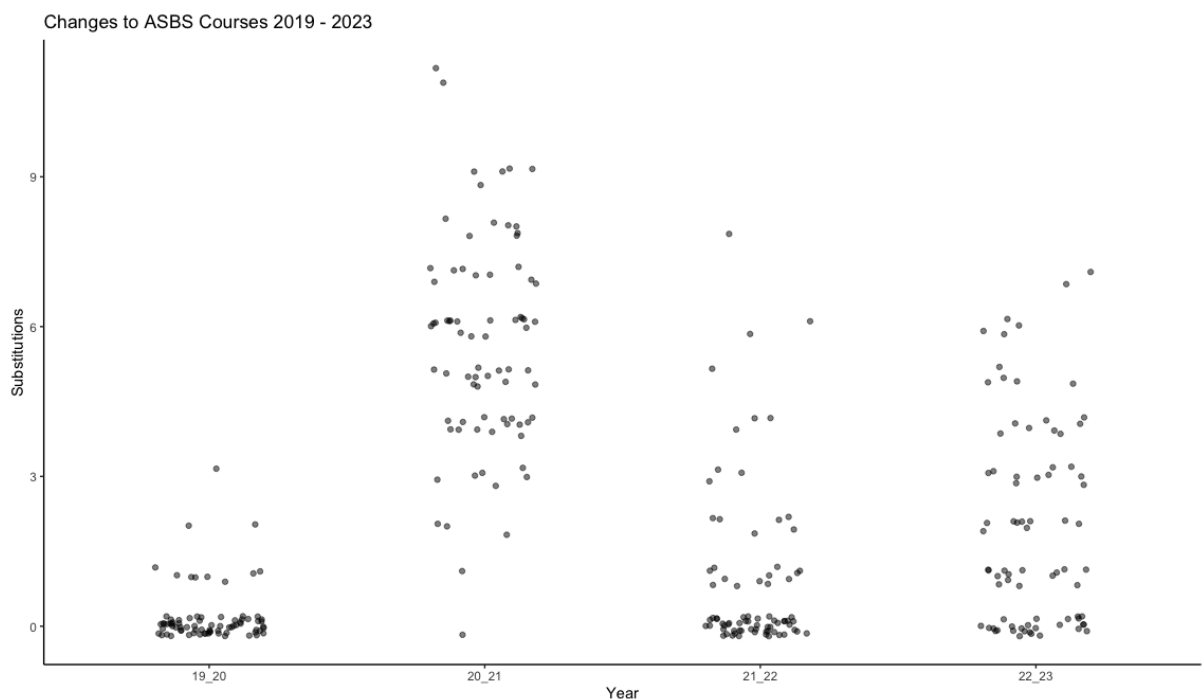


Figure 5 – Course substitutions

The graph demonstrates the number of changes made to courses as the recorded substitutions according to the character matrix described in the Methodology section. Each dot represents a single course in the Academic Year 19/20, 20/21 etc. Substitutions (on the y axis) are changes made since the previous year.

The plot at Figure 5 allows the full dataset to be seen, rather than reducing the data to a few statistics, such as a mean. This shows where taxa cluster in each year. In most years, the taxa cluster around zero substitutions (except for Academic Year (AY) 20/21 when all courses were taught completely remotely). This supports a parsimonious interpretation of change where course leaders make minimal changes to courses. In AY 19/20 (the year before Covid-19 impact) there is variation with up to three substitutions made on some courses. This aligns with the narrative of digital drift where teaching gradually incorporates new technologies in an unstructured and unplanned way (Tesar 2020). It also supports the cultural evolution perspective where traditions are subject to random variation. The following year, there is a noticeable increase in substitutions with no discernible clustering. Given that only two substitutions are strictly required to change courses to remote teaching, there appears significant effort into restructuring courses during this period. The following year (21/22) sees a return to clustering around zero substitutions as lock-down restrictions were still in place. However, there is more change than during AY19/20, perhaps to allow for learning from experience from the previous year. There was also some limited face-to-face teaching for small groups in this year. In AY 22/23 the University resumed campus-based teaching. Although we may speculate that this would trigger big changes, the amount of substitutions are more modest than AY 20/21 and cluster around zero. The picture is confused by a few larger changes in courses that seized the opportunity to return to a very traditional approach by removing asynchronous material. However, the plot demonstrates that conservatism was more prominent after the period of remote teaching, that is many courses did not remove remote teaching additions from earlier years. Table 2 shows the mean amount of change per year, measured in substitutions and the minimum number of substitutions required in each year. To change to remote teaching (or back to campus), a minimum of two substitutions are required: removal of campus lectures and the addition of a replacement method (or vice versa). In other years, no substitutions are required. On average academics made changes quite close to the minimum required.

Academic Year	Minimum substitutions required	Mean (substitutions)	Mode (substitutions)
19/20	0	0.19	0
20/21	2	5.56	6
21/22	0	0.89	0
22/23	2	2.01	0

Table 2 – Substitutions made and required

In most years, the amount of change experienced was conservative and close to the minimum required. In AY 20/21, however, the amount of change was significant and could not be described as parsimonious. As Figure 5 shows, however, the average was raised by a few courses which

demonstrated remarkable levels of change (up to 11 out of a possible 16 substitutions). The shift to remote teaching and asynchronous development was also strongly encouraged by the school. The mode number of substitutions presents a more conservative response (except for AY20/21), indicating that most courses experienced very little change in most years. The year the University returned to campus was subject to the most conservative change. Returning to traditional teaching would require the return of campus-based lectures and, additionally, the removal of asynchronous materials. Only a few courses went to these lengths, resulting in many blended courses as a result. This narrative could be more easily described as a 'new normal' than a 'return to normal'.

Phylogenetic trees

Phylogenetic trees for Academic Years (AY) 18/19 - 19/20, 18/19 – 20/21 and so on were constructed. These are shown at Figure 6 (below). The purpose of this analysis is to visualise the amount of change (in terms of evolutionary distance) and the nature of that change. These visualisations are based on evolutionary distance and clustering, rather than the simple substitution analysis above.

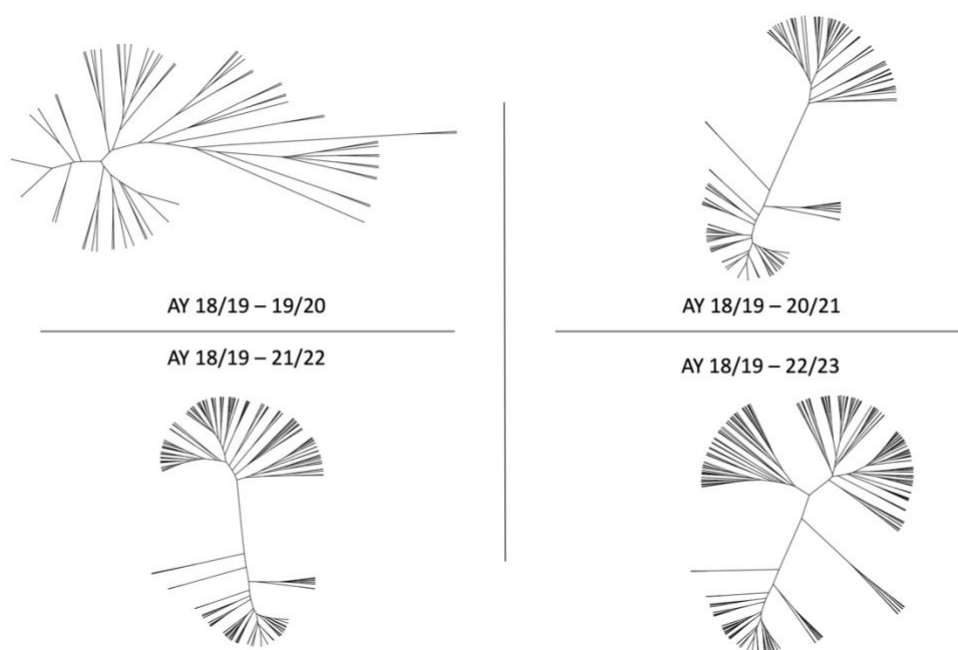


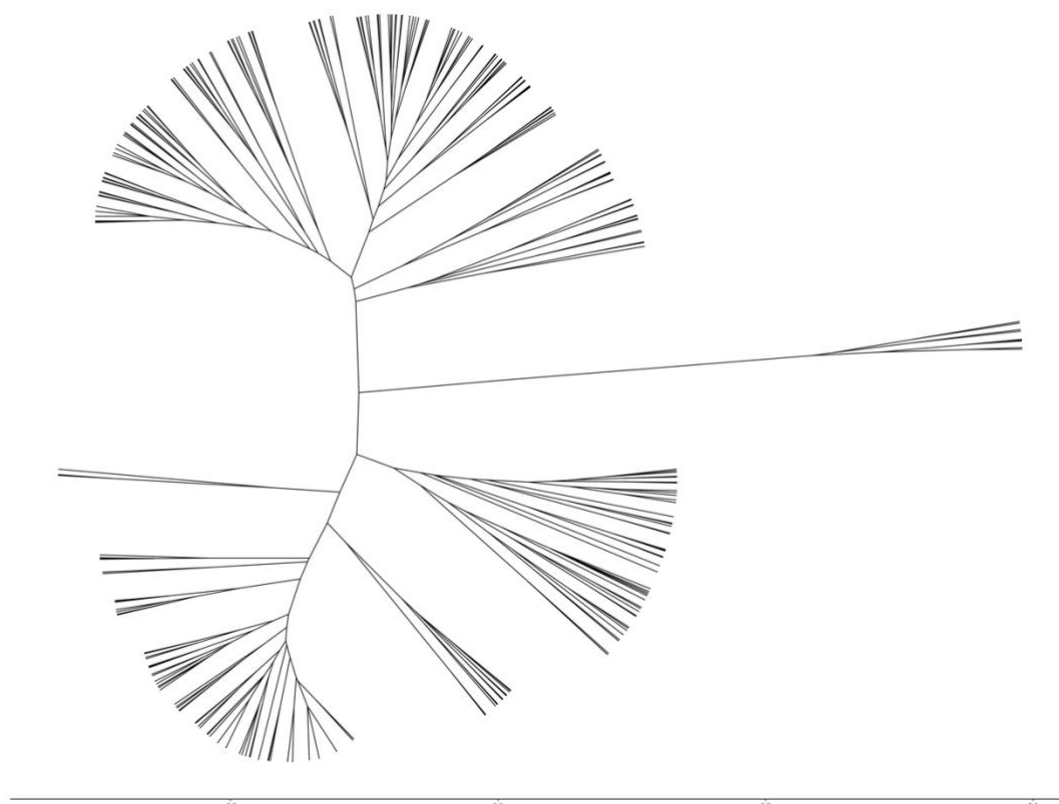
Figure 6 – Phylogenetic trees of business courses 2018 - 2023
The trees above are organised to show the evolutionary change in 102 ASBS courses from the base AY 18/19, adding a year's changes in each tree until AY 22/23. The trees are constructed from distance tables which are then clustered using the UPGMA technique.

The visualisation shows the development of clusters of practice over the period. By AY22/23 there are four distinct conglomerations which develop

from a broader spread of approaches emerging over the Covid-19 pandemic. This demonstrates that the evolution of courses from the beginning of the pandemic was not a single-year event. Rather, there is a clear response to the introduction of remote teaching (also recorded in the jump in substitutions (see figure 5)), but further development over the following two academic years, until very distinct clusters of practice emerge. It is remarkable that in the final year, courses returned to campus, but this did not instigate a change in teaching practice. The base year, AY 18/19 also shows a degree of clustering which became more distinct later. This supports an argument that the pandemic merely reinforced an existing ‘digital drift’ of teaching traditions.

Figure 7 (below) shows the phylogenetic tree, for the whole period, shown with the original campus-based courses uppermost. This shows the evolutionary distance (shown by the length of the connecting edges, which can be compared with the scale) from the original traditions to the various iterations of course formats over the period of Covid-19. The scale of evolutionary change centres on zero, with courses evolving in opposite directions. This shows how changes were not driven a unified strategy, since very different responses resulted.

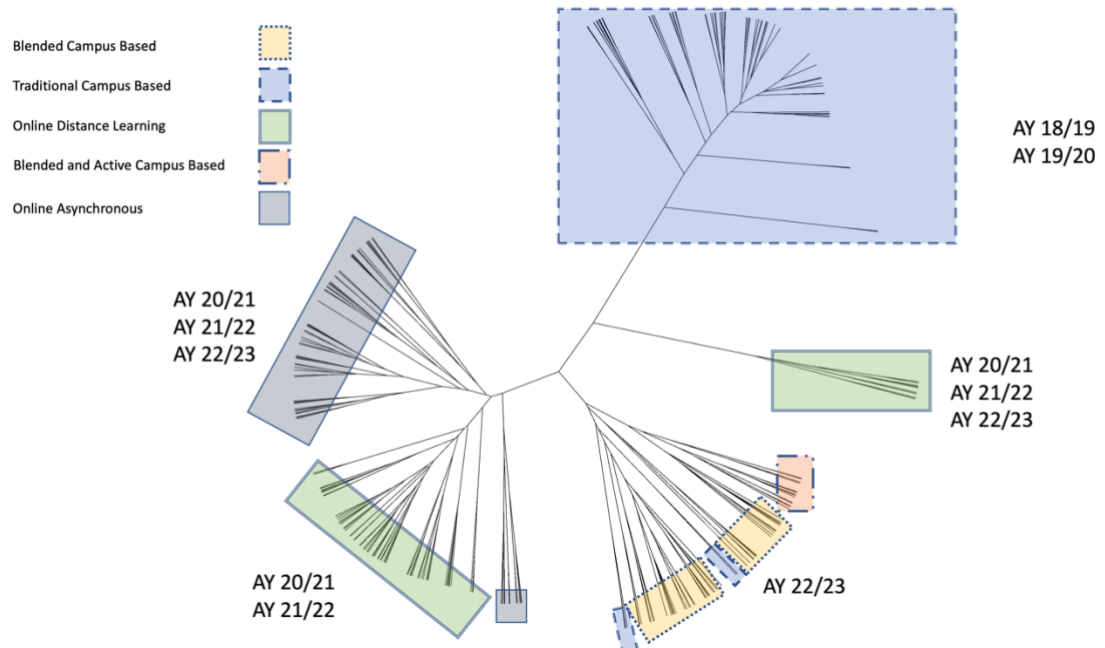
Phylogenetic analysis of ASBS courses 2018 - 2022



*Figure 7 – Unrooted phylogenetic tree of business courses 2018 – 2023
The tree shows a cluster of traditional campus-based courses from pre-Covid-19 uppermost. The branches and clusters below are alternative formats which evolved*

over the crisis. The scale of evolutionary change at the bottom of the graph shows that clusters of courses evolved in opposing directions.

More detail can be added by comparing the course codes (not shown on these illustrations) to the original dataset which also includes data on the course format, this is shown at Figure 8 (below):



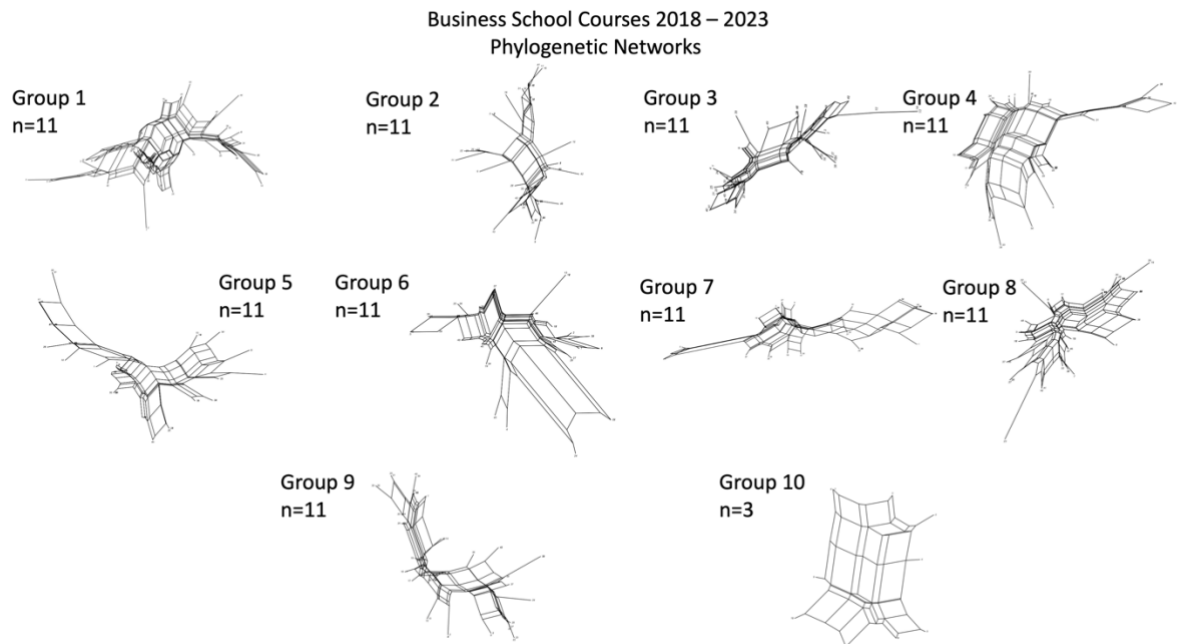
*Figure 8 – Detailed phylogenetic tree of business courses 2018 – 2023
This shows the tree with added detail from the original dataset which identifies the formats of the various clusters*

Figure 8 shows that courses between 2020 and 2022 were online (mostly in the bottom left of the tree) but some were asynchronous, while others blended both synchronous and asynchronous material as well as active learning techniques to create courses like online distance learning (ODL). Notably, some courses in these clusters remained online after the return to campus in 2022. The cluster in the bottom right part of the tree are an assortment of blended and active campus-based courses. Most courses in 2023 were characterised by campus-based lectures with legacy asynchronous materials, making them effectively blended courses. Some courses returned to a solely campus-based synchronous format.

Phylogenetic Networks

Due to the computational complexity of the NeighbourNet algorithm, it is only possible to analyse small groups of courses, rather than 102 courses simultaneously. Because the evolution of courses is not dependent on assessing all taxa, this is not an analytical limitation. The courses evolve independently, the aim of the analysis is to discover the degree of evolutionary change across courses and not to assert a genealogy of

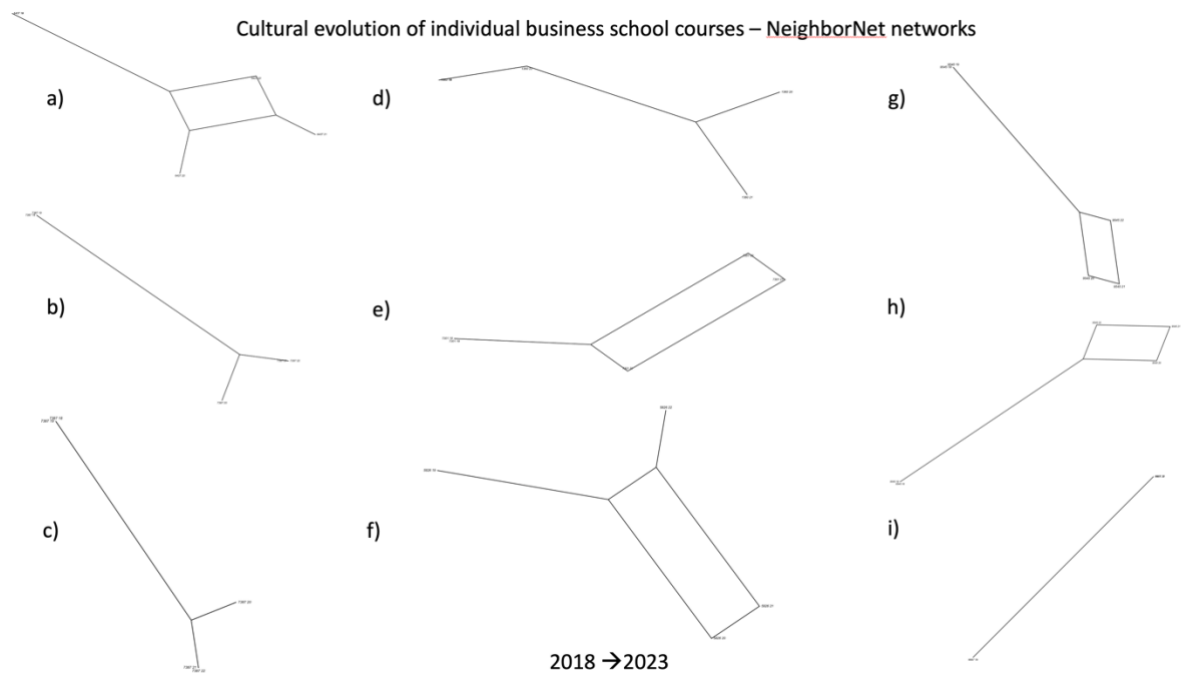
courses. Therefore, the courses were split into groups of 11 (with a final group of 3) for an initial analysis. Each course was also analysed individually. The initial analysis is shown at Figure 9 (below):



*Figure 9 – NeighborNet networks of business courses 2018 -2023
The graph shows 10 phylogenetic networks of randomly assorted business courses and their cultural evolution over five years. The groups were split into 11 taxa for computational reasons, leaving a single smaller group of 3.*

The networks are used to analyse the degree to which courses had phylogenetic signals (linear evolutionary change) and ethnogenetic signals (horizontal transfer of ideas). All the networks show some degree of phylogenesis, which is indicated by the longer leaves seen emerging from the main body of the network. These leaves could indicate large and sudden change. However, all the networks are dominated by blocky or square connections, showing ethnogenesis or horizontal transfer. This shows the widespread sharing of ideas and techniques (hybridisation) which occurred through most of the period. This is indicative of widespread improvisation and imitation.

Individual course analysis was also undertaken. This was conducted on courses which ran over the whole period, omitting courses which did not run each year. A sample was generated by running the NeighborNet algorithm for successive courses until the exercise failed to generate any new network shapes and theoretical saturation was achieved. A sample of 9 courses is given at Figure 10 (below) to represent significant themes from the dataset.



*Figure 10 – Phylogenetic networks of 9 sample business school courses
The networks are based on the NeighborNet algorithm and demonstrate the
evolution of each course from 2018 to 2023 (from left to right)*

The sample at Figure 10, is representative of the network types from the entire dataset of networks ($n = 102$). A common pattern seen at networks a), e), g) and h), consists of a strong phylogenetic signal seen as a tail on the left side, and a box on the right. This indicates early and significant change, followed by extensive consolidation through sharing teaching techniques. Another common pattern (seen at b), c) and d)) has a long tail with fork structure on the right-hand side. This indicates a large change followed by alternate strategies employed in the following years. In network d), there is reticulation so the 2022 instance is much closer to the years 2018 and 2019 than years 2020 and 2021. Finally, network i), shows a large change and then no change at all in the following years.

Discussion

This research shows that HEIs are more resilient than predicted by ERE researchers prior to the pandemic (e.g. Meyer and Wilson 2011). This resilience comes from the persistence of teaching traditions which both respond to change and retain their form. It would be an exaggeration to suggest this is a *pivot online* since the response was unstructured, and more like improvisation and imitation. I posit that a similar response may result from future crises, such as the emerging dilemma surrounding AI in education. It would also be an exaggeration to suggest the response would be pedagogical at all, rather a haphazard selection of existing approaches and technology seems likely. Business continuity plans generate structured responses to crises but this relies on a strategic approach and close control of human resources. Neither is characteristic of HEIs. However, a framework of resources with guidance does appear to have worked well in the context of the business school. This supported the period of innovation by allowing some structure while retaining academic autonomy, and preserving teaching traditions. An example of a similar response might be to create a set of teaching resources to transform assessment in HE, in response to a threat from generative AI. Presently HEIs are focussing on a policy response (Rudolph *et al.* 2023), however a more flexible course of action would allow academics to improvise new assessment formats without impacting on the essential traditions underpinning their teaching.

These analyses are not predictive of specific courses of action in a crisis. Indeed, the business school took the unusual step of promoting asynchronous teaching, in contradiction to the general preference for synchronous videoconferencing during the initial lockdowns in 2020 and 2021 (Bond *et al.* 2021). The analysis instead explores the assumption from cultural evolution that innovation is blind and conservative (Blute 2010). Reviews of ERE during Covid-19 already support the assessment that response to the crisis was unstructured and unsupported by institutions, rather than purposeful strategic reactions (Oliveira *et al.* 2021). The aim of my research is to evaluate what happens when a clear framework for change is promulgated by the institution. In this scenario, we might expect something closer to the 'pivots' advocated by HE optimists at the beginning of the crisis.

However, my analysis shows the actual case was more nuanced than either approach would predict. The overall degree of change was large at the beginning of the lockdown period. This might suggest a 'huge leap forward' or a 'pivot online'. However, the change was unstructured. The framework of resources established by the school created a wealth of new teaching techniques, which were widely imitated. It appears that an array of responses occurred, a large and unstructured experimentation with novel online techniques. The choice of techniques was not uniform across the school, subjects or programmes. This was followed by inertia as courses returned quickly to something quite close to pre-covid random variation and

changes made earlier were locked in. The analysis shows that a 'return to normal' did not occur and that teaching at the school was irreversibly changed.

In this discussion, I will outline how my data and analysis supports the notion of digital drift raised by Westera (2004) and Tesar (2020) and predicted by sociocultural evolutionary theory (e.g. Blute 2010). This will be followed by a discussion reflecting on prominent narratives of the crisis around a 'return to normal', 'pivots' and the 'new normal'. I will show how the 'pivot online' and a 'return to normal' was, at best, a forlorn hope; but 'new normal' narratives were insightful. I will then delve into the types of change that occurred with a view to outlining how institutions might plan realistic responses to future crises. I will then turn to the role of the institution in supporting academic adaptations. In this section I will contrast the school response to the wider response in HE. This analysis demonstrates the role of guided innovation, specifically a framework for imitation, to overcome the natural conservatism of teaching traditions. In the following section, the role of collaboration, imitation and improvisation is discussed, leading the discussion towards an appreciation of the intrinsic resilience of HEI. I make the point, here, that contrary to popular narratives, the much-reported inertia of education establishments makes them tougher. Towards the end of the section, I will outline how all this makes a contribution to the field of ERE and how a evolutionary framework creates a new and insightful perspective on educational catastrophes. Finally, I will outline the limitations of the study.

Digital Drift

The analysis of substitutions shows a small amount of random variation in the year prior to the Covid-19 crisis. While the mean level of substitution was extremely low (0.19), it should be noted that there was no requirement for any change at all. There were no school, subject or programmatic reviews or accreditation visits in that year, that might have supported the view that the changes were deliberate or managed. Changes correlated most with a change of course convenor, which at an organisational level, may be considered as random. The type of substitutions appear to be based on preference and always involved the addition of some new method, e.g. online quizzes. This supports the view expressed by Westera (2004) and Tesar (2020) that HE is highly resistant to change while also experiencing an unstructured drift towards adopting technology where it is convenient to do so. This is also supported by theories of cultural evolution which predict a randomised drift of cultural features in much the same way genes drift without any external selective force (Blute 2010).

Pivots, returns to normal and the new normal

The same analysis highlights a very healthy response to the lockdowns and the need for remote teaching. Far from simply switching to synchronous videoconferencing, the business school executed an impressive reaction to the crisis, adopting an array of techniques from ODL. The mean and mode

number of changes was 6, whereas the minimum was 2 changes (which is the minimum substitutions for synchronous videoconferencing). Here, the school clearly departed from a minimal response. This was encouraged by the school who created strategies and standards around asynchronous delivery and then further assisted by the peer-development of a framework of ODL resources (Honeychurch and Offord 2021). The resulting courses were far closer to purposely ODL courses than is reported elsewhere in HE. However, a pivot suggests a conscious and reversible decision to a specific strategic option. In this case the changes were unstructured and varied. The courses did not simply pivot back to the pre-covid normal. The stickiness of these changes suggests that academics were reluctant to reverse the changes made, by removing digital content. It seems they preferred to remain as blended courses. This supports a new normal narrative and supports the commentary of the time, that everything would change after the pandemic. The response is predicted by punctuated equilibrium, a significant finding since this has not been widely researched in cultural contexts (Mesoudi 2016, p, 151). Imitation clearly plays a role, as seen in the extensive 'borrowing' of techniques between courses and this supports Blute's observation that the neglect of Tarde's attention to imitation in sociological research is regrettable (Blute 2022).

The phylogenetic networks at Figure 9 show how an early surge in change quickly gave way to consolidation and, in some cases, reticulation to an earlier state of the tradition (e.g. campus-only courses). Other courses remained in a lockdown form of remote teaching. For the most part, courses fell into a form of blended learning, although the analysis does not support any pedagogical planning behind this.

Forms of improvisation

The phylogenetic tree at Figure 8 shows a wide array of responses. Speculatively, I assess this to be supported by the framework instituted by the school which supported a diverse set of responses (see Honeychurch and Offord 2021). The observation is well founded, given the global response was, in almost all cases, a shift to synchronous videoconferencing (Bond et al. 2021, Oliveira et al. 2021). The framework became a kind of 'cheat sheet', allowing extensive imitation.

A large cluster of courses (see Figure 8) are exclusively from the final year of analysis. This cluster consists of courses using blended and active techniques as well as a minority which returned to strictly traditional campus-based courses. Mixed with other years, some 22/23 courses also stuck to the asynchronous online course format, somewhat like ODL courses offered by other institutions (the business school did not offer ODL programmes until 20/21 and only one programme exists to date). Between the pre-covid period and 2023, courses took on a wide variety of forms. These forms do not follow any set plan or pedagogy, suggesting the choice of response was random. After the initial response to the crisis, the amount of change

(measured by substitutions) calms down rapidly. There is a period of consolidation which is not disturbed by the ultimate return to campus. In fact, the ability to return to physical teaching, does not greatly impact the diversity of teaching traditions.

The period of rapid change, bracketed by periods of stability is reminiscent of *punctuated equilibrium*, an observation that organisms show similar change profiles in biological evolution. Alex Mesoudi makes a number of comparisons with cultural evolution in this respect (e.g. see Mesoudi 2016, p.151). The substitution data, combined with the diversity of forms illustrated by the phylogenetic trees, describes a period of digital drift punctuated by a frenetic period of improvisation.

Imitation

The business school response varies wildly with the wider picture in HE described by ERE researchers (e.g. Bond et al. 2021, Oliveira et al. 2021). While the data considered here sheds no light on the reason for this, I was aware that the school developed an extensive framework of resources to help academics 'self-teach' online teaching methods. Indeed, I was instrumental in creating the resources and co-wrote a case study of the project (Honeychurch and Offord 2021). The school response therefore drew on a range of resources not available in many other institutions. The framework is of interest as it did not set out to create external support in the form of new technologies and expertise to implement it. Resource intensive support, in the form of teaching teams, learning technologists, videographers etc. are available to institutions that routinely deliver ODL (Oliveira et al. 2021; Johnson et al. 2020). This kind of resource takes time to marshal and was beyond the reach of most traditional institutions at the time of the early Covid-19 pandemic (Oliveira et al. 2021). The use of the framework, therefore, highlights the imitation option and allows me to assess whether this supported the business school to accomplish the 'pivot online' and, if not, what contingencies were achieved. It also allows me to consider an alternative to the random variation of tradition suggested by cultural evolution. I cannot provide evidence that the framework was extensively referenced, however, changes correlate with the techniques outlined in the framework. The analysis does evidence extensive imitation, whether or not this was from the framework, external resources, other academics or a mixture. However, the number of academics with ODL experience was very limited, this seems to be the least likely source of imitation.

The diversity of responses which included blended learning, active learning and entirely asynchronous online courses, was at odds to that reported by ERE commentators (e.g. Bond et al. 2021). However, the lack of structure around the response leads me to conclude that improvisation was more prevalent than any kind of pivot. A deliberate pivot would presumably have been reversed when the campus became available once more. This did not happen.

In conclusion, although innovation was supported by the leadership and from extensive collaboration, the ultimate response was unstructured. Attempts to guide improvisation towards asynchronous course design was only partially successful, as many courses tempered the call for asynchronicity (required by the framework) with synchronous videoconferencing. It seems the traditional requirement for real time teaching was too much of a stretch for many course convenors. Therefore, the response was influenced slightly by institutional guidance, and tradition, but it was largely unstructured.

Improvisation in action

The networks at Figure 9 demonstrate a great deal of horizontal transfer of ideas between randomly sampled groups of 11 courses. It is important to note that these courses could not have shared a strictly evolutionary path. That is, all the courses in my dataset evolved independently. Academics did not collaborate on specific courses to an extent that would affect the evolution of a group of courses together. There was no evidence of programmatic direction to course convenors to create similar courses over this specific period (presumably this does occur periodically as programme directors have to make their programme coherent). However, all academics did share access to resources which could be copied into their courses.

This shared knowledge can be seen clearly in the horizontal transfer of ideas, known as ethnogenesis, in the networks. The blocky areas of the network graphs show where courses shared similar patterns of teaching traditions. While it is very unlikely academics collaborated directly, they are sharing a common resource and the evidence of this is clear in the networks. Since academics worked together on the framework (Honeychurch and Offord 2021), the ethnogenetic signals can be interpreted as intense collaborative improvisation and imitation. The individual course networks at Figure 10, show that a more limited range of techniques was commonly used after the initial 'panic' of 20/21. This is a different form of ethnogenesis where academics appear to be sharing ideas from their earlier courses, consolidating by retaining or discarding traditions tried earlier.

The ethnogenetic analysis shows widespread collaboration and improvisation followed by continued imitation of ideas between courses and within courses, especially after the initial response. Overall, it suggests a common palette of teaching traditions, developed internally and used experimentally for a while before consolidation. This is also theoretically significant since cultural evolutionists have tended to assume a greater degree of hybridity in the evolution of modern technology but there is little research in this area (Mesoudi 2016, p.102).

Resilience

The business school, like so many HEI (and other organisations) was unprepared for the pandemic. Businesses often create business continuity

plans for such events, but this was not the case in HE (Karlsson and Offord 2023). This lack of preparation was noted as a serious weakness in the wake of the H1N1 pandemic scare (Oliveira et al. 2021) but little remedial action took place. However, the business school did respond to the crisis by creating its own framework to guide the response. Although, guiding principles were set out, much of the work to create the framework was a bottom-up 'bricolage' of techniques (Honeychurch and Offord 2021). The impact of the framework, measured through this phylogenetic network analysis was an impressive response to the crisis through changes that were far greater in number than strictly required. The analysis also shows a wide array of reactions to the crisis. The extent and diversity of the remedial work to get teaching back on track, then, was impressive and shows intrinsic resilience at the school.

From my position in the eye of the storm in our business school in 2020, I viewed resistance to change from colleagues as self-sabotage, while rolling my eyes at the *pivot online*. On the one hand, colleagues seemed genuinely powerless to adapt and on the other, they courted hopeless fantasies of salvation. Yet the persistence of tradition appears to be source of great resilience. The teaching traditions within HE are a source of identity and also the basis for change, since innovation is based on old forms (*descent with modification*). The hopeless leap to ODL, resulted in a kind of halfway position which, although painful, did bring change and genuinely brought about new teaching techniques.

These findings are a counterpoint to the gloomier predictions from ERE research (e.g. Bond et al. 2021) and the presumed conservatism of cultural evolution (Blute et al. 2010). However, the changes made were largely experimental and improvised, rather than a guided 'pivot' or strategic change. The investment in change, by developing new kinds of courses is likely to be protected by academics, leading to the changes becoming 'sticky' and irreversible. The organisation is resilient but also guards vested interests.

Contribution

This analysis has demonstrated several important modifications to thinking about crisis in HE from an ERE perspective and adds new understanding of evolutionary perspectives. The school clearly avoided the more common contingency of trading lectures for Zoom. It did so at minimal financial expense (although with considerable individual effort). This offers a new insight to the sometimes-pessimistic view from ERE research that, under duress, educational establishments will simply adopt videoconferencing. Although the school was unable to institute temporary learning spaces, as recommended by ERE research (Oliveira et al. 2021), it was able to explore a wide array of alternatives to Zoom. It is recommended that the use of internally created frameworks is researched in the field of ERE. It should be added that frameworks differ from business continuity plans, risk management plans and the like, which would presumably encourage a more

structured rehabilitation. However, the framework supports academic autonomy and resilience.

The concept that the Covid-19 pandemic was simply another chapter in the ongoing story of digital drift (Tesar 2020) is broadly supported since there is clear evidence of digital drift prior to and after the early response. The scale of change clearly accelerated but the types of change did not alter over the 5-year period, hence there is an argument that the pandemic did not radically alter HE's long-standing trajectory of inertia, resistance to change, conservatism and slow substitution. However, this analysis takes an extra step of comparing the sociocultural approach and pointing out that although change is slow and traditions are highly influential, they are also subject to periods of intense change through punctuated equilibria (Mesoudi 2016, p.151).

This study also supports policy planning in HE by demonstrating the effect of self-created frameworks as a possible alternative to more business-like risk management techniques. Although such frameworks are unlikely to exert control over an institution's response, they clearly support improvisation, imitation and resilience. These may be a far better bet than hubristic attempts to make strategic pivots. Broadly, the array of possible crisis responses is limited to existing institutional knowledge and technologies. The school did not create or adapt any novel techniques or traditions during this time. Rather, it exploited well known methods to improvise a response. In future crises, similar reactions are highly likely and policies can be written around this pragmatic idea, rather than ambitious 'moon shots'.

The findings of this research have important implications for the next crisis, the rise of generative pre-trained artificial intelligence (such as GPT-3 and GPT-4). An ongoing and heated debate is dominating HE (Rudolph *et al.* 2023) as to the impact of generative AI on assessment in HE. The range of suggested responses from banning chat bots to incorporating them (*Ibid.*) are another example of the kind of unstructured response catalogued from my dataset on remote teaching. My findings suggest that, if the AI crisis develops to the point of making traditional assessment obsolete, we will likely see a wide range of improvisations based on imitation, rather than a structured management plan, or strategy. Indeed, this already appears to have started (*Ibid.*).

Sociocultural theories of inertia and innovation as blind variation are supported, but this research also supports the theory of punctuated equilibria where change can escalate. This is an important contribution as examples of punctuated equilibrium are rarer in cultural studies than in biology (Mesoudi 2016, p.100). Additionally, Tarde's emphasis on the importance of imitation (Blute 2022) is fully supported by this research. Imitation is equally important in cultural evolution studies (Mesoudi 2016, p.190). Re-discovering the works of Gabriel Tarde might, therefore, provide a useful theoretical

synthesis of social theories of innovation and a counter-balance to positivistic, Durkheimian approaches that remain so influential.

Finally, this research demonstrates that the inertia commonly reported in Higher Education as a blight or shortcoming, is the source of considerable resilience. The persistence of teaching traditions, coupled with an ability to rapidly improvise, is at the heart of the fortitude shown by the business school, although this came at a cost like many other HEIs (Oliveira *et al.* 2021). There is a protective culture which is undoubtedly highly important to the future of HE. It also demonstrates that this protection does not mean that HE cannot, or will not respond to threats on the scale of a global pandemic. However, the nature of the HE response cannot necessarily be planned or controlled and can lead to unexpected results, such as irreversible changes and new normals.

Limitations

This research is not generalisable to other HE contexts. The business school in question clearly responded to the Covid-19 crisis in a way which is not typical of that reported in ERE research thus far (e.g. Bond *et al.* 2021). It could be viewed as a case study where its specificities offer insights (into the evolution of teaching traditions) but not predictions of how HE institutions respond to a specific crisis. Further research should be conducted into the use of internal frameworks for peer collaboration versus top-down contingency planning to discover whether such fall-backs are effective in HE.

The research is deductive, it uses *a priori* theories of cultural evolution, such as parsimony, modification with descent and punctuated equilibrium. While these theories explain the data, the results are nuanced and likely specific to the business school. The visualisations of the data as trees and networks are descriptive but allowed me to deduce a range of case-specific responses to the crisis. The theoretical framework (sociocultural evolution) offers no specific predictions, just guidelines, suggesting teaching traditions have inertia but can experience sudden change. Cultural complexity means that universal truths and predictions are extremely unlikely. Future research should incorporate multiple contexts to discover what, if any, patterns are repeated from this analysis.

Conclusion

The Covid-19 pandemic is a public health disaster resulting in an estimated 6.9 million deaths so far (WHO 2023). Additionally, the pandemic has impacted on economic stability, education, society, and global politics. In education, the removal of physical teaching spaces threatened to overthrow the organising principle of teaching practice since medieval times (Smith 1998, Westera 2004). ERE researchers gauging HE readiness for a pandemic based on the H1N1 scare cast severe doubt that universities could respond to a pandemic (Meyer and Wilson 2011). Scepticism was warranted given that educational researchers had already pointed out that HEI were incredibly resistant to change (Westera 2004). Yet, early in the crisis, a narrative emerged of a 'pivot online' (Nordmann 2020). The failure of this plan is well documented; ODL was too big an undertaking and HEIs lurched, instead, into a haphazard shift to remote teaching (Oliveira et al. 2021).

But was the call for a pivot online hopelessly naïve and doomed to failure? Can educational technology substitute elements of teaching delivery in a straightforward manner? Westera (2004) noted that despite the inertia in HE, substitutions of classroom elements with digital alternatives had been occurring in an unstructured way, for decades (writing 20 years ago). Tesar (2020) also note the same digital drift and posit that Covid-19 was nothing more than a continuation of this trend. Therefore, could the campus be substituted with educational technology? Hamilton and Friesen (2013) note that neoliberal solutioneering assumes an instrumental and essentialist attitude to technology. Educational technology is assumed to be a good fit for educational problems (instrumentalism) and, in any case, always an improvement in the situation (essentialism). This 'silver bullet' approach surely underpinned the call for a pivot online. Its failure, therefore, surely must be a wounding blow to instrumentalism and the assimilation of HE by educational technology companies?

The business school in my study got a little further with the pivot online than was commonly reported in HEIs (Bond et al. 2021). By developing a framework for promoting ODL techniques, the school was able to introduce several asynchronous online features, blended and active learning. While it is doubtful these courses were close to the production values of established ODL establishments, it demonstrates universities can respond rather more effectively than simple synchronous videoconferencing. Sociocultural evolutionary theories warn us that genuine innovation is both rare and blind. We might, therefore, be cautious about proclaiming the school to have responded with strategic insight and adaption to the new circumstances. Indeed, this research shows that response was impressive but essentially random improvisation. Changes were frozen as inertia reasserted itself after the early stages of the pandemic.

Yet this punctuated equilibrium of an otherwise gentle drift towards digital, is a source of great resilience which guided the school to successfully make permanent changes in its capacity for online, blended and active learning. The school did not have business continuity plans but instigated a framework of resources instead. The framework supported academic autonomy while allowing intensive imitation, collaboration and improvisation followed by consolidation of new traditions. The adaption was similar to the flexible imitation reported in traditions research (Morin 2015. P.122). My research shows that considering teaching as a tradition is a useful perspective, as it invokes conservatism and resistance to change while allowing for periods of rapid (but random) improvisation. This response is not only realistic, but also pragmatic since pivots are a forlorn hope.

This demonstrates that HEIs can be more responsive to calamities than perhaps than commentators believe. This resilience comes not from an innovative culture but the persistence of teaching as a profoundly human social tradition and the role of imitation in the diffusion of new ideas. While this has been a cause of much frustration with education in general, it is also its greatest strength. This is because the conservation of tradition is not absolute or inflexible, but subject to constant, if minimal, change. Digital drift, in this case, furnished educators with the technology they needed to survive what was initially seen as an existential threat. Additionally, and perhaps unexpectedly, this study shows that a business school was able to initiate a spectacular demonstration of improvisation that went far beyond a conservative shift to remote teaching. It is therefore, possible to punctuate the equilibria which dominates HE. In this case a suite of new techniques were added. The dense network of information surrounding the changes (demonstrated by the network diagrams) show how this information was imitated between courses. My study does not prove that this information came directly from the framework devised by the school, but comparison with the norms discovered by ERE researchers (e.g. Bond *et al.* 2021) makes it very likely.

It is important to point out that this period of improvisation was not structured or under control in any sense. I can rule out any kind of strategic response including the so-called *pivot online*. This was not a deliberate plan, it was more like experimentation. Additionally, changes that were made were *sticky*, they were largely retained. The result was an accidental blending of campus-based courses with asynchronous digital content. Now this genie is out of the bottle. This was a genuine evolutionary event, the system has now resumed its digital drift, until the next crisis.

15122 words

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Appendix one: mathematical models used for phylogenetic analysis

For a fuller explanation of phylogenetic analysis see Huson *et al.* (2010).

Recall the hypothetical course 3145 from the Methodology section:

Character	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
3145_18	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0
3145_19	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0
3145_20	1	0	0	1	0	0	1	0	1	1	1	1	1	1	0	0
3145_21	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1
3145_22	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0

Table A1.1 Character matrix for hypothetical course 3145

The distance table records evolutionary distances between taxa. This is calculated by counting the number of substitutions required to render two taxa the same. In other words, how many characters are different between two instances of a course. For example, from the table (above) we can see that 7 changes would be required to make the 2018 and the 2019 courses the same. Hence the evolutionary distance between these two courses is 7. Mathematically this is expressed:

$$diff(x, y) = |\{i | x_i \neq y_i\}|,$$

*Evolutionary distance (also known as the Hamming Distance) is the difference between two sequences x and y where for a certain index number i , the number of instances where x is not identical to y are calculated (Huson *et al.* 2010, p.33).*

The corresponding distance table is shown at the table (below):

	18	19	20	21	22
19	7				
20	11	6			
21	15	8	4		
22	13	6	4	2	

Table A1.2 – Example distance table

The table shows Hamming distances between instances of a hypothetical course in each year from 2018 to 2019

The NeighborNet algorithm assesses the splits S by deriving the weighted splits from the distance table using the following equation:

$$S = \{x_p, x_{p+1} \dots x_q\} / X - \{x_p \dots x_q\}$$

The splits S are the result of the specific set of instances of x divided by the complete set of instances minus the same specific set.

Appendix two: character matrix for 102 business courses 2018 - 2023

Taxa	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16	Year
6437_18	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	2018
6437_19	0	1	0	1	1	0	1	0	0	1	1	1	0	0	0	0	2019
6437_20	1	0	0	1	0	0	1	0	1	1	1	1	1	1	0	0	2020
6437_21	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	2021
6437_22	1	1	1	1	1	0	1	0	1	1	1	1	1	1	1	0	2022
7387_18	0	1	0	1	1	1	0	1	1	0	1	0	0	0	0	0	2018
7387_19	0	1	0	1	1	1	0	1	1	0	1	0	0	0	0	0	2019
7387_20	1	0	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2020
7387_21	1	0	0	1	0	1	0	1	1	1	1	1	0	0	1	0	2021
7387_22	1	0	0	1	0	1	0	1	1	1	1	1	0	0	1	0	2022
0000_18	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	2018
0000_19	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	2019
0000_20	0	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
0000_21	0	0	0	0	1	1	0	1	0	0	1	0	0	0	1	0	2021
0000_22	0	0	0	0	1	1	0	1	0	0	1	0	0	0	0	0	2022
1360_18	0	0	0	1	1	1	0	1	1	0	1	1	0	0	0	0	2018
1360_19	0	0	0	1	1	1	0	1	1	0	1	1	0	0	0	0	2019
1360_20	1	0	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2020
1360_21	1	0	0	1	0	1	0	1	1	1	1	1	0	0	1	0	2021
1360_22	1	0	0	1	1	1	0	1	1	0	1	1	0	0	0	0	2022
0063_20	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2020
0063_21	1	1	0	1	0	1	0	0	0	1	1	0	0	0	1	0	2021
0063_22	1	1	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2022
8205_18	0	0	0	1	1	1	0	1	1	0	1	0	0	0	0	0	2018
8205_19	1	0	0	1	0	1	0	1	1	1	1	0	0	0	0	0	2019
8205_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
8205_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
8205_22	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2022
7301_18	1	0	0	1	1	1	0	1	1	0	1	0	0	0	0	0	2018
7301_19	1	0	0	1	1	1	0	1	1	0	1	0	0	0	0	0	2019
7301_20	1	1	0	1	0	0	0	1	1	1	1	1	0	0	0	1	2020

7301_21	1	1	0	1	0	0	0	1	1	1	1	1	1	0	1	1	2021
7301_22	1	0	0	1	1	0	0	1	1	1	1	0	1	0	1	0	2022
9910_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
9910_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021
9910_22	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2022
9466_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
9466_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
9466_20	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2020
9466_21	1	1	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2021
9466_22	1	0	0	1	1	1	0	1	1	1	1	1	0	0	1	0	2022
7649_20	1	1	0	1	0	0	1	0	1	1	1	1	1	0	0	0	2020
7649_21	0	0	0	1	1	1	0	1	1	1	1	0	0	0	1	0	2021
7469_22	0	0	0	1	1	1	0	0	1	1	0	0	0	0	1	0	2022
9545_18	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	2018
9545_19	0	0	0	1	1	1	1	0	1	0	0	0	0	0	0	0	2019
9545_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
9545_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
9545_22	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	0	2022
2294_20	1	1	1	1	0	0	1	1	1	1	0	1	1	1	0	0	2020
2294_21	1	1	1	1	0	0	1	1	1	1	0	1	1	1	1	0	2021
2294_22	1	1	1	1	1	0	1	1	1	1	0	1	1	1	1	0	2022
1914_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
1914_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2021
1914_22	0	0	0	1	1	1	0	1	1	1	1	0	0	0	0	0	2022
3886_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
3886_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
3886_22	1	1	0	1	0	1	0	1	1	1	1	0	1	1	1	0	2022
4684_18	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2018
4684_19	0	0	0	0	1	1	0	0	0	0	0	0	0	0	0	0	2019
4684_20	1	0	0	1	0	1	0	1	1	1	1	1	0	0	0	0	2020
4684_21	1	0	0	1	0	1	0	1	1	1	1	1	0	0	0	0	2021
4684_22	1	1	0	1	0	1	0	1	1	1	1	1	0	0	0	0	2022
6687_18	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2018
6687_19	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2019
6687_21	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	2021
6687_22	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	2022
8931_21	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	2021
8931_22	1	0	0	1	0	1	0	0	0	0	1	0	1	0	0	0	2022
1275_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
1275_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021

1275_22	1	1	0	1	1	1	0	1	1	1	1	0	1	0	1	0	2022
1236_18	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2018
1236_19	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2019
1236_20	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	2020
1236_21	1	1	0	0	0	1	0	0	1	1	1	0	0	0	0	0	2021
1236_22	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2022
2662_18	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2018
2662_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019
2662_20	1	0	0	1	0	1	0	1	1	1	1	1	1	1	0	0	2020
2662_21	1	0	0	1	0	1	0	1	1	1	1	1	1	1	0	0	2021
2662_22	1	0	0	1	1	1	0	1	1	1	1	1	1	1	1	0	2022
7134_18	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2018
7134_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019
7134_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
7134_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2021
7134_22	1	1	0	1	1	1	0	0	0	1	1	0	1	0	1	0	2022
2355_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
2355_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
2355_20	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	2020
2355_21	1	1	0	1	0	1	1	1	1	1	1	1	1	0	0	0	2021
2355_22	1	0	0	1	1	1	1	1	0	1	1	1	0	0	1	0	2022
6679_18	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2018
6679_20	1	1	0	1	0	1	1	0	1	1	1	1	1	0	0	0	2020
6679_21	1	1	0	1	0	1	1	0	1	1	1	1	1	0	1	0	2021
6679_22	1	1	0	1	0	1	1	0	1	1	1	1	1	0	1	0	2022
3066_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
3066_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
3066_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
3066_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021
3066_22	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2022
2584_20	1	1	0	1	1	1	0	0	0	1	1	0	1	0	0	0	2020
2584_21	0	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2021
2584_22	1	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2022
2104_20	1	1	0	1	0	1	0	0	0	1	1	1	1	0	1	0	2020
2104_21	1	1	0	1	1	1	0	0	0	1	1	1	1	0	1	0	2021
2104_22	1	1	0	1	1	1	0	0	0	1	1	1	1	0	1	0	2022
3704_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
3704_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
3704_20	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
3704_21	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2021

3704_22	1	0	0	1	1	1	0	1	1	1	1	0	1	0	1	0	2022
4582_20	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
4582_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
4582_22	1	0	0	1	1	1	0	1	1	1	1	0	1	0	0	0	2022
3643_20	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	0	2020
3643_21	1	1	0	1	0	0	1	1	1	1	1	1	1	1	1	0	2021
3643_22	1	1	0	1	1	0	1	1	1	1	1	0	0	0	1	0	2022
2964_18	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	2018
2964_19	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	2019
2964_20	1	1	0	1	0	0	0	1	1	1	1	0	1	1	1	0	2020
2964_21	1	1	0	1	0	0	0	1	1	1	1	0	1	1	1	0	2021
2964_22	1	0	0	1	1	1	0	1	1	1	1	0	1	0	0	0	2022
5826_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
5826_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
5826_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
5826_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
5826_22	0	1	0	1	1	1	1	1	1	1	1	0	0	0	1	0	2022
6236_18	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	2018
6236_19	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	2019
6236_20	1	1	0	1	0	1	0	1	0	1	0	0	1	0	0	0	2020
6236_21	1	1	0	1	0	1	0	1	0	1	0	0	1	0	1	0	2021
6236_22	1	1	0	1	0	1	0	1	0	1	0	0	1	0	1	0	2022
1149_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
1149_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
1149_20	1	1	0	1	0	0	0	0	0	1	1	1	1	0	0	0	2020
1149_21	1	1	0	1	0	0	0	0	0	1	1	1	1	0	0	0	2021
1149_22	1	1	0	1	0	0	0	0	0	1	1	1	1	0	0	0	2022
1479_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
1479_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
1479_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2020
1479_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2021
1479_22	1	1	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2022
2357_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
2357_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
2357_20	1	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	2020
2357_21	1	0	0	1	0	1	0	1	1	1	1	1	1	1	0	1	2021
2357_22	1	0	0	1	1	1	0	1	1	1	1	1	0	1	1	1	2022
1238_18	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	2018
1238_19	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	2019
1238_20	1	1	0	1	0	1	0	0	1	1	1	0	1	1	0	0	2020

1238_21	1	1	0	1	0	1	0	0	1	1	1	0	1	1	0	0	2021
1238_22	0	0	0	1	1	1	0	0	0	1	0	0	0	0	0	0	2022
1579_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
1579_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
1579_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2020
1579_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
1579_22	1	1	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2022
1259_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
1259_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
1259_21	0	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2021
1259_22	0	1	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2022
6122_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
6122_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
6122_20	1	1	0	1	0	1	0	0	1	1	1	0	1	0	0	0	2020
6122_21	1	1	0	1	0	1	0	0	1	1	1	0	1	0	0	0	2021
6122_22	0	1	0	1	1	1	1	0	1	1	1	0	1	0	1	0	2022
6983_18	1	1	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
6983_19	1	1	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
6983_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
6983_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021
6983_22	1	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2022
6111_18	1	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	2018
6111_19	1	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	2019
6111_20	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	0	2020
6111_21	1	1	0	1	0	1	0	1	1	1	1	1	1	1	1	0	2021
6111_22	1	0	0	1	1	1	1	1	1	1	1	1	0	1	1	0	2022
9408_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
9408_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
9408_20	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2020
9408_21	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2021
9408_22	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2022
6071_19	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2019
5331_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
5331_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
5331_20	1	1	0	1	0	1	0	1	1	1	1	0	0	0	1	0	2020
5331_21	1	1	0	1	0	1	0	1	1	1	1	0	0	0	1	0	2021
5331_22	1	1	0	1	0	1	0	1	1	1	1	0	0	0	1	0	2022
8087_18	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	2018
8087_19	0	0	0	1	1	1	0	0	0	0	0	0	0	0	0	0	2019
8087_20	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020

8087_21	1	0	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2021
8087_22	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2022
6977_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
6977_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
6977_20	1	0	0	1	0	1	0	0	0	1	1	1	1	1	0	0	2020
6977_21	1	0	0	1	0	1	0	0	0	1	1	1	1	1	0	0	2021
6977_22	1	0	0	1	0	1	0	0	0	1	1	1	1	1	0	0	2022
9042_18	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	2018
9042_19	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	2019
9042_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2020
9042_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2021
9042_22	1	1	0	1	1	1	0	1	1	1	1	0	0	1	1	0	2022
8702_18	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	2018
8702_19	0	0	0	1	1	1	0	1	1	0	0	0	0	0	0	0	2019
8702_20	1	0	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2020
8702_21	1	0	0	1	0	1	0	1	1	1	1	1	1	0	0	0	2021
8702_22	1	0	0	1	1	1	0	1	1	1	1	1	0	0	1	0	2022
7544_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
7544_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
7544_20	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2020
7544_21	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2021
7544_22	1	1	0	1	0	1	0	0	0	1	1	1	1	1	0	0	2022
5485_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
5485_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
5485_20	1	1	0	1	0	1	0	0	0	1	1	0	0	0	1	0	2020
5485_21	1	1	0	1	0	1	0	0	0	1	1	0	0	0	1	0	2021
5485_22	1	1	0	1	0	1	0	0	0	1	1	0	0	0	1	0	2022
8728_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
8728_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
8728_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2020
8728_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2021
8728_22	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2022
1400_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
1400_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
1400_21	0	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2021
1400_22	0	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2022
2998_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
2998_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
2998_20	1	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
2998_21	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	0	2021

2998_22	1	1	0	1	1	1	0	0	0	1	1	0	0	1	1	0	2022
1317_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
1317_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
1317_20	0	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
1317_21	0	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021
1317_22	0	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2022
9387_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
9387_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
9387_20	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2020
9387_21	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2021
9387_22	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2022
1090_18	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	2018
1090_19	0	0	0	1	1	0	0	0	1	0	1	0	0	0	0	0	2019
1090_20	1	0	0	1	0	0	0	0	1	1	1	0	1	0	0	0	2020
1090_21	1	0	0	1	0	0	0	0	1	1	1	0	1	0	0	0	2021
1090_22	1	1	0	1	1	0	1	1	1	1	1	0	0	1	1	0	2022
5581_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
5581_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
5581_20	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	2020
5581_21	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	2021
5581_22	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	2022
7264_18	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
7264_19	1	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
7264_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2020
7264_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	1	0	2021
7264_22	1	1	0	1	1	1	0	0	0	1	1	0	1	0	1	0	2022
8861_18	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	2018
8861_19	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	2019
8861_20	0	1	0	1	0	1	0	0	1	1	1	1	1	1	0	0	2020
8861_21	0	1	0	1	0	1	0	0	1	1	1	1	1	1	0	0	2021
8861_22	0	0	0	1	1	1	0	0	0	1	1	0	0	1	1	0	2022
2627_18	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	2018
2627_19	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	2019
2627_20	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	2020
2627_21	1	1	0	1	1	1	0	0	1	1	1	0	1	1	1	0	2021
2627_22	0	0	0	1	1	1	0	0	0	0	1	0	0	1	0	0	2022
9110_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
9110_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
9110_20	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
9110_21	1	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021

9110_22	0	1	0	1	0	1	0	0	0	1	1	1	0	0	0	0	2022
3294_18	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	2018
3294_19	0	0	0	1	1	0	0	0	0	0	1	0	0	0	0	0	2019
3294_20	0	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	2020
3294_21	0	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	2021
3294_22	0	1	0	1	0	0	0	0	1	1	1	1	1	0	0	0	2022
6880_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
6880_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
6880_20	1	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
6880_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
6880_22	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2022
3372_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
3372_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
3372_20	1	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	2020
3372_21	1	0	0	1	0	0	0	0	0	1	1	1	1	0	0	0	2021
3372_22	0	1	0	1	1	0	0	0	0	1	1	0	0	0	1	0	2022
4024_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
4024_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
4024_20	0	1	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2020
4024_21	1	0	0	1	0	1	0	0	0	1	1	0	1	0	0	0	2021
4024_22	1	1	0	1	0	1	0	0	0	1	1	0	0	0	0	0	2022
8361_18	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	2018
8361_19	0	0	0	0	1	1	0	0	0	0	1	0	0	1	0	0	2019
8361_20	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	0	2020
8361_21	1	1	0	1	0	0	0	1	1	1	1	1	1	1	1	0	2021
8361_22	1	0	0	1	1	0	0	1	1	1	1	1	0	1	1	0	2022
7664_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
7664_20	1	1	0	1	0	0	0	1	1	1	1	0	1	1	1	0	2020
7664_21	1	1	0	1	0	0	0	1	1	1	1	0	1	1	1	0	2021
7664_22	1	1	0	1	1	0	0	1	1	1	1	0	1	1	1	0	2022
2263_18	0	0	1	0	1	1	0	0	0	1	1	0	0	1	0	0	2018
2263_19	0	0	1	0	1	1	0	0	0	1	1	0	0	1	0	0	2019
2263_20	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	0	2020
2263_21	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	0	2021
2263_22	1	1	1	1	0	0	1	0	0	1	1	1	1	1	1	0	2022
6628_18	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2018
6628_19	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2019
6628_20	1	1	0	1	0	0	0	0	0	1	1	0	1	0	1	0	2020
6628_21	1	1	1	1	0	1	0	0	1	1	1	0	0	1	1	0	2021
6628_22	1	1	1	1	1	1	0	0	1	1	1	0	0	1	1	0	2020

3636_18	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	2018
3636_19	0	0	0	1	1	1	1	0	0	0	1	0	0	0	0	0	2019
3636_21	1	1	0	1	1	0	1	0	0	1	1	0	0	1	1	0	2021
3636_22	1	1	0	1	1	0	1	0	0	1	1	0	0	1	1	0	2022
8889_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
8889_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019
8889_20	1	1	0	1	0	1	0	0	0	1	1	0	1	1	0	0	2020
8889_21	1	1	0	1	0	1	0	0	0	1	1	0	1	1	0	0	2021
8889_22	1	1	0	1	0	1	0	0	0	1	1	0	1	1	0	0	2022
7922_18	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2018
7922_19	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2019
7922_20	1	1	0	1	1	1	1	0	0	1	1	0	1	1	1	0	2020
7922_21	1	1	0	1	1	1	1	0	0	1	1	0	1	1	1	0	2021
7922_22	1	1	0	1	1	1	1	0	0	1	1	0	1	1	1	0	2022
5942_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
5942_20	1	0	0	0	0	1	0	0	0	1	1	0	1	0	0	0	2020
5942_21	1	0	0	1	1	1	0	0	0	1	1	0	0	1	1	0	2021
5942_22	1	0	0	1	1	1	0	0	0	1	1	0	0	1	1	0	2022
1873_18	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2018
1873_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019
1873_20	1	1	0	1	0	1	0	0	0	1	1	0	1	1	0	1	2020
1873_21	1	1	0	1	1	1	0	0	0	1	1	0	0	1	0	1	2021
1873_22	0	0	0	1	1	0	1	0	0	1	1	0	0	1	0	0	2022
6411_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
6411_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
6411_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2020
6411_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	1	0	2021
6411_22	1	1	0	1	1	1	0	1	1	1	1	0	0	1	1	0	2022
6938_18	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	2018
6938_19	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	2019
6938_20	0	1	0	0	0	1	0	0	0	1	1	0	1	1	0	0	2020
6938_21	0	1	0	0	0	1	0	0	0	1	1	0	1	1	0	0	2021
6938_22	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	2022
1059_18	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2018
1059_19	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2020
1059_20	0	1	0	1	0	1	0	0	0	1	1	0	1	1	0	0	2020
1059_21	0	1	0	1	0	1	0	0	0	1	1	0	1	1	0	0	2021
1059_22	1	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2022
9086_18	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2018
9086_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019

9086_20	1	1	0	0	0	1	0	0	1	1	1	0	0	0	1	0	2020
9086_21	1	1	0	0	0	1	0	0	1	1	1	0	0	0	1	0	2021
9086_22	1	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2022
2940_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
2940_19	0	0	0	1	1	1	1	0	0	1	1	0	0	0	1	0	2019
2940_20	1	1	0	1	1	1	0	0	1	1	1	0	1	0	1	0	2020
2940_21	1	1	0	1	1	1	0	0	1	1	1	0	1	0	1	0	2021
2940_22	1	1	0	1	1	1	0	0	1	1	1	0	1	0	1	0	2022
9140_18	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2018
9140_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019
9140_20	1	1	0	1	0	0	0	0	1	1	1	0	1	0	1	0	2020
9140_21	1	0	0	1	1	1	0	0	0	1	1	1	0	0	1	0	2021
9140_22	0	0	0	1	1	1	1	0	0	1	1	0	0	1	1	0	2022
9693_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
9693_19	1	0	0	1	1	1	0	0	0	1	1	0	0	0	1	0	2019
9693_20	1	1	0	1	0	1	0	0	1	1	1	0	1	0	1	0	2020
9693_21	1	1	0	1	0	1	0	0	1	1	1	0	1	0	1	0	2021
9693_22	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	2022
5142_18	0	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	2018
5142_19	0	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	2019
5142_20	1	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	2020
5142_21	1	1	0	1	0	0	0	0	1	1	1	0	0	1	0	0	2021
5142_22	0	0	0	1	1	0	0	0	1	0	1	0	0	1	0	0	2022
4832_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
4832_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
4832_20	1	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	2020
4832_21	1	0	0	1	0	0	0	0	0	1	1	0	1	0	0	0	2021
4832_22	1	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0	2022
5511_18	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2018
5511_19	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2019
5511_20	1	1	0	1	0	0	1	0	1	1	1	1	1	1	1	0	2020
5511_21	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	2021
5511_22	1	1	1	1	0	0	1	0	1	1	1	1	1	1	1	1	2022
8279_18	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	2018
8279_19	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	2019
8279_20	1	1	0	1	0	0	0	0	0	1	1	0	1	0	0	0	2020
8279_21	1	1	0	1	0	0	0	0	0	1	1	0	1	0	0	0	2021
8279_22	0	0	0	1	1	0	0	0	0	1	1	0	0	0	0	0	2022
1540_18	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2018
1540_19	0	0	0	1	1	1	0	0	0	0	1	0	0	0	0	0	2019

1540_20	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2020
1540_21	1	1	0	1	0	1	0	0	0	1	1	1	1	0	0	0	2021
1540_22	0	0	0	1	1	1	0	0	0	1	1	1	0	0	0	0	2022
6752_18	0	0	0	1	1	1	1	0	0	1	1	0	0	0	0	0	2018
6752_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
6752_20	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2020
6752_21	1	1	0	1	0	1	0	1	1	1	1	0	1	0	0	0	2021
6752_22	1	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2022
1320_18	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2018
1320_19	0	0	0	1	1	1	0	0	0	1	1	0	0	1	0	0	2019
1320_20	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	0	2020
1320_21	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	0	2021
1320_22	0	0	0	0	1	1	0	0	0	1	1	0	0	1	0	0	2022
2440_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
2440_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
2440_20	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	2020
2440_21	1	1	0	1	0	1	0	1	1	1	1	0	1	1	0	0	2021
2440_22	1	0	0	1	1	1	0	1	1	1	1	0	0	1	1	0	2022
7055_18	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2018
7055_19	0	0	0	0	1	1	0	0	0	0	1	0	0	0	0	0	2019
7055_20	1	1	0	0	0	0	0	0	1	1	1	0	1	1	1	0	2020
7055_21	1	1	0	0	0	0	0	0	1	1	1	0	1	1	1	0	2021
7055_22	1	1	0	0	1	0	0	0	1	1	1	0	0	1	1	0	2022
2225_18	0	0	0	1	1	1	0	0	1	0	1	0	0	0	0	0	2018
2225_19	0	0	0	1	1	1	0	0	1	1	1	0	0	0	0	0	2019
2225_20	0	1	0	1	0	1	0	0	1	1	1	0	1	0	1	0	2020
2225_21	0	1	0	1	0	1	0	0	1	1	1	0	1	0	1	0	2021
2225_22	0	0	0	1	1	1	0	0	1	1	1	0	1	0	1	0	2022
3471_18	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2018
3471_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
3471_20	0	1	0	0	0	1	0	0	0	1	1	0	1	0	0	0	2020
3471_21	0	1	0	0	0	1	0	0	0	1	1	0	1	1	1	0	2021
3471_22	0	0	0	0	1	1	0	0	0	1	1	0	1	1	1	0	2022
2667_18	0	0	0	0	1	1	0	0	0	1	1	0	0	0	0	0	2018
2667_19	0	0	0	1	1	1	0	0	0	1	1	0	0	0	0	0	2019
2667_20	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	0	2020
2667_21	1	1	0	1	0	1	0	0	0	1	1	0	1	1	1	0	2021
2667_22	1	0	0	1	1	1	0	0	0	1	1	0	0	1	1	0	2022
2865_18	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0	2018
2865_19	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0	2019

2865_20	1	0	0	1	0	1	0	0	1	1	1	0	0	1	0	0	2020
2865_21	1	0	0	1	0	1	0	0	1	1	1	0	0	1	0	0	2021
2865_22	0	0	0	1	1	1	0	0	1	1	1	0	0	1	0	0	2022

Appendix three: R code for phylogenetic trees and network analysis

```
# R Script for Phylogenetic Analysis Course Evolution
#load phylogenetic packages
library (ape)
library (cultevo)
library(phangorn)
library (tidyverse)
library (ggtree)
library (ggplot2)
#load data
courses <- as.matrix(read.csv(file.choose(),row.names=1, header
= TRUE, sep=","))#code allows user to select filepath
courses <- as.data.frame(courses)
courses1821 <- filter(courses, Year != "2022")
courses1820 <- filter(courses1821, Year != "2021")
courses1819 <- filter(courses1820, Year != "2020")
sub <- read.csv(file.choose(),header = TRUE, sep=",")#import the
substitution data (a matrix with amalgamated course substitutions
per year)
#summary of substitutions
str(sub)
summary(sub)
mean(sub)
sd(sub)
min(sub)
max(sub)
hist(sub)
#generate a plot of substitutions per year to demonstrate whole
data set using jitter and alpha
a <- ggplot(sub, aes(Year, Substitutions ))+geom_jitter
(width=0.2,alpha=0.5)+
  ggtitle ("Changes to ASBS Courses 2019 - 2023")+
  theme_classic()
```

```

#filter yearly data
b <- filter(sub, Year=="19_20")
mean(b$Substitutions)
c <- filter(sub, Year=="20_21")
mean(c$Substitutions)
d <- filter(sub, Year=="21_22")
mean(d$Substitutions)
e <- filter(sub, Year=="22_23")
mean(e$Substitutions)
#mode substitutions
#create a function for mode
Mode <- function(x) {
  ux <- unique(x)
  ux[which.max(tabulate(match(x, ux)))]
}
Mode(b$Substitutions)#replace with c,d,e as required
#heatmap for substitutions
ggplot(sub, aes(Year, Substitutions , fill = Substitutions)) +
  geom_tile(color = "black") +
  scale_fill_gradient2(mid = "blue",
                        high = "red") +
  coord_fixed()

#statistical distance table
x <- dist(courses, method="manhattan", diag = TRUE, upper =
TRUE)
h <- hammingdists(courses)

#UPGMA analysis of distance table
hc <- hclust(h, "average")
#save as phylo object
tr <- as.phylo(hc)
#Phylogenetic Tree with GGTREE
#splitstree
#use ape to create a nexus file for Splitstree
tr <- nj(h)#creates phylo object from a distance matrix returning an
estimated tree
phylo tree = as.phylo(hc)
plot(tr, type="unrooted")
write.tree(tr,"tree")

```

```

write.nexus(courses,file="splits", translate = TRUE)

#use phangorn to plot splitstree network(toy datasets only)

#uses phangorn
courses <- as.matrix(read.csv(file.choose(),row.names=1, header
= TRUE, sep=","))
x <- dist(courses, method="manhattan", diag = TRUE, upper =
TRUE)
nnet <- neighborNet(x)#uses phangorn
plot(nnet, "2D")

#ggtree - use phylo object
p <- ggtree(tr, layout='equal_angle') +
  theme_tree2()+
  geom_tiplab(size=4,geom = "text", offset =0.1, linetype =
"solid")+
  ggtitle("Phylogenetic analysis of ASBS courses 2018 - 2022")

```