A Framework for the Analysis of Personal Learning Networks

Nicholas S. R. Fair

Knowledge Engineer, IT Innovation, University of Southampton

N.S.Fair@soton.ac.uk

Abstract

This paper reports on research undertaken to map and analyse Personal Learning Networks (PLNs). PLNs are the total preferred connections to the different people, technological devices, services, and information resources an individual uses for learning activities and learning goals in all learning contexts. Drawing from Education, Web Science, Digital Sociology and Network Science, a Framework was developed which conceptualises PLNs as egocentric interaction networks involving a mode, purpose and endpoint. The Framework introduces the idea of measuring the frequency of interaction along paths consisting of pre-determined, generalised nodes (and node sets). This eliminates network differences at the micro level and allows meaningful comparison and aggregation of individual PLNs into groups or whole samples.

Quantitative survey data was collected as part of a FutureLearn MOOC and in real-time converted by a bespoke mapping and visualisation tool into an online PLN map. Analysis indicates that regardless of any contextual factors, individuals interact nearly three quarters of the time via digital devices, and just a quarter of the time face-to-face or non-digitally. One third of those interactions are with smartphones, most often for the purpose of gathering information from web searches. Individuals also interact more frequently with non-humans than they do with humans. Chi-square significance testing to examine the effect of a range of external shaping factors found that the PLNs of apparently diverse groups display a considerable homogeneity. Gender, country of residence and position on the Digital Resident-Digital Visitor spectrum have no effect on the size and use of a PLN. Age and being a UK HE student have the most effect. There may also be evidence of a Network Lifecycle, with a critical period of PLN growth occurring during the age of 18-25.

This means that universities are ideally placed, indeed may even have a duty of care, to foster PLN development in educationally and personally productive ways. If HE institutions are to respond to the networked student, living, working and learning in a network age, then no longer can the learner be considered separately from the network of people, devices, services and information resources they use for daily life. Transitioning towards a PLN-centred, networked learning HE pedagogy and learning design may arguably be the most suitable response to a study body which is increasingly and inextricably embedded in a sociotechnical reality.

Keywords

Personal Learning Network, networked learning, analysis framework, pedagogy, social network analysis, methodology.

Background

Although a long established physical phenomenon, it is particularly since the evolution of the World Wide Web in the early 1990's that networks have become increasingly central to how we understand the world and undertake daily life. In academia, networks have appeared as an analytical, conceptual or explanatory approach since the 1920's (e.g. Bott, 1927; Moreno, 1937; cited in Scott, 2017). However, it is over the past thirty years that networks have grown in importance and application across diverse academic fields, (e.g. social sciences (e.g. Castells, 2011 vol.12; Law, 1992, 2008; Raine & Wellman, 2012), mathematics (e.g. Scott, 1998), and education (e.g. Siemens, 2005a, 2005b; Downes, 2005, 2006; Goodyear, 2002, 2005). Networks today are also a central feature of daily life, not just of academia. The availability and affordability of mobile digital

technologies, social media networks and wifi networks (for many but not all), mean that by the age of thirteen, 79% of UK children have a smartphone, 74% have an active social media profile, and they spend fifteen hours per week online (Ofcom Media Report: Children & Parents, 2016). Social media networks have become an influential part of how many individuals form their identity and their relationships to others (e.g. BBC School Report, 2016; Davis, 2015), earn an income (e.g. emarketer, 2017), or feel excluded or isolated (e.g. O'Keefe & Clarke-Peterson, 2011; Luxton et. al., 2012). In short, digitally enabled networks have become embedded in the activities of living, learning and working to such an extent that it is not possible, or even productive, to consider an individual separately from their network.

Sociotechnical Theory (e.g. Cummings, 1978; Bijker, 1997; Geels, 2002) formalises this interdependence by suggesting that the development of societies and technologies are reciprocally co-dependent and that both social and technical phenomena can not be fully understood in isolation from the other. Applied to education, this means that learning, as a process, can not be separated from the networks used for learning. In practical terms, a typical HE undergraduate arrives at their institution with a well-established network of digital (online) and non-digital (offline) relationships to people, devices, services and information resources that they have seamlessly integrated into their regular activities in all contexts. In short, they are at the centre of their own Personal Learning Network (PLN).

Given this sociotechnical relationship, and the increasing centrality of networks to daily life and study, it is important that researchers can meaningfully map and analyse PLNs in order to identify commonalities and differences. These can then be used to inform HE pedagogy and learning design. The knowledge thus gained can be applied to avoid a potential disconnect between a student's personal learning behaviours and the formal learning experience they receive from their HE institution, and the potentially negative consequences for learning, engagement, student satisfaction and TEF ratings which such a disconnect could cause.

What is a Personal Learning Network (PLN)?

Personal Learning Networks (PLNs) are complex to define and there is no consensus on a single definition within the literature. It is perhaps therefore worth beginning with what PLNs are not. PLNs are not the same as a Personal Learning Environment (PLE), which is an institutionally supported system for student interactions with learning technology (White & Davis, 2013), or an institutional Virtual Learning Environment (VLE). Rather, PLNs are autonomously created by an individual and feature the people, devices, services and resources for which they have a personal preference at a given point in time.

Also, although there are a number of similarities between them, PLNs are also not Professional Learning Networks (Trust, 2012), Personal Professional Learning Networks (Rajagopal et al., 2012), or Personal Knowledge Networks (Grabher and Ibert, 2006). This is because PLNs are not 'professional' (i.e. based in a workplace), and 'knowledge' implies something different from learning (an outcome rather than a process). Also, a PLN is not a 'learning network', which in the literature is synonymous with a community of individuals intentionally interacting for a shared learning goal, interest or need (a community-network view). It is instead an ego-centric network focussed on the individual (and their personal connections) as the unit of analysis.

Consequently, this paper will adopt the terminology Personal Learning Network (e.g. Siemens, 2005b; Downes, 2007b; Kop & Hill, 2008; Carvalho & Goodyear, 2014). A PLN is both a learning artefact (and therefore

capable of becoming a unit of analysis) and a vehicle which *"foster[s] interaction amongst and a learning process 'within' its participants"* (Rusman et. al., 2016). Drawing together the key elements of the various definitions in the literature, and taking as broad a view of learning as possible, this paper defines a PLN as the total preferred connections to the different people, technological devices, services, and information resources an individual uses to assist them with their learning activities and learning goals in all learning contexts.

PLNs are autonomously built, maintained and used by the creator and are heavily shaped by the wider socio-cultural contexts within which the creator and the network are situated. PLN interactions can occur online and off, and in formal, non-formal and informal learning contexts. They are dynamic and subject to constant change and evolution as a result of individual drivers and contexts, wider contextual influences, and the technological affordances of the time.

A Framework for the Analysis of Personal Learning Networks

This paper will present a Framework for the Analysis of PLNs that aims to bridge a gap revealed in the networked learning literature. Traditionally, it had been difficult to meaningfully compare individual network maps, as they are so different from each other and are often constrained to small sample sizes, making meaningful generalisations from individual egonets to larger populations hard (e.g. Moses & Duin, 2015; Van Waes et al, 2016; Jordan, 2016). Equally, it has also been difficult to account for the shaping effects of personal, contextual factors which lead to individual differences in network behaviours, attitudes and connections when studying whole networks (e.g. Krutka & Carpenter, 2016; Trust et al, 2017; Visser et al, 2014). This framework aims to overcome this gap between the micro and the macro scales of network research.

The Framework for the analysis of PLNs is underpinned by connecting theories and concepts from a range of fields, including Education, Web Science, Digital Sociology and Network Science, as indicated in the graphic below:

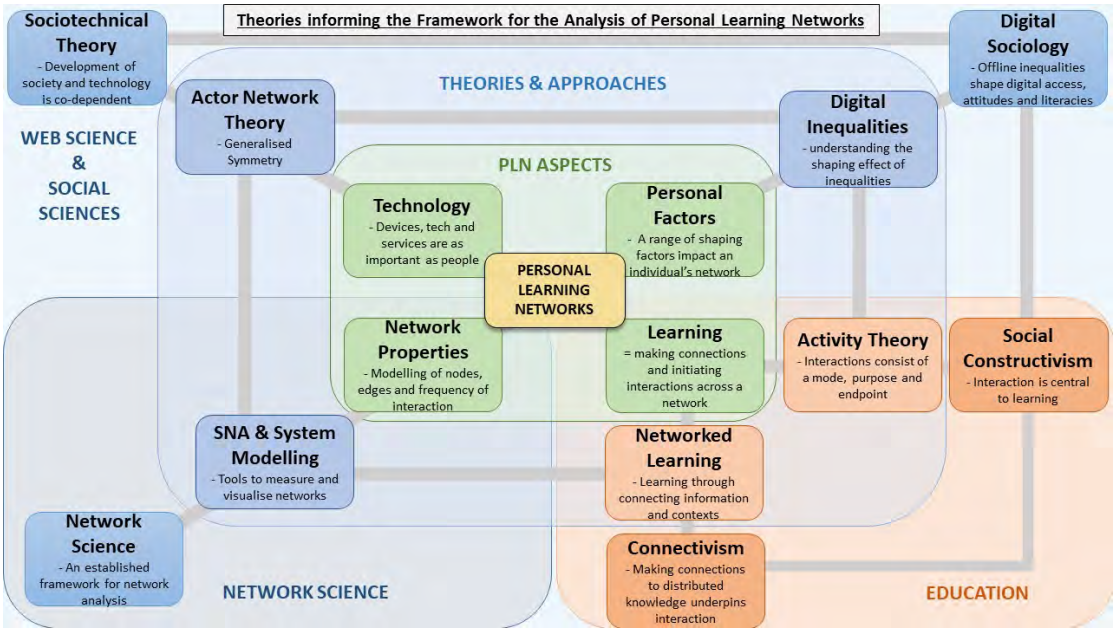

Figure 1: The networked theoretical foundations for the framework for the analysis of PLNs

Web Science suggests that it is impossible to understand a phenomena without understanding that it has both a social (human) and a technical (non-human) aspect, and that these can not and should not be understood separately. This is known as Sociotechnical Theory (e.g. Cummings, 1978; Trist, 1981; Bijker, 1997; Geels, 2002), and is formalised for analysis by the concept of Generalised Symmetry from Actor Network Theory (e.g. Latour, 1987; Law, 1992; Callon, 1999), in which human and non-human actors in a network must be considered as equally significant to the construction and use of the network.

Network Science (and Mathematics) also provides a toolkit for the empirical analysis and mapping of networks - Social Network Analysis (e.g. Granovetter, 1973; Scott, 1988; Borgatti et. al., 2018), where the frequency of network interactions can be measured and networks visualised. To this System Modelling (e.g. Checkland, 1981; Checkland & Scholes, 1990; Davies & Ledington, 1991; Wand, 1996; Checkland, 2000) introduces the idea of abstraction and generalisation for modelling networks across different domains. From the Social Sciences, research by digital sociologists has identified a considerable range of shaping factors which can result in digital inequalities in access to technology and differences in digital literacies, and motivation to use and attitude towards technology. These are predicted to have a shaping effect on the size and use of a network (e.g. Pew Research Center, 2018; Ofcom, 2017; Orton-Johnson & Prior, 2013; Davies et. al., 2012; Daniels et. al., 2016; Witte & Mannon, 2010).

From Education, social constructivism focusses on the key role played by interaction in learning, suggesting that these interactions should be meaningful if they are to be effective for learning purposes. In PLN terms therefore, every interaction has an Interaction Purpose. In addition, Activity Theory introduces the importance of the mediating artefact (e.g. Engestrom, 2001; Carvalho & Goodyear, 2014) in interactions. From this the concept of the Interaction Mode, was developed. Drawing from Connectivism (e.g. Siemens, 2005a, 2005b; Downes, 2005, 2006) and Networked Learning (e.g. Illich, 1971; Goodyear, 2002, 2005; De Laat et. al., 2006), it is also the case that before meaningful interaction can occur, connections to distributed knowledge and diverse others must be made and patterns of relationships across learning contexts and knowledge domains identified. These connections constitute the Interaction Endpoints in the PLN Framework.

This allows for a full conceptualisation of PLNs as an interaction network consisting of an Interaction Mode (the medium through which it is conducted), an Interaction Purpose (a learning activity) and an Interaction Endpoint (a human or non-human other). The Framework views learning as simultaneously individual (autonomous and uniquely shaped by contextual factors – 'personal'), social (involving meaningful interactions with human and non-human others – 'learning') and networked (involving the making and maintaining of diverse connections – 'networks'). Learning is, in other words, centred on a learner's Personal Learning Network.

Consequently, a Framework for the Analysis of PLNs has been developed (see Fig 2 below)

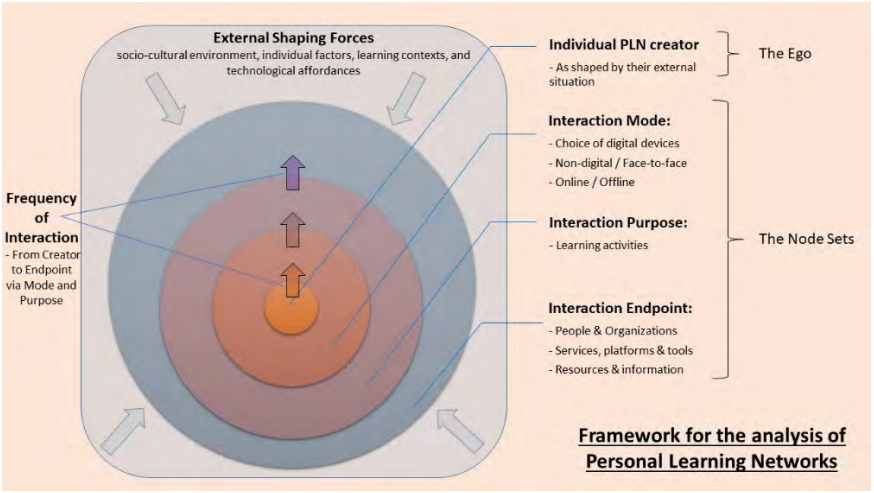

Fig 2: The Framework for the Analysis of Personal Learning Networks

This framework allows for the mapping of individual PLNs based on an interaction path from the Ego to a Mode, used for a Purpose, to interact with an Endpoint. However, in order for each individual PLN map to be usefully aggregated for analysis and comparison (thereby reconciling the micro and macro levels of network research), the Framework proposes two approaches adapted from System Modelling. The first is that the researcher must define all the nodes in the network in advance of going into the field. By defining the nodes in the network in advance, every individual PLN will consist of the same nodes (if present), meaning that there will be no variation between individual respondents at the network scale. This means that individual PLNs can be usefully compared and aggregated. However, this solution requires very considerable thought about what choices the researcher makes concerning what nodes to include.

The Framework therefore proposes a second approach – the identification and use of generalised nodes, grouped into generalised node sets. For example, it is not particularly informative to know that John interacts with Jane or with Facebook, if the aim is to try to compare John's network with a Random Other, who is unlikely to know Jane and who might not use Facebook. Therefore, within the generalised node sets laid out by the Framework – mode, purpose and endpoint - generalised nodes such as Smartphone (as opposed to 'iPhone10') and Face-to-Face (to encompass all non-digital interactions, including with non-humans) form part of the Interaction Mode node set; Gathering Information and Collaborating & Communicating (instead of 'reading about crystalography' or 'groupwork on my module assessment') form part of the Interaction Purpose node set; and Social Network Services or Friends (rather than 'Facebook' or 'Jane') can be found in the Interaction Endpoints node set.

This pre-determining of generalised nodes (and node sets) does mean that some granularity is lost, however, that is a necessary consequence of reconciling the micro and macro. It also means that individual PLNs can be aggregated into subsets, according to a range of shaping factors (e.g. age, gender, ethnicity…etc), thereby allowing the significance of the effect of these factors on the size and use of PLNs to be statistically analysed.

In summary, based on existing theories and research, the Framework for the Analysis of PLNs conceptualises PLNs as an egocentric interaction network, featuring pre-determined, generalised nodes, grouped into pre-determined node sets (Interaction Mode, Purpose and Endpoint). This ensures continuity between the networks of individual respondents, meaning that PLNs at the individual, group and whole sample levels, at large sample

sizes, can be meaningfully and robustly analysed. The Framework contributes to bridging the gap between the micro and the macro levels of network analysis, potentially opening new possibilities for Networked Learning research.

Methodology

The framework was used to inform the design of an online, closed question, quantitative survey, hosted on iSurvey. The survey asked respondents to recall the number of times (frequency) they interacted along single paths through their learning network during a single day. These paths emanate from the PLN creator via an Interaction Mode (mobile/smartphone; tablet; laptop; desktop; and face-to-face/non-digital), through an Interaction Purpose (searching & browsing; gathering information; communicating & collaborating; creating & sharing; socialising; and gaming/hobbies), to an Interaction Endpoint (too many to list, but which includes humans and non-humans).

In an original approach to sampling and data collection, this survey was hosted on the 'Learning in the Network Age' MOOC (University of Southampton/FutureLearn), which was written and produced by this author, in collaboration with others, specifically for this research. A unique, bespoke, automated analysis and mapping tool was commissioned to immediately turn the survey results into an individual online PLN map, and provide access to the aggregated (and filterable) PLN map for the whole sample (see figure 3 below).

However, the use of the MOOC also meant that a certain sample bias was inevitable. Clearly those who do not/can not access the web (still about half the world's population), and those who can access the web but do not have the motivation or digital literacies level to undertake self-directed online learning, or who do so using other MOOCs and platforms, are excluded from this sample. Post-event Recall is also a limiting factor to consider.

Data Analysis and Results

This innovative methodology resulted in one of the largest and most diverse samples for a research programme with the aim of mapping learning networks to date. In total, 737 respondents resident in 84 different countries, from 20 different ethnicities and from the full range of ages, positions on the Digital Resident – Digital Visitor spectrum (White & Le Cornu, 2011) and main daily activities (working, studying, volunteering or at leisure) were returned. In total, 58% of respondents were female (n=425); 25% were aged 18-25 (n=180); 65% were of White ethnicity (White British, American, Irish, Any Other White) (n=474); 36% were resident in the UK (n=264); 61% placed themselves on the Digital Resident side of the spectrum (n=451); and 70% were either working or studying as their main activity (n=508).

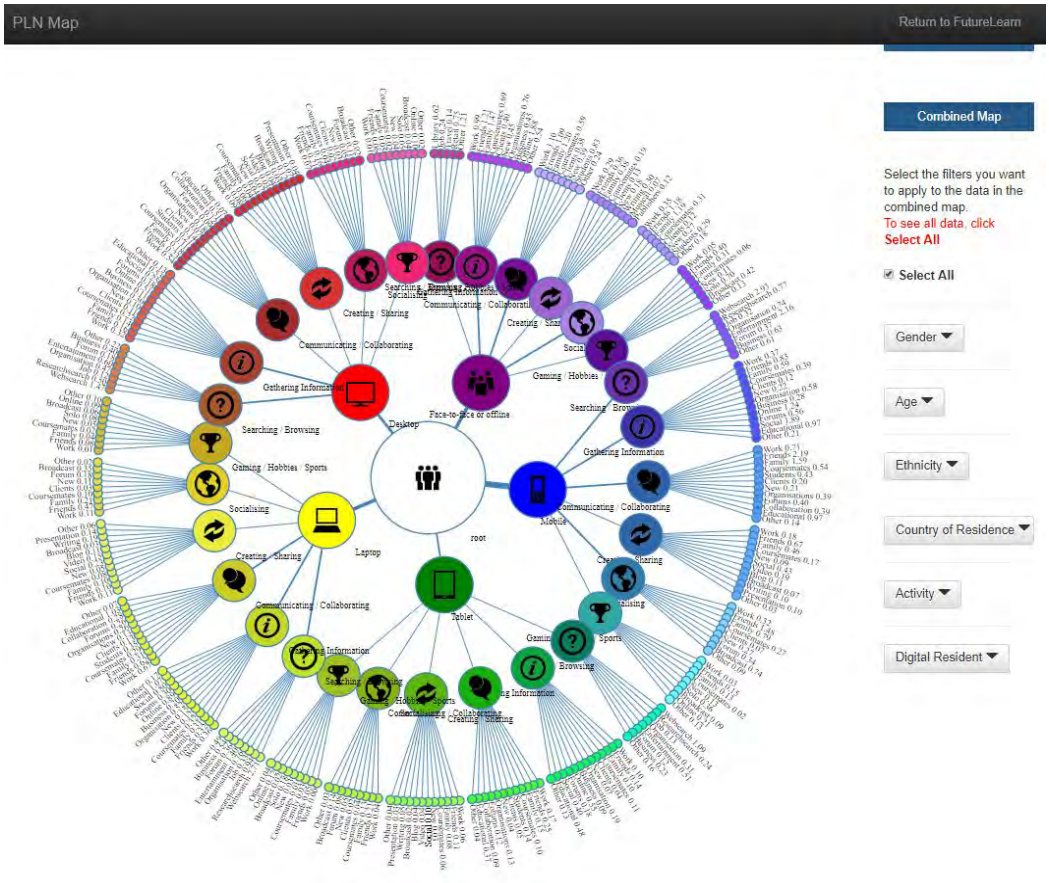

Fig 3: The aggregated PLN map for the whole sample (n=737)

The network map mirrors the Framework in that the PLN creator (the ego) sits at the centre and interactions proceed from them to Interaction Mode (the first ring of nodes), then to Interaction Purpose (the second ring of nodes), before culminating in an Interaction Endpoint (the third ring of nodes). The thicker the edge connecting each node, the more frequently that interaction has occurred. This provides a clear visualisation of the data returned from MOOC participants through the online survey.

Early results for the whole sample indicates that regardless of who we are, where we live, and our contexts, attitudes and activities, almost one third of our total daily network interactions are with our mobile/smartphones (33%), and almost three quarters are with technological devices (74%). Face-to-face and/or non-digital interactions constitute just over one quarter of our interactions (26%). [Note - All percentages provided here are the percentage of total network interactions].

Over three quarters of our interactions are for the purposes of gathering information (28%), searching & browsing (26%) and communicating & collaborating (23%). We interact more often with non-humans (e.g. websites, platforms, digital services…etc) (52%) than with humans (42%), with the remainder being non-discernible. Those interactions will most often be with web search engines (9%), educational platforms (possible sample bias here) (6%), friends (13%), and family (10%).

The Framework also returned results for a range of sample subsets, including different genders, ages, ethnicities, countries of residence, position on the Digital Resident-Digital Visitor spectrum and main activity on the day of reporting. Differences between subsets were tested for statistical significance by conducting Chi-Square tests

with a p-value of <0.05%, or at a 95% confidence level. Input values were weighted according to their occurrence in the sample (*n*). Tests were conducted to identify any significant differences in network size, interaction mode, interaction purpose and interaction endpoints (top-level, human and non-human) between the subsets.

The results indicate that there are far more similarities than significant differences between apparently diverse groups. Gender, country of residence and position on the Digital Resident-Digital Visitor spectrum (White & Le Cornu, 2011) has no statistical effect on the size, mode, purpose or endpoints of a PLN. In contrast, ethnicity and the main activity an individual is engaged in on a given day (e.g. working, studying, volunteering/caring, at leisure) will significantly affect the human interaction endpoints in a PLN, but not any other part of the network.

Being a UK HE student (subset = aged 18-25, resident in the UK and studying) will have a significant effect on interaction mode, but not on any other aspect of a PLN. UK HE students make statistically significantly higher use of mobile/smartphones and laptops than the whole sample (48%), but have significantly fewer face-to-face/non-digital interactions (18%) and make almost no use of tablets or desktops (4% combined). There is also no statistical difference between the PLNs of female and male UK HE students in any aspect.

The largest effect, however, is a result of the age of the PLN creator. Age will significantly affect not only the people with whom the PLN creator interacts (human interaction endpoints), but also their choice of interaction mode. The data provides some evidence for the possible existence of a Network Lifecycle, featuring phases of change which parallel age (see table 1 below). This 'Lifecycle', consists of periods of immaturity, expansion, maturity and decline.

Table 1: The differences in PLNs based on age, which hint at a possible 'Network Lifecycle'

Network Lifecycle phase / PLN aspect	**Immaturity – age Under 18**	**Expansion – age 18-25**	**Maturity – age 25-65**	**Decline – age Over 65**
Network size (nodes)	236	333	333	303
Most frequent interaction mode	Face-to-face / non-digital (36%)	Mobilephone (43%)	Mobilephone (30%)	Face-to-face / non-digital (31%)
Most frequent interaction purpose	Communicating & Collaborating (24%)	Searching & Browsing (28%)	Gathering Information (29%)	Gathering Information (32%)
Most frequent interaction endpoints	Humans (53%) – friends (18%) – family (17%)	Non-humans (52%) – web search engines (8%)	Non-humans (52%) – web search engines (8%)	Non-humans (58%) – web search engines (8%)

Discussion

The Framework and methodology proved effective in mapping and analysing PLNs at the individual, group and whole sample scales. The findings clearly indicate the extent to which interactions with digital devices and non-

human endpoints are inextricably embedded in daily life and learning. Individuals, no matter who they are, where they live, or what their contexts are, reside at the centre of a sociotechnical network, which frames and enables their daily interactions.

The data has also revealed a surprising degree of homogeneity between the PLNs of diverse groups, with only four significant shaping effects found (age, ethnicity, main activity, UK HE student), which only affect two aspects of a PLN (interaction mode and human interaction endpoints). In a challenge to the literature, gender, country/region of residence and position on the digital resident-digital visitor spectrum have no significant effect on a PLN. PLNs are more similar than they are different.

The data also suggests a possibility of a Network Lifecycle, with the critical growth phase coinciding with being 18-25. Changes occur in interaction mode, with mobile/smartphone use significantly increasing, while face-to-face/offline interactions decline, even more so for 18-25's resident in the UK and studying (i.e. UK HE students). Further significant changes occur to human interaction endpoints, with family interactions falling to their lowest point in life, while friend interactions climb to their highest level, which again is more pronounced for UK HE students. The data also suggests non-significant, but potentially interesting, changes with networks growing considerably in size, searching & browsing replacing communicating & collaborating as the main interaction purpose, and, for the first time in life non-human interactions outnumbering human ones.

This raises challenging questions for HE educators and learning designers, concerning among others, the ratio of face-to-face vs independent study hours; the importance of mobilephones in learning; the role of humans (especially educators) in the network; the value of literacies and skills vs content transmission; and what constitutes appropriate assessment activities.

In short, while at university, UK students become more deeply embedded in their networks as both they, and their PLNs, undergo change and develop patterns which will remain for the rest of our working adult lives. This means that HEI's are critically positioned, and may even have a duty of care, to guide and facilitate this network growth in educationally and personally productive ways. The findings have helped inform a PLN-centred networked learning pedagogy, where learning is sociotechnical and networked, and which, due to PLN homogeneity, likely to be largely inclusive (rather than exclusive). This pedagogy prioritises nurturing and developing the growth, maintenance and use of PLNs, by aligning learning design to the modes, purposes and endpoints that are most frequently activated in a PLN, and identifying and developing those parts of a PLN which are under-activated. This development would equip graduates with a mature, fully functioning and well-maintained learning network, which would have an immediate educational value by aligning the HE learning process with student's behavioural norms, as well as having value beyond university in the workplace and for lifelong learning.

A PLN-centred pedagogy also focusses on developing digital literacies and networking skills through blended, peer, social, autonomous and self-directed learning as a default. It also demands appropriate assessments, which reward collaboration, creativity and PLN development, and a reassessment of the role of educators (and their re-skilling). Finally, it also recognises some of the structural barriers to transitioning to this pedagogy, including the limitations of the contractual model of HE currently en vogue in the UK.

To conclude, this research indicates that PLNs can not be ignored in Higher Education, that learners and their learning networks are inseparably linked and that those personal learning networks, when fully understood and correctly developed through innovative PLN-centred networked learning pedagogy and learning design, can provide one valuable approach to responding to the needs and expectations of networked HE students living, learning and working in a network society.

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