Chapter 43
Technology-Enhanced Professional Learning

Allison Littlejohn and Anoush Margaryan

Abstract Societal and technological changes are transforming the ways people work and learn. As work roles evolve, learning for work becomes continual and personalised. These transformations evidenced in work and learning practices are partly governed by advances in technology. Consideration of work practices, professional learning processes and technologies mediating work and learning within a single domain of 'Technology-enhanced Professional Learning' enables analysis of the dialectical relationship between technology and practice. This chapter begins by presenting a single framework that integrates perspectives across the domains of work practices, learning processes and digital technologies. Key trends are outlined from the literature within each domain. Using a framework for TEPL as an analytical lens, emerging work and technology practices and their implications for professional learning both in and for work are examined. Finally, the chapter outlines the implications of these developments for work and learning.

Keywords Technology-enhanced learning • Professional learning • E-learning • Work-based learning • Workplace learning

43.1 Macro-level Trends Impacting on Work and Learning

Societal and technological changes are transforming the ways people work and learn. Society is facing complex problems on a global scale (Castells 1997). Issues such as our growing requirements for energy, our need for improved healthcare and the effects of global warming require deep, specialist knowledge to find solutions.

A. Littlejohn (✉) • A. Margaryan
Caledonian Academy, Glasgow Caledonian University, Glasgow, UK
e-mail: Allison.Littlejohn@gcu.ac.uk

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The knowledge required to solve each problem is progressively distributed across a number of people in specialist roles, rather than within a single job function. People increasingly work together in agile groups that form, collaborate then disperse and reform as new projects and tasks arise (Sloep 2009; Sloep and Berlanga 2011). These new and dynamic forms of organisation result in shifting social relationships at work, with systemic, new work practices evolving continually to accommodate these transformations (Bietz 2013). These changes impact on the way labour is divided, as people with deep expertise collaborate around shared work problems in new forms of organisation. These trends – changes in work patterns, increased collaboration and new forms of organisation – are impacting on the ways people work and learn.

The transformations evidenced at work are partly brought about by advances in technology. Many contemporary work practices are mediated by technologies (Engeström 2009). Some practices capitalise on the automation of tasks that are repetitive or complex and require computation. Others exploit technologies to enable people to collaborate in radically new ways (Nickerson 2013). For example, in many places around the world it is now routine for people to collaborate across conventional geographic, disciplinary, organisational, and sectoral boundaries (Bietz et al. 2010). As individuals collaborate remotely, they no longer rely on a single organisation to employ them. Increasing numbers of people are employed by more than one organisation or are self-employed, working in parallel across different roles (Beck 2000). Power increasingly shifts from organisations towards individuals taking responsibility for their own work and, by extension, their professional learning, to enable them to function productively within new workplace configurations. Therefore, the co-evolution of work, learning and technology is having a profound effect on society and on work. However, it is yet to have a significant impact on professional learning.

Conventional forms of professional learning, such as formal training, allow large numbers of people to reach a specific level of competency. However, these forms of learning are unlikely to meet the learning needs of professionals in contemporary work contexts (Collin et al. 2012). The reason is because although learning a standard curriculum may be helpful for some (limited) work tasks, perpetual change at work means that set curricula are no longer an effective means of professional learning (Väljataga and Fiedler 2013). Professional learning should be reconceptualised to capitalise on new forms of organisation, different feedback formats and the numerous ways people and the resources they require for their learning and work can be brought together (Littlejohn and Margaryan 2013). Therefore a fundamental rethink of how professional learning aligns with these emergent trajectories in work, technology and society is required. Professional learning is ongoing: as people deal with constant changes in employment and work practices, they need to learn new knowledge to solve the new problems they face at work (Hager 2004; Felstead et al. 2009; Hadwin et al. 2011; Illeris 2011). Professional learning should be personalised: as work becomes more specialised, each individual's learning needs are bespoke, influenced by environmental (job role, tasks, culture) and intrapersonal factors (previous knowledge, skills, attitudes).

One way forward in advancing professional learning is to reconceptualise it as a function of three key integrated dimensions – work practices, learning processes

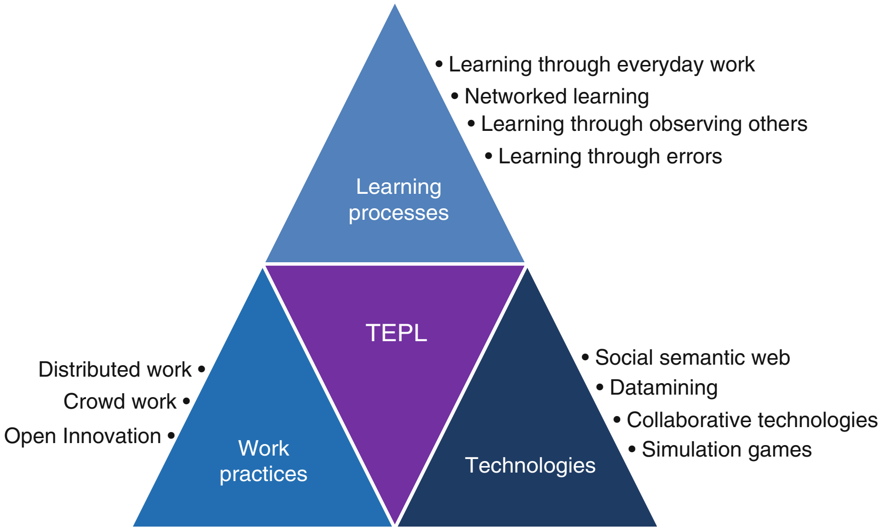

Fig. 43.1 Technology-enhanced professional learning: work practices, learning processes and technologies

underpinning work practices and technologies mediating work and learning – within the single domain of 'Technology-enhanced Professional Learning' (TePL) (Fig. 43.1). This integrated conceptualisation is necessary, since the development of new technologies is not significantly driven by the understanding of learning processes or work practices. There is a dialectical relationship between technology and practice. This integrated perspective therefore emphasises the need to consider work practices and learning processes in technology development; emerging forms of work and learning should influence technological developments, just as technological developments influence work and learning.

TePL is positioned here as a phenomenon representing current practice in knowledge work, how people learn through everyday work and how technology supports these activities. It is intended as a framework to conceptualise what is happening in knowledge-intensive workplaces, rather than an 'approach', a 'method' or a 'thing to be integrated'. Within each of these three dimensions there are a number of themes and approaches that are gaining prominence in the literature. The purpose of this chapter is to explore these critical areas and examine their impact on technology-enhanced professional learning. Many of the concepts outlined in this chapter are primarily applicable to knowledge workers, since this group of employees tend to use digital technologies as a focal point for their work. However, these concepts are applicable to any type of work where digital technology tools are central to carrying out that work. The chapter concludes by examining the trends and practical possibilities around technology-enhanced professional learning.

43.2 Dimensions of Technology-Enhanced Professional Learning

43.2.1 Work Practices

Work practices have been changed by digital technologies. One of the most significant changes is that people can work remotely via networked technology. Essentially, work is no longer tied to a specific workplace and can take place remotely from almost any location where a network connection is available (Bietz et al. 2010). There has been a dramatic increase in *distributed work* where networked technologies are used to assemble dispersed groups of people within and across organisations to collaborate (Bietz et al. 2010; Ashton 2004). A specific form of distributed work is *crowd work*, whereby large numbers of people outside organisational boundaries are brought together to work on specific tasks (Nickerson et al. 2009). *Open innovation* is another form of work that allows organisations to update their products rapidly and effectively (Chesbrough 2003). This section analyses these three examples of work practices in detail to draw out key trends and factors.

Networked technology tools are becoming ubiquitous in many parts of the world. Technology allows distributed groups of people to work together almost seamlessly, even though they may never have met face-to-face. One advantage of distributed work for organisations is that work can be co-ordinated flexibly (Bietz 2013). People from diverse domains can be assigned to projects depending on their specific expertise. Tasks can be redistributed across different sets of people located in different parts of the organisation. Organisations can capitalise on the knowledge and skills of people no matter where they are located. However, in distributed work all interactions have to be mediated by technology. The ways people relate to one another differs from the sorts of relationships within established forms of work (Bietz et al. 2010). Distributed employees tend to work in loosely-connected, fluid and agile groups compared with more stable, strongly-tied groups of people working face-to-face. Sometimes people find it more difficult to bond and form a shared identity than in co-located settings. Shared identity is particularly problematic when group composition is changed frequently, for example when new projects are commissioned and work tasks transform. Even different patterns of distribution of people can impact on work practice and performance. For example teams with members working face-to-face and others working at a distance may experience effects related to shared identity: people working face-to-face may share identity, while co-workers at a distance may feel excluded (Voida et al. 2012). Professionals working in distributed settings, therefore, may potentially face a mis-match within the group and reduced collaborative performance (Bos et al. 2006). The impact of technology on distributed work practice allows work to be divided in new ways and enables new forms of collaboration. However, distributed work disrupts conventional relationships so when people work at a distance their relationships change. The effects of distance and diversity on work relationships and productivity are complex and, therefore, the consequences of the distribution of work are not well understood (Bietz 2013).

Crowd work is similar to distributed work in that it involves large numbers of dispersed people connecting via networked technology to perform a set of work tasks (Kittur et al. 2013). A key difference between distributed work and crowd work is in the ways in which people connect. In distributed work, individuals are brought together as teams to work on a specific problem. Crowd work, on the other hand, involves outsourcing discrete tasks to large numbers of disconnected individuals (crowds) (Nickerson et al. 2009). Crowd workers perform many thousands of tasks during a year and they often choose to work on specific tasks they are good at. The relationships – including learning relationships – of crowd workers to their co-workers is different from the usual sorts of associations of employees in established organisations (Nickerson 2013). In conventional workplaces, people have the opportunity to learn from more experienced colleagues. Crowd workers generally have no knowledge of other people working in parallel on similar tasks. Crowd work is organised through online platforms that assign people specific tasks, for example the Mechanical Turk platform (https://www.mturk.com). Typically an employer sends out a request for work through this type of crowd work platform. Crowd work tasks are usually short or repetitive. Large numbers of people browse lists of these tasks and select those they want to work on. Each crowd worker is paid per task, rather than hired as a full-time or part-time employee. When a task has been completed, the crowd worker is free to select another task – possibly from a different employer – or decide not to continue working. Therefore, crowd work not only changes relationships amongst co-workers, but it radically transforms what we understand as work and how we view the workplace (*ibid*).

Open innovation is another process that involves changing relationships. Through open innovation people within organisations connect with others outside the company to source ideas to improve their products (Chesbrough 2003). Broadly, there are two types of open innovation: the so-called 'outside-in' and 'inside-out' open innovation. In the 'outside-in' version, organisations reach out to external people (typically researchers, customers) to bring new ideas into product design and manufacture. At the opposite end of the scale, the 'inside-out' approach is where organisations take new ideas to the market and sell Intellectual Property. One example is Ideagora, Internet-based platforms where people and organisations come together to exchange ideas or seek out new markets for products or applications (Tapscott and Williams 2007). The process brings together diverse groups of people to work on a single problem – for example, designers, researchers, manufacturers, customers, venture capitalists and government agencies. Similar to people who are involved in distributed work and crowd work, their relationships with each other and with the organisation are fluid. They are bound together by a common goal, even though they have diverse motivations. Their capacity to work together is related to their ability to exchange and acquire knowledge through professional learning.

43.2.2 Learning Processes

Changes in work practices bring about opportunities for new forms of professional learning (Ericsson 2009; Ericsson et al. 2006; Hagar 2011). Contemporary professional learning processes are described in the literature, some notable examples being *learning through everyday work*, *learning through observing others*, *learning through networks* and *learning from errors*. Trends related to learning processes have been noted in the literature. Analogous to the trends in work processes, changes in learning processes are connected with the ways people inter-relate and how they associate with their workplace (Billett 2001; Edwards 2010; Eraut 2002; Lee et al. 2004).

A great deal of continual professional learning takes place on the job, *through everyday work* activities and through 'being proactive in seeking out learning opportunities' (Eraut and Hirsh 2010, p. 30). Conventional formal learning, such as classroom-based training, is usually recognised by employees as 'learning'. However, on-the-job learning tends to be intertwined with work to such a degree that it is difficult to distinguish from normal work activities (Littlejohn et al. 2009). On-the-job learning is unstructured, incidental, difficult to standardise and complex to evaluate and assess. An example of on-the-job learning is a product design engineer working with a large engineering company in a multi-disciplinary project based team where she is the expert from her specific discipline (Littlejohn et al. 2012). Through her daily work she learns about new materials available on the market and the value they bring to her product designs. A large proportion of her time is spent accessing and interpreting existing knowledge held within and outside her company, as well as working in project teams to create new knowledge in the form of design specifications and research reports. Her on-the-job learning involves setting learning goals aligned with her work tasks. She learns through collaborating with others, drawing on her professional and personal networks: co-workers, contractors, professional contacts in external organisations as well as family and friends. It is almost impossible to distinguish her learning from her work. At the same time, through working with other people, she (explicitly or implicitly) supports other people's learning, through sharing her knowledge, fluidly shifting her role back and forth from learner to instructor. Technology systems are already on-stream to enable people to exploit these sorts of learning opportunities. These systems allow people to structure their on-the-job learning around their daily work tasks, linking to and learning with colleagues who share similar tasks and goals. However, to capitalise on the full potential of on-the-job learning, people have to recognise and purposefully plan, instantiate and reflect on how and what they learn in their daily work (Milligan et al. 2013). Exploiting these opportunities for professional learning requires a shift in cultural perceptions of where and how professional learning takes place, how learning is assessed and how learner-instructor roles are perceived.

Technology-enhanced, on-the-job learning is particularly useful in contexts where people's roles are fluid and constantly changing and where learning has to be personalised for each individual. Each person has a unique job role, so the learner (rather than an instructor) can understand where and how to develop deep expertise

(Engeström 2004, 2009). Technology systems can help source and use relevant knowledge across disciplinary or organisational frontiers in ways that allow individual learners to build new knowledge (Littlejohn et al. 2012). Digital networks provide dynamic environments that connect work and learning through the collaboration around 'objects of inquiry', or resources that people collaborate on while working and learning (Paavola and Hakkarainen 2005; Paavola et al. 2004). Therefore a key trajectory in professional learning is that learning is largely directed and mediated by individuals themselves.

One way individuals can direct and mediate their learning is by *observing other people*. An example of this sort of learning is mimetic learning: learning by observing and imitating others who have greater expertise (Billett 2013). Mimetic learning complements people's direct interpersonal interactions with others, including direct instruction and mentoring. While observing others, learners can gather relevant information on their own performance by noting the outcomes of and reactions to their actions (Boshuizen and Van de Wiel 2013). People can ask colleagues who are more experienced for feedback on how to improve their performance (Ashford et al. 2003). This form of learning is feasible only in environments where feedback-seeking behaviour is encouraged. Technology systems are being developed to provide feedback through intelligent systems that can analyse an individual's actions and compare it with expert performance (Negnevitsky 2005). However, systems that exploit artificial intelligence to enhance professional learning are relatively immature (Berendt et al. 2013). Social technologies allow professionals opportunities to learn through observation of the choices and actions experts make when going about their everyday work (Sie et al. 2013). For example, social bookmarking is a process where people record and tag resources they source online. These resources and tags can be shared with others. Employees can browse the resources and tags collected by other people with greater expertise. Other examples of social technologies are blogs and microblogs (such as Twitter or Yammer), which are useful tools for knowledge sharing and professional learning (Java et al. 2007; Margaryan et al. 2014). With the advent of the social semantic web, self-guided, online social learning is becoming a more genuine and attractive option for professionals, particularly in situations where continual informal learning is interspersed with specific cases of formal learning (Sloep 2013). However, effective use of the tools requires a level of digital competence that professionals in some disciplinary fields may not yet have (Littlejohn et al. 2012).

Another modern-day learning process that requires digital competence is *learning through networks.* Networked, self-regulated, social learning is becoming more realistic and attractive as professional learning moves from prominently formal towards continual informal learning interspersed with specific formal learning. Individuals learning through networks connect with other people and resources, forming transient networks and communities (Sloep 2009; Pataraia et al. 2014). Groups of learners transcend geographical, organisational and disciplinary boundaries, connecting people with others who are working, learning and creating new knowledge around a common problem. Learning – and working – through networks has similarities to the distributed learning and crowd work settings, offering opportunities for new forms of professional learning. Professionals tap into these professional networks to find the knowledge and expertise they require to learn how to solve specific work problems (Nardi et al. 2000). Individual learners benefit from the knowledge and expertise of others, drawing on professional networks and supported by networked technologies. Peer support is a critical factor in networked learning, particularly where peer recommender tools and trust-enhancing profile systems are being developed to support co-work within virtual teams (Sloep 2013; Ley et al. 2013). However, networked learning approaches encourage individuals to link with other people outside their immediate groups. For example, an investment banker designing a system to lessen financial risks in his company reads a blog from a safety scientist who has implemented a mechanism to reduce incidents in hazardous workplaces. Although the context of application is different, the key principles fit with the banker's work task. He amends and implements these principles, contacting the safety expert for advice.

A further example of networked learning is where people collaborate around a shared problem. For example engineers working on a bridge design will bring knowledge together from different disciplinary domains into a single project, building knowledge and ideas via a network. In this case, the design is an 'object' that connects professionals who are working and learning together (Knorr-Cetina 2001) The idea of social objects and objectual practice is not new and has been studied extensively within the context of science research (*ibid*). While advances in the Social Semantic Web and network technologies will open up opportunities for networked professional learning, capitalising on the affordances of these tools requires a cultural shift in how professionals view learning.

An approach to learning that has been gaining importance in organisational contexts is *learning from errors* (Ohlsson 1996). Learning from errors is significant in hazardous work environments including the energy sector or aviation industry (Bauer and Harteis 2012). This approach to learning is based on the assumption that the collective knowledge residing within individuals in a workplace can be translated into organisational learning and behavioural change in people's work practice. Learning from errors is closely related to learning from incidents, where individual employees and organisations as a whole seek to understand and learn from past safety incidents to avert future problems (Lukic et al. 2010). The central idea underpinning learning from errors and learning from incidents is that individual and group knowledge is translated into organisational learning by which, in both approaches, problems are analysed to abstract knowledge. This knowledge can be accumulated and embedded within the work environment in ways that can generate changes in professional practice and prevent future incidents. As with the other learning processes described in this section, employees' active engagement in the learning process is essential for effective learning (Lukic et al. 2012).

All the approaches to learning described in the section provide opportunities for professional learning to evolve into forms of learning that are helpful for contemporary work. However, what is clear from all these examples is that technology solutions have to fit with new work and learning processes.

43.2.3 Technologies

Earlier in this chapter we outlined the trend towards collaborative and dispersed work. Ideally technology tools for professional work and learning should allow for collaboration by dispersed groups of people (Ley et al. 2008). Two general examples are *Collaborative Technologies* and the *Social Semantic Web*. These examples have been selected as examples of technologies that impact technology-enhanced professional learning because they already are being integrated into a wide range of work contexts. Another example of how work is being impacted by digital technologies is through *datamining*, which provides new knowledge that can aid learning and work (Berendt et al. 2012). A further significant use of technologies for professional learning is the use of technology environments to simulate authentic environments for learning. One interesting example is the use of *simulation games* to provide realistic learning activities representing work tasks. Providing learning activities that simulate real-world work situations and offer an opportunity for individuals to experiment and 'fail' in a safe environment can motivate people to engage in professional learning.

Digital technologies allow data to be 'captured' and 'mined'. These data may take various forms, for example the data may be available as 'knowledge resources' (objects) or as learner behaviours (patterns) (Berendt et al. 2012). These data can be analysed to provide new insights for learning and work. *Datamining* and analytics to support learning are relatively undeveloped. One example of datamining for learning is learning analytics, which measures and analyses people's behaviours to provide feedback and recommend actions for learning and expertise development. However, learning analytics systems are being developed in ways that support conventional, formal learning from pre-determined curricula, missing the wider range of opportunities around professional learning.

There are a wide range of ubiquitous *collaborative technologies* in daily use, including email, content management platforms, shared document repositories, audio or video-conferencing, and many more. Social media introduces further tools for knowledge-sharing, including wikis, weblogs, microblogging services, collaborative publishing and annotating, media sharing and social bookmarking. These tools support social knowledge construction and knowledge-sharing activities on the individual and organisational level. This functionality allows individual learning and knowledge to be available for organisations or collectives (Bernardi et al. 2011; Ley et al. 2013).

The *social semantic web (SSW)* supports learning in work environments by providing a platform for the creation and sharing of user-generated knowledge (Breslin et al. 2009; Bingham and Conner 2010; Vassileva 2008). Employees increasingly use their own social software, rather than enterprise technologies, for work and learning. Consequently their collective knowledge becomes distributed across different social technology tools and spaces. Semantic Web technologies provide a means by which people can structure and integrate their knowledge. This knowledge extends beyond artefacts and resources created by employees to include online traces of employees' online activities dispersed across various tools. These traces can be turned into relevant, contextualised information within the workplace (Jeremić et al. 2013). SSW allows common formats for the exchange of information about knowledge resources (Jovanović et al. 2009; Mikroyannidis 2007). In this way the SSW offers opportunities for 'bottom up' use of technologies by employees as they regulate their professional learning (Siadaty et al. 2013).

Digital technology can also simulate authentic environments for professional learning. An example is *simulation gaming* to provide realistic learning activities that simulate real-world work situations and offer an opportunity for individuals to experiment and 'fail' in a safe environment or experimentation may be hazardous or dangerous for the learner or for other people. Sometimes termed 'serious games', 'business games', 'management games' (Faria 2001; Faria et al. 2009) or 'policy games' (Mayer 2010), simulation games offer realistic learning opportunities that are useful particularly in situations where learning or experimentation may be hazardous or dangerous for the learner or for other people. These types of games combine characteristics of 'pure simulation' (abstract models that represent and reconstruct work processes) and underlying reference systems (such as authentic work situations), with key elements of games that simulate social dynamics (Kriz 2003). Examples include learning situations for surgeons and other medical professionals, where trialling different forms of practice could be dangerous for patients (Lukosch et al. 2013) or for energy sector employees, where experimentation could result in a major incident. Alternatively, simulation games can visualise materials that cannot be seen. For example chemists can experiment with molecules at the atomic level. Simulation games support situated and authentic learning by providing an environment in which players can relate their actions (within the game) to their work activities (Yusoff et al. 2009). Simulation games can be implemented in workplace settings in ways that allow two-way interaction between the game (simulating a real-world work environment) and the work environment itself (Klabbers 2006). Therefore the games can be used to provide insights into work processes, supporting decision making and enabling participation within real organisations. In this way the games are not only useful for learning, but can also be used to analyse and improve organisational systems (*ibid*).

Simulation games have key elements that differentiate them from 'pure simulations' such as flight simulators used in aviation training, which do not include these sorts of game mechanics. Key elements of games include game principles (for example, rules), game mechanics (including scoring), and gaming means (for example, competition). Game principles are generally guided by 'rules' that are typically pre-defined. These rules define the game space and govern the actions of the players (Klabbers 2006). Game mechanics are usually administered by a 'scoring system'. Scoring allows each player to assess his or her performance, thereby increasing their engagement in the game. Scoring is related to the element of competition, which is widely used to engage players in the game process. Competition compares the knowledge and/or skill of one player with the skills of others playing within a single game environment. Other important game elements include 'reality', 'meaning', and 'play' (Harteveld 2011). 'Reality' describes how a game models the real world;

'meaning' is related to the value the game adds to the player's ability to perform in real world situations; and 'play' is the player's immersion in an interactive, fictitious scenario. All three elements – reality, meaning and play – are important for simulation game design since they have the potential to increase player motivation, engagement and immersion (Harteveld 2011).

In the next section we consider the trends outlined in this section and examine their implications for professional learning.

43.3 Trends and Implications for Professional Learning

From the analysis in the previous section, three key facets of professional learning appear to be critical:

First, in a constantly-changing and knowledge-driven society professional learning has to be *continual* (Eraut 2004; Hager 2004; Siadaty et al. 2013). Yet current forms of professional training largely focus on large cohorts of people learning general concepts at the same time, rather than on individuals continually learning knowledge that is specific to their work activities.

Second, as job roles become unique to each worker, individuals have to take responsibility for *self-regulating* their own learning, rather than replying on guidance from an instructor (Littlejohn et al. 2012; Margaryan et al. 2013). The more personalised job roles become, the more critical it is that learning is designed to support each individual to learn what they need (Tynjälä 2009; Engeström 2013). Yet, professional learning often is predicated on people having generic, rather than specific, job roles (Fiedler 2013). In fact, much of the learning that goes on in the workplace is largely informal and social and goes unrecognised (Colley et al. 2002; Hart 2010; Tynjälä 2008).

Third, as employment and work practices change, work *relationships transform*. As the focus of work shifts from tasks within a single organisation to distributed work within the network, people coalesce around 'epistemic objects' (knowledge objects such as a report or an output from a shared task), rather than group, team or organisational structures. These transformations impact relationships amongst employees as well as the relationships of people and organisations (Nickerson 2013; Bietz 2013). Current professional training tends to be designed around conventional forms of employment, missing fresh opportunities for learning.

These three facets of professional learning are examined in detail in this section.

43.3.1 Continual Professional Learning

Continual professional learning is important for both organisations and for individual workers (Clow 2013). Organisations benefit from continual learning that enables employees to solve more complex problems or deal with new tasks efficiently (Clow 2012). For individuals, continual learning expands their skills and competencies in ways that allows them to adapt to changing work situations, thus extending their employability. The capability of an individual to continue to be employable under conditions of considerable change has been termed career adaptability (Brown et al. 2012). Career adaptability is an aspect of the self-regulation of an individual in response to the need to adapt to disequilibrium caused by changes in job roles, work tasks and so on (Savickas 2005). Adaptability extends beyond employability in recognising that work practices never reach equilibrium, and are continually evolving in response to workplace transformations (*ibid*). Although the concept of career adaptability has psychological roots, it is influenced by psycho-social factors such as guidance from others (Brown et al. 2012).

Guidance and feedback, task planning and reflection on outcomes have been characterised as important elements of non-formal, workplace learning (Eraut 2002; Kyndt et al. 2009). These activities are achieved through regularly interacting with colleagues, evaluating progress, self-evaluation or feedback from others (Dunn and Shriner 1999; Sonnentag and Kleine 2000; Van de Wiel et al. 2004, 2011a, b). Often the interactions between individuals are informal and serendipitous. Nevertheless, these connections could form a basis for professional learning activity (Siemens 2005), providing opportunities for feedback – from peers, experts and from computer systems.

Organisations have been seeking to capitalise on individuals' knowledge in ways that benefit the collective (Nonaka et al. 1998; Lewis et al. 2007). Some organisations have implemented performance management practices and systems to encourage employees to engage in continual learning by integrating learning and performance improvement goals within their work (Ericsson 2009; Luthans and Peterson 2003). These organisational processes support professionals in managing and advancing their own learning, and are often administered via networked technology systems (Davenport 2005; Davenport and Pruzak 2000). However, despite the promise of these technologies, many performance management systems are limited in their design. Some systems are used as a repository, storing examples of individual's work, learning resources and qualifications. Other systems are linked to enterprise tools, limiting the social networks employees can utilize, restricting knowledge flow across the network, and limiting the cross-application of data.

Technology systems are most effective in supporting professional learning when they support social activities. Examples of these sorts of activities include coaching or feedback from experts or more knowledgeable peers (Kicken et al. 2009). There are a range of data routinely generated through work activities that can be used to support these sorts of activities (Siadaty et al. 2013). Data on work tasks, priorities, goals, connections and employee behaviours can be collected, analysed and used to support professional learning (ibid). Some systems gather the data available about the user to enable the system to 'adapt' to individual learners' preferences and characteristics and support continual learning (Shute and Towle 2003).

One example of an adaptive system is APOSDLE (http://www.aposdle.tugraz.at/): a suite of tools and services designed to support individuals with formal and non-formal work-related learning (Lindstaedt et al. 2009). System development was funded under the European Commission's 6th Framework Programme. APOSDLE is an example of a social, semantic network-based system that connects employees within an organisation by comparing the textual and semantic similarity of their work and learning activities (Beham et al. 2010). A User Profile Service stores and maintains user data about current work tasks, work domain and learning goals as well as the individual's learning history. The system uses semantic models (based on each individual's work task, work domain and learning goals) to recommend learning paths and to identify other users with similar paths or who have achieved similar goals (Ley et al. 2008). These sorts of social, semantic systems provide a platform for continual learning largely through the collaborative creation and sharing of user-generated knowledge (Berlanga et al. 2007, 2008; Brouns et al. 2007; Bingham and Conner 2010; Vassileva 2008). Professionals use the platform as a focal point to continually plan their learning, integrating non-formal on-the-job learning with formal training as appropriate.

These technology systems provide a useful platform for continual professional learning, however underlying problems have been identified. Adaptive systems have the potential to support professional learning through the creation of multidisciplinary knowledge across geographic, organisational and disciplinary boundaries (Ley et al. 2013). In this way they seem ideally suited to contemporary workplaces where roles are specialised and autonomous. However, these adaptive technology tools tend to draw data from enterprise systems that are linked to organisational structures, providing a 'top-down' interface. On the one hand this interface provides a 'top-down' structure that can guide learning (Sloep 2013). However, this structure constrains the learner's autonomy as to how and where to develop deep expertise. This autonomy is critical for contemporary professional learning and development (Engeström 2009) so systems designers have to find ways to collect social, semantic data beyond organisational, disciplinary and geographic boundaries. There are examples where access across boundaries has been achieved, for example in the Open Source Software domain, development of the Linus operating system and Apache web server involved the integration of data across boundaries (Weber 2004). Similarly, the ATLAS project at CERN, which aimed to find evidence for the existence of Higgs boson, set up an open system for data exchange (Boisot et al. 2011). Despite these examples, the problem of accessing and collecting distributed data is difficult to resolve, since it would require agreements to share data across commercial sites and international alignment of privacy laws (Sloep 2013).

Adaptive systems can help source and use relevant knowledge in ways that allow individual learners to build new knowledge (Littlejohn et al. 2012). These systems are designed to meet individual's work and learning needs, with the recognition that each learner's needs are different. However, the effectiveness of the tools depends on the willingness of professionals to work across boundaries and their ability to operate across cultures. Equally, it is dependent on the motivation and aptitude of individuals to self-regulate their learning (Van de Wiel et al. 2004; Zimmerman 2002).

43.3.2 Self-Regulated Professional Learning

Workplace learning is structured by and deeply integrated with work tasks (Billett 2001). As professionals specialise in their roles, learning becomes unique to each individual (Engeström 2013). Where expertise becomes deep and narrow, each individual worker cannot rely on formal training designed to transmit generic knowledge to groups of people with similar roles (Stenstroem and Tynjälä 2009; Fiedler 2013). Specialists have to be capable of identifying their own learning needs, which can be fluid depending on changing circumstances. They must cultivate an understanding of where and how it is appropriate to develop deep expertise (Engeström 2004; Carneiro et al. 2007). Each individual has to be capable of drawing on the knowledge available to her (resources and the know-how of other people), making decisions about what to learn, when and how (Siadaty et al. 2010). This process has been termed "self-regulated learning".

Self-regulated learning can be defined as "self-generated thoughts, feelings and actions that are planned and cyclically adapted to the attainment of personal learning goals" (Zimmermann 2002). Social-cognitive theories of self-regulated learning (Pintrich 2000; Zimmerman and Schunk 1989; Winne 2010) posit that the regulation of learning is social. Each individual ideally can plan and structure their own learning, through goal-setting, self-monitoring and self-reflection (Zimmerman 2002). In formal learning contexts these stages occur consecutively, however, in the social professional learning situations, these self-regulatory processes are much less clearly delineated and much more closely interwoven with everyday work tasks (Margaryan et al. 2013).

Through regulating their own learning, professionals can solve everyday work problems, and develop a range of competencies that enables them to attain career adaptability, as outlined in the previous section (Brown et al. 2012). Organisations can support employees' learning by identifying individuals' self-regulation ability, encouraging and supporting them to improve (Fontana et al. in press). Similarly, by understanding their capacity for self-regulation, professionals themselves can improve their ability to take forward their own learning.

Self-regulation is based around "attaining and maintaining goals, where goals are internally represented desired states" (Vancouver and Day 2005). Even though learning goals are centred around individual people, goal setting and attainment takes place at the intersection of the individual and the collective (Littlejohn et al. 2012). Learning and development goals tend to be associated with work tasks and are often shared by individuals engaged in collaborative work. However, the role of the collective in self-regulated learning, particularly professional learning, is not well understood.

Some attempts to improve professionals' self-regulation have focused on the use of digital networks to provide a point of connection for individual learners with the broader collective. Networks are important in situations where practice is distributed and where people work in transient groups (Sloep 2009). In these contexts, the conventional forces that bring people together, such as geographic location or team affinity, lose their binding force (Jensen and Lahn 2005) and have to be reinvented. Here, people tend to work around shared epistemic objects – knowledge resources that people collaborate around while working and learning (Knorr Cetina 1997, 1999; Paavola and Hakkarainen 2005; Paavola et al. 2004). An example of an epistemic object is an electronic patient journal that is used as a focal point for health professionals from a variety of disciplines to collaborate around, sharing and building knowledge about the patient (Bruni 2005). These objects provide the focal point and structuring resources for the construction of new professional practices (Lahn 2011). These objects can be viewed as products (the instantiation of professional knowledge) and processes that reshape professional practices (Hakkarainen et al. 2004). For example, these objects provide a mechanism for professionals to integrate knowledge from diverse domains, rather than limiting themselves to specific knowledge domains (Lahn 2011). Bringing knowledge together from across different boundaries is critical when planning effective professional learning.

One example of a learning and development planning tool that aims to support professionals in drawing upon knowledge from across diverse domains is SRL@Work. To connect knowledge across domain boundaries in an effective way, professionals have to align their own learning goals with the learning goals and activities of their colleagues, and of the organisation (Siadaty et al. 2013). It is difficult and time consuming for professionals to make these alignments themselves, so the network system recommends connections by using pre-defined ontologies to link and integrate user traces within the network. Data is collected about specific learning activities, tools and prior knowledge that users have (Siadaty et al. 2011). The system uses these ontologies to identify gaps in learners' competences. The system monitors learning progress and recommends learning strategies to users, sharing and documenting their learning experiences and comparing self-observed performance against peer performance (Siadaty et al. 2012).

SRL@Work provides a system that potentially aids professionals to improve their ability to self-regulate their learning. However, these sorts of systems are still experimental and have significant constraints. SRL@Work uses both social and organisational workplace factors to support self-regulation. The social factors allow individuals to plan their learning goals in relation to the goals of other people, drawing on collective knowledge. These social factors help to make previously unforeseen and unanticipated connections (of people or knowledge) across boundaries. However, the evaluation results indicate that, although users see value in these social factors, they place greater importance on organisational factors when planning their goals (Siadaty 2013). This limitation was evidenced in earlier career management tools that steer the individual into updating his or her skills in relation to organisational working conditions, rather than focusing on broader career patterns and trajectories (Brown et al. 2012).

Another problem is that professional communities tend to be defined by their knowledge domain and characterised by "epistemification" or the ways in which different professions view knowledge (Stutt and Motta 1998). This form of cultural identity limits professionals when they plan their own learning trajectories, restraining the potential diversity and multidimensionality of learning processes (Lahn 2011).

Changes in work practices mean that boundaries are no longer clear. Therefore the relationships amongst people and between individuals and organisations are changing.

43.3.3 Transformed Relationships

Informal learning tends to involve interacting with other people. Therefore, as informal learning becomes increasingly important for work, relationships between people become ever more critical for learning (McDonald and Ackerman 1998). However, work tasks increasingly are divided and shared across groups of people who are distributed. Therefore it seems that individuals have fewer opportunities to connect and form conventional face-to-face, working relationships (Bietz 2013). These shifts in work patterns change the ways in which we view work relationships and how people draw on others for professional learning.

Relationships are not only changing within groups of workers, but relationships between employees and organisations are altering. People are no longer working in a specific role in a single organisation for an extended period of time (Beck 2000). They may work across several roles or change jobs frequently. Increasing numbers of people are choosing self-employment or multiple employment (ibid). Connections with co-workers and even with organisations, can be transitory. This issue is particularly difficult in work processes where people are contracted to work on specific work tasks, rather than in job roles, for example crowd work (Nickerson 2013). Similar to distributed work, crowd work involves distributed sets of people connecting via networked technology to perform a set of work tasks (Nickerson et al. 2009). However, the difference between distributed work and crowd work is in the ways that people connect (Kittur et al. 2013). While in distributed work individuals are intentionally brought together as teams to work on a specific problem, crowd work enables organisations to outsource discrete tasks to large numbers of disconnected individuals, who often have no knowledge of others who are working on similar tasks. Examples of crowd work include Mechanical Turk (https://www.mturk.com), which uses a technology system to assign people short work tasks. These sorts of emerging work practices alter relationships between people, organisations and products. First, since people are contracted to work on specific work tasks, rather than in job roles, their associations with organisations are sometimes underdeveloped. Second, people who connect with others in large groups to work on a specific task may not know, or form work relationships with, their colleagues. Third, by drawing on the input of large numbers of people, outputs of work tasks become difficult to attribute to an individual person, or even a group of people.

When people share the same working space it seems easier to establish conventional working relationships (Bos et al. 2006). People who collaborate with others in distributed groups may not know other colleagues well or may interact with them only as long as it takes to complete a single task (Bietz 2013). Consequently, interpersonal and group dynamics that are taken for granted in face-to-face settings may suffer.

However, distributed teams have different forms of professional practice that provide unique opportunities for individuals to learn, particularly in situations where the teams comprise people with diverse expertise (Bos et al.2006).

For informal learning, people have to find others with specific expertise to help them solve problems (McDonald and Ackerman 1998). Group members have to maintain an awareness of each others' knowledge (Argote and Miron-Spektor 2011; Edwards 2011). Knowing what others know and what they are working on is extremely difficult. Social semantic web technologies are being developed to raise people's awareness of the knowledge available within their network as they plan their learning and development. These technology systems offer new ways of connecting individual employees in ways that help them plan their learning trajectory by drawing on the collective knowledge within an organisation and beyond.

Knowledge workers use a variety of social software tools in their daily work and learning (Siadaty et al. 2013). These tools connect individuals with the collective knowledge distributed across different social networks and technologies. Typical examples of social software tools are conferencing tools (Skype or Google Hangout), blogs, microblogs (Twitter), wikis, social network sites, RSS-feeds, sharing services, social bookmarking and tagging tools (Breslin et al. 2011). These sorts of applications have enabled learners to support one another's learning, to model practice and epistemic values, to engage in dialogue and collaboratively construct knowledge (Dron and Anderson 2009). Various perspectives on learning view these forms of knowledge construction in different ways: connectivism stresses the importance of connecting people and knowledge through digital networks (Siemens 2005), constructionism place emphasis on the social creation of knowledge (Papert and Harel 1991) while trialogical learning highlights the intersection of the individual with collective knowledge (Paavola and Hakkarainen 2005).

As individuals interact with the collective knowledge within a social network, they leave digital 'traces' of their actions and interactions (Littlejohn et al. 2012). These traces can be turned into relevant, contextualised information that can support continual learning (Jeremić et al. 2013). Learner interactions can be collected and aggregated within specific ontologies that provide structure and meaning to the data. This allows the data to be analysed, providing learners with feedback, recommendations, or new knowledge that would not be available through directly accessing the contributions of other people (*ibid*). A number of prototype systems that feed back data in ways that support professional learning have been developed. Examples include GroupMe! – a system designed to allow groups of learners to use, share and integrate collective knowledge (Abel Henze et al. 2009) and MetaMorphosis+, an online environment to build collaborative knowledge in the domain of medicine (Kaldoudi et al. 2011).

Other forms of social semantic technology systems are using learning analytics to raise people's awareness of the knowledge available in their networks. Learning analytics is the measurement, collection, analysis and reporting of data about learners and their contexts (Siemens and Gasevic 2012). The data is used to understand and optimise learning processes and the environment in which these occur. Learning analytics is mainly used in formal learning settings, such as professional training or education. Its key components include data, goals, measures of goal attainment, models that compute the value of goal attainment and predictive models that use these values as variables, modelling results from the given data (Berendt et al. 2013). Learning analytic systems use automatic or semi-automatic ways of reporting results to selected stakeholders (learners or tutors). Optionally, the data can be used within an application designed to improve learning. Examples of learning analytic applications include, connecting learners with similar learning goals to promote collaboration (Littlejohn et al. 2012); utilising 'clickstream' data – information about sourced materials or user input - to give learners feedback about their learning behaviours and choices (Ferguson and Buckingham Shum 2012); using learner models to recommend personalised learning resources to learners (Greller and Drachsler 2012); or applying predictive models to forecast when a learner is 'at risk of dropping out' (Berendt et al. 2013). In formal learning settings, analytics focus at the level of a 'course' or another administrative structure (Ferguson and Buckingham Shum 2012). By contrast, in informal learning settings, analytics focus at the level of groups and networks of learning (Berendt et al. 2013). Informal learning settings have no set syllabus, course structure, or accreditation and learning interactions are not usually guided by teacher-learner relationships. One example of an informal, professional learning setting is a 'learning network' – groups of professionals who learn by sharing and developing knowledge within digital network environments (Sloep and Berlanga 2011).

These transformations in professional learning allow us to identify key issues that should be addressed in the future.

43.4 Future Directions for Technology-Enhanced Professional Learning

A number of key directions for future research and development within Technology-enhanced Professional Learning arise from our discussion.

First, ***an integrated analysis of work practices, learning processes and technology use*** is critical to the development of a better understanding of professional learning. In our analysis we highlighted the close intertwinement of work and learning. This intertwinement means that understanding what and how people learn at work and how to support these learning processes with technology is impossible without an in-depth understanding of the work itself. Therefore, future research in Technology-enhanced Professional Learning should be firmly grounded in the analysis of the technology-mediated work practices, establishing empirical connections with work practices within the various contexts and domains of investigation. Although there is a growing body of literature providing (largely journalistic) accounts of digitally-mediated work practices (Howe 2008; Nielsen 2011; Shirky 2008; Tapscott and Williams 2010) these do not examine learning processes. Similarly, recent studies describing learning and work practices (Eraut 2002; Billett 2010) tend to overlook the technological dimension of learning.

Second, this sort of integrated understanding of work, learning and technology requires ***strengthening the interdisciplinary dialogue.*** As the reader can see from the scope of the literature discussed in the previous sections research and development in work practices, learning processes and digital technologies is conducted within a range of disciplines – sociology, learning sciences, organisational learning and management sciences, computer sciences and information systems, to name a few. Therefore, the refinement of the understanding in Technology-enhanced Professional Learning requires a concerted, interdisciplinary analytical effort, drawing on the wide range of foundational and applied disciplines concerned with human learning, work and technology – not only sociology, workplace learning, management and organisation studies, and computer and information science, but also psychology, economics, biology, political economy, and others, At present, such a systematic, wide-ranging interdisciplinary effort is lacking. Future work in this area should build upon the conceptual, empirical and methodological instrumentation developed and practiced within these different disciplines. To strengthen the interdisciplinary dialogue, action at two levels is required: at the level of the individual researcher and at the systemic level of the field (Lyall et al. 2011). At the individual level, researchers can increase their awareness of relevant literature from the different relevant disciplines. At the systemic level, the development of interdisciplinary curricula for training early-career TEPL researchers would be useful, as would the establishment and the expansion of the number of systematically structured interdisciplinary discussion fora, for instance interdisciplinary networks or special interest groups within key professional associations.

Thirdly, ***improving research methodology*** is critical. Much of the research in Technology-enhanced Professional Learning relies on retrospective, self-report methods and on laboratory experiments conducted in controlled settings where few of the critical workplace interdependencies and environmental influences are observed. Yet the dangers of overreliance on self-reported, retrospective methods are known. In particular, previous research has suggested those individuals' judgments of their learning may be inaccurate (Townsend and Heit 2011) and that individuals may have limited or no direct introspective access to higher order cognitive processes such as learning (Nisbett and Wilson 1977). Methodological limitations impede the development of a holistic view of how technology-enhanced professional learning occurs in real-world workplace settings. Future research should incorporate methods that allow a more holistic, in-situ, multidimensional and longitudinal analysis of learning processes, work practices and technology use patterns in realistic, workplace settings. Potential solutions include the application of real-time data capture and of data triangulation approaches such as ethnographic methods (Szymanski and Whalen 2011) and building on a mixture of qualitative and quantitative, intra-individual and inter-individual measures (Johnson and Onwuegbuzie 2004).

In conclusion, the co-evolution of work and technology practices offer opportunities for how professional learning is conceptualised and instantiated. The framework for Technology-enhanced Professional Learning defined in this chapter can be used to plan and take forward new forms of professional learning supported and enhanced by digital technologies.

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