

Student Inquiry, Networks of Knowledge and Linked Data

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Abstract

This paper explores the potential for the development of new learning opportunities in higher education, through students being conceptualised not as consumers, recipients or commodities, but rather as co-researchers and co-producers of knowledge. Specifically, it discusses the implications of new forms of networked knowledge enabled by the emergence of semantic web and linked data technologies and the reconceptualising of the Internet as a 'global data space'. We draw on our experience of initiating and supporting a range of projects in UK higher education in the course of an extended programme of research and development. Some of these involved the design and development of new technology platforms, while others were focussed on the redevelopment of taught courses, assignments and assessed activities. What these projects had in common is that they all took place in the context of complex learning settings in which some variety of case based learning is used. They involved students drawn from different disciplines in higher education in 'research-based learning' about curriculum contexts, and about pedagogical aspects of these contexts. New digital tools were developed in the form of rich web applications that allowed learner interaction with content, in many cases underpinned by data from multiple sources and in diverse formats. In the development of these online technologies, students located, analysed, synthesised and, in some cases, generated new data, and, perhaps more significantly, participated in local or global knowledge networks. What we will argue is that these types of projects involve not only the development of specific techno-literacies, but also that they form the basis of broader 'critical digital literacies'. These in turn equip students to enter workplaces better positioned to inquire into the particularities of the educational settings in which they work and the practices in which they are engaged. They can thus undertake 'counter-research' in which dominant rhetorics are challenged, and evidence bases for policy and practice are subjected to scrutiny, critique and reinterpretation. This presents the potential for students to undertake critical and politicised inquiry as part of a broader reframing of the purposes of higher education.

Keywords

Inquiry Based Learning, Digital Literacy, Linked Data, Politicised Inquiry, Higher Education

Introduction: Students as Researchers and Producers

This paper encourages a reconceptualisation of students in higher education as co-researchers and co-producers of knowledge. Our experience and examples relate to the field of networked learning as it was defined by Goodyear et al. (2004) as 'learning in which information and communication technology ... is used to promote connections: between one learner and other learners, between learners and tutors; between a learning community and its learning resources'. This foregrounds a social and collaborative view of learning that has been widely influential in networked learning design (Jones, 2008). This collaboration and participation of students in creating environments for networked learning can support the development of critical digital literacies enabling critical inquiry and transformative learning (Jandrić, 2016).

Considering this stance more broadly in the context of higher education, perceptions of learning and the role of students are fundamentally tied to views of the purpose of Universities in society. In the UK, the University has historical origins in the medieval era when, despite its focus on religious learning, the University was conceived of as a community of scholars and was based on a participative approach to learning and inquiry (Barnett, 1990; 19). Universities remained at least nominally independent of the state and their role as providers of education for established and emerging elites prevailed until the latter parts of the twentieth century.

Peters (2011) discusses the prospects for what he terms the ‘post-historical’ university (that is, one where the dominant rhetorics of Kantian criticality, Humboldtian sensitivity to different cultures, or the Leavisite literary ‘canon’ are incorporated into new kinds of institutions) and is cautiously optimistic about the shift from educational elitism to more recent ‘massification’ of higher education. However, this shift has been accompanied by the marketisation of higher education in many economies including the UK, and the accompanying reconstruction of the student as a neoliberal subject. Central government funding was cut to encourage marketisation, competition and commercial links to be made (Williams, 1997), with the Dearing Report (1997) setting the scene for changes in funding which have had significant impacts not only on student finance but on pedagogical practice and the relationship between educational providers, teachers and learners. The shift from a system based on central funding and student grants to one based on student fees and loans has granted students ‘sovereign consumer’ status (Scullion, Molesworth and Nixon, 2011).

Against this background, positioning students as producers rather than consumers, and achieving this through engagement in inquiry and research appears to be a radical step. However, if the knowledge that is being produced and the inquiries are limited in scope, then there is a danger that stressing production within market economies risks not only their work, but students themselves merely becoming different kinds of ‘commodities in formation’ (Caella, cited in Toscano, 2011: 269), shaped by sets of standards, competencies, literacies and ‘graduate attributes’. In those areas of higher education which are explicitly concerned with the preparation of students to enter workplaces or professions, what constitutes legitimate inquiry and useful knowledge production may be determined either directly or indirectly by the same neoliberal priorities that have marketised all other aspects of students’ experience of higher education.

For example, in one area in which the authors work, namely initial (pre-service) teacher education, a primary concern for many students is the securing of employment which offers them longer-term personal security, rather than a short-term, ‘term-time only’ or supply-teaching contract without a guarantee of tenure, advancement or the financial security that would allow them to obtain a long-term tenancy or mortgage (Jones et al., 2007). Seeking employment opportunities often takes place concurrently with final year undergraduate dissertation project work, leading students pragmatically to select research topics or approaches that address gaps in their current profile of professional competences (in England, defined by the Department for Education, (2011), or which might otherwise improve their employment prospects. In Bernstein’s terms, the research project then becomes a secondary ‘field’ in which a selective and reductive version of academic research is performed as a pedagogical exercise (Atkinson, 1985, pp. 171-175) in order to demonstrate students’ potential to be ‘research informed teachers’. In terms of Healey & Jenkins’ typology of undergraduate research (2009), there is a tension between an aspiration to ‘research-based’ learning, in which students engage in authentic and academically rigorous inquiry, and factors which may lead to a more limited ‘research oriented’ learning: a training to engage with rather than in research and ultimately to become ‘informed’, but potentially less critical, consumers of research.

The governance of education has also shifted from government departments and local authorities to a form of self-governance through performance management based on tracking and inspection of data (Ozga, 2009). Learning analytics as the collection and representation of performance data has a fast expanding influence on education management and is also hailed as a positive way to ‘help students improve their learning behaviours’ (Baker and Inventado, 2014). However, power lies with the organisations that collect, analyse and represent educational data which is now collected on a vast scale. Choices about instruments of measurement and analysis affect the interpretation of that data and therefore the policy and practices associated with it (Williamson, 2015). Commercial organisations such as Pearson education are acting as ‘digitised centers of calculation’ to develop policy instruments (Williamson, 2015). It is therefore even more imperative that students of education as the professionals of the future are engaged in critical inquiry involving their own analyses and representations of data. Rather than allowing multinational corporations to collect and serve them data showing judgements about the quality of learning such as ‘learning gain’ or ‘value added’, educational professionals need to be able to select, manipulate and represent their own data. Our examples in this paper show how open source digital tools can be used to support this engagement with data and we argue for a reconceptualisation of the meaning of professionalism in education to support the view of the teacher as activist.

Student Inquiry, Research Objects and Knowledge Networks

The examples used for this paper were part of an extended programme of research and development initiated through a major project funded by the UK Economic and Social Research Council (ESRC) and Engineering and

Physical Sciences Research Council (EPSRC): ‘Ensemble: Semantic Technologies for the Enhancement of Case Based Learning’. The Ensemble Project explored the pedagogical opportunities presented by emerging semantic web and linked data technologies, particularly in complex, controversial and rapidly-evolving fields where case based learning was the pedagogical approach of choice. This involved working with teachers and students in undergraduate and postgraduate courses to explore both the nature and role of the cases around which learning is focused, and the part that emerging Semantic Web technologies and techniques can play in supporting this learning. The project ran from 2008-2012 and the activities initiated in the course of its work (see Martinez-Garcia et al, 2012, for an overview of these) have been continued through a series of smaller-scale, discipline-specific curriculum development activities.

In the course of the Ensemble project, 14 undergraduate students worked as associates within the project group following the pattern of the Undergraduate Research Opportunities Programme (UROP) initially established at MIT, and then adopted, first at Cambridge under the auspices of the Cambridge-MIT Institute (Good et al, 2007), and then more widely in the UK. These students were engaged in a range of research activities including the identification of data sources for use in semantic web applications; working with data visualisation tools to explore these data and their interrelationships; and developing web applications that incorporated semantic web and linked data technologies and approaches. Notable examples included an interactive timeline of plant evolution; an interactive resource supporting the engineering students to develop maths skills; and a spatial representation of biographical data from the UK Data Archive’s collection on life in Edwardian England. As Tracy and Jordan (2012) explain, as well as developing domain knowledge, the participating students developed insights into technological and pedagogical issues. This combination led to their contribution to knowledge production through the development of new semantic web technological ‘products’: data sets, visual representations and online tools. Students were involved in the classification, structuring and representation of knowledge in areas which they were familiar with as learners, as well as from beyond their own disciplinary experience. This engagement required them to reflect on and assess their own disciplinary knowledge from an ‘outsider’ perspective and to consider pedagogical theories in making design decisions. Their contributions were reflected in publications and presentations, and in later use of data and prototypes they had developed; several of the students went on to develop their UROP project work into final-year dissertations and other projects.

Later in the Ensemble project, beginning in 2010, staff and students in Education Studies at Liverpool John Moores University were involved in the development and use of an interactive timeline of the History, Philosophy and Sociology of Education (Litherland and Forrester, 2013). This timeline was built using technologies developed by the SIMILE project at MIT, principally the ‘Exhibit’ framework (Huynh et al. 2007) and by the Ensemble Project team themselves. Data sets and other resources were identified and presented to students using a highly interactive web application in which a multi-tracked timeline allowed students to explore the relationship between social, political and philosophical developments and educational provision. Thus, for example, the interplay between the women’s suffrage movement, the growth of the labour and trade union movement, and the provision of public education in the UK could be explored, with the timeline linking events and offering students opportunities to read further, inspect primary sources (texts, images and video) and examine quantitative data sets relating to student and teacher numbers, union membership, economic and social indicators.

Initial versions of this timeline were, like the pilot studies and prototype applications of the UROP projects, developed ‘for’ students (albeit sometimes ‘by’ other students), and content was largely based on existing curriculum coverage and other resources identified by teachers of the courses concerned. In fact, as Edwards et al. (2011) discuss in relation to the plant sciences timeline developed previously, this led to a carefully bounded set of data being offered to students, within complex and linked, but ultimately constrained, ‘microworlds’ (Carmichael and Tscholl, 2013) or ‘knowledge neighbourhoods’ (Stutt and Motta, 2004). Data sets presented were generally simplified and other resources to which students were directed were selected, rather than the students being encouraged to explore and identify sources from across wider networks. As in the case of the dissertations mentioned above, this involved students in a secondary reproduction of academic practice, performed as a pedagogical exercise. Edwards et al. (2011; 224) highlight the tensions between engaging students in networked learning in open and complex cyberspaces in (rather than the closed spaces of virtual worlds and simulations) and “keeping it in the comfort zone for the students” (227-228), a process which meant that while developing skills working with data handling and interactive representations, they remained consumers, albeit of sophisticated and customised digital products.

This awareness led to subsequent work in developing and using semantic web and linked data technologies where attempts were made to break through these boundaries, engage students with authentically complex

networked knowledge, and support them in the construction and sharing of new knowledge. This was achieved in a number of ways, one of which was to engage teachers and learners in participatory design and development activities, often involving rapid prototyping, rather than devoting time to developing microworlds that were increasingly rich, complex, and visually appealing, but which were, at the same time, carefully bounded and curated.

The first of these involved teachers and students of contemporary dance, with whom researchers and developers from the Ensemble project worked to develop web technologies to support the design, evaluation and sharing of ‘telematic dance’ performances, in which digital technologies were used not only to record performances but to enhance them. These activities have been described and theorised elsewhere (Brooks, 2012; Morris, 2012; Carmichael, 2015), but the key points of interest for us here were the fact that the idea of students as co-producers was already well-established in this setting; and that the nature of dance students’ lives and their potentially precarious employment meant that they were already conscious of the need to establish and maintain personal and professional networks. As Morris (2012) describes, this was manifested in their interest in using linked data approaches, in combination with social media platform, to engage audiences, other performers, and potential employers.

A second area of development has involved supporting students in engaging with data sources directly, with mediation being provided through the design of tasks, training activities, and the provision of contextual metadata and commentaries, rather than through the translation and simplification of existing data into resources with specific and limited pedagogical purposes. In the context of undergraduate inquiry, this has typically involved students using open government data sources provided through the UK government Data Hub (<http://data.gov.uk/>). Data from the government’s annual school census (‘Schools, Pupils and their Characteristics’) is provided in structured form. This allows students to draw on them in order to formulate research questions and contextualise their own studies, but their use also highlights shifts, not only in educational provision, but also in its conceptualisation, as the data collected and the technical ontologies with which it is organised have evolved in response to policy imperatives. Asking why specific data are collected now that were not collected a decade ago (or vice versa), or asking why classification and category systems have changed, provides points of departure for critical and reflexive student inquiries.

Encouraging students to engage systematically and in larger numbers with these data has been the focus of a project at Liverpool John Moores University in which two second year undergraduate students enrolled on the Mathematics and Education Studies programme were employed as undergraduate interns (much as in the precious UROP schemes), and developed an online directory of open data sources of particular relevance to undergraduate inquiry in education (Tracy, Morris and Jones, 2016). As well as collating metadata about the datasets and sources, they wrote critical narratives to accompany each source which were then made available online (<https://redtech.ljmu.ac.uk/projects/freefund/data.html>). This process revealed a range of technical issues (data sets were incomplete, inconsistent, or included estimates) but also broader questions about the application of problematic categories, indicators and concepts, often related to emerging policy discourses about issues of equity and social justice.

These developments go beyond the building of microworlds or providing ‘teaching data sets’ for students with specific pedagogical purposes; although the development of the directory involved only a small number of students and staff, its purpose is to encourage students to engage with open data beyond a tightly bounded knowledge neighbourhood, explore linked data approaches, and engage with the complexities and problematic aspects of secondary analysis of existing networked data, and this form of mediated access to authentic, complex and untidy data represents an opportunity for broader digital literacies to be addressed: a subject to which we shall return shortly.

Perhaps the most ambitious developments of these activities has involved students’ incorporating data they collected and interpreted themselves into existing data networks. In another initiative in Education Studies, undergraduate students conducted inquiries into the aspects of the history of education, the outcome of which were then linked to the existing timeline of the History, Philosophy and Sociology of Education. Litherland and Forrester (2013; 10) describe how their work complemented and extended existing data presented in the timeline and included historical studies of the UK national curriculum; UK educational policy post 1988; policy on special needs and inclusion; and the changing role of audiovisual technologies. As well as existing online data sources, the students also conducted interviews about their chosen focus of inquiry, and these too were linked to the timeline.

The students reflected not only on their experiences of developing specific new techno-literacies associated with semantic web and linked data technologies and data representation, but also the ways in which policy contexts and political developments underpinned what they had previously seen as unproblematic issues of educational practice. The students also developed greater awareness of the processes by which data and other resources came to be incorporated into pedagogical applications and curriculum activities. However, Litherland and Forrester (2013; 13) do identify epistemologically naive views about reliability and bias, and little awareness of how human intervention or algorithmic processes might operate in the context of complex networks of data. This was also an issue highlighted in a project, parallel to the main work of Ensemble into digital archiving, which explored how semantic web technologies could be used to allow small scale educational research projects to be self-archived in order to gradually build up networks of linked data, along with related research instruments, protocols and interpretational frameworks (Martinez-Garcia, and Corti, 2012).

One pattern that emerges from all of these examples is that none of them involve students generating conventional assignments or dissertations. As De Roure (2014) argues, and as the authors discuss in detail elsewhere (Tracy and Carmichael, 2017), if student inquiry is to align with academic inquiry more generally, then it may need to be broadened in scope to reflect shifts towards 'data-driven or data-intensive science' (De Roure, 2014; 234) where humans and machines are linked in networks. Semantic web technologies and associated methodologies and tools to enable data analysis and knowledge modelling will therefore need to be accessible to scientists, students and non-experts (Fox and Hendler, 2009; 148). These will need to be incorporated into any programme designed to prepare students to engage in emerging data practices. De Roure suggests that the most appropriate mechanism for research dissemination in this new paradigm is that of the semantically rich, aggregated and shareable research object (2014; 236). Such research objects can present the richness and complexity of research data together with discussion of theory and conclusions, enabling others to develop them further, adding additional data or offering annotations, interpretations and analyses. If students are to be involved in the production of knowledge, then student inquiry may need to be oriented towards the production of such flexible and generative research objects, rather than extended essays and dissertations modelled on the conventional academic paper. This, in turn, demands a rethinking of the nature and scope of the digital literacies associated with these emerging practices.

Critical Digital Literacies and Networked Learning

Throughout our experience of working with students and academic staff in the development of semantic web technologies we theorised our approach as participatory and exploratory, and a key outcome for all involved in the research and development was improved understanding of the affordances and applications of the concepts of the semantic web and the varied technologies associated with it. Technology-Enhanced Learning, even that which talks about learning as 'production' tends towards a mechanistic and technocratic framing of competences or literacies, and may not necessarily acknowledge subjectivities or critical perspectives (Hinrichsen & Coombs, 2013). Thus our perspective was not to understand the research and development activities we supported and observed purely in terms of students developing discrete abilities or skills (e.g. Glister, 1998) or even a form of techno-literacy, but rather as broader digital literacy which evolved over the course of our research, and in the course of the student projects we supported. This was due in part to the emergent and dynamic nature of the technologies themselves, but also the varied socio-cultural contexts, in which they were developed and applied (Kress, 2010), and the role, concerns and intentions of the students who took part in the projects we have described. Kress's (2010) semiotic approach to digital literacy enabled us to connect our participatory research methods to the development of digital literacy by encouraging learners to develop their understanding of learning, subject knowledge and technological affordances through their participation in the projects (Gillen and Barton, 2010; 12).

More recently, Gourlay and Oliver's (2014) sociomaterial view of digital literacy provides a framing both for the research and development practices of the projects in which we were involved, and of the emergent practices in which students, as intending teachers, were engaged. Gourlay and Oliver (2014; 147) highlight the role of the material within their critique of theories of digital literacy and warn against any tendency to simplify and categorise into different levels, types or stages, as this hides the nuanced and situated nature of practices. Their analysis of learner practices during academic work showed that they created and coordinated sociomaterial assemblages during the 'acquisition, curation, destruction and creation of texts' (Gourlay and Oliver, 2014; 152). While, as explained above, our view would extend beyond conventional texts to 'research objects', this notion of assemblages enables the linking of digital literacies to the development of a broader disposition towards critical inquiry into the changing conditions and emergent practices in higher education and in the workplaces for which students are being prepared.

The examples we have provided in this paper involved varied academic contexts, combinations of new and emerging technologies, and data of different kinds and from diverse sources. If these were to be incorporated into higher education programmes then it is possible to envisage a progression through a number of different settings, each with particular challenges and opportunities for student participation and engagement, and for the development of new practice. At the same time we remain mindful of the argument made by Gourlay and Oliver about the need to avoid thinking about digital literacies as simple sequences or hierarchies of skills. We have presented and discussed examples of settings, or assemblages, involving:

- (a) Navigation around online tools presenting linked data through web interfaces or other applications that can be manipulated in a variety of ways. This enables exploration to inspire questions to be formulated but the data may have been simplified, are bounded within a 'microworld', and options for representation have been restricted by external developers or teachers.
- (b) Data searching and retrieval from external sources, typically using familiar software or prebuilt 'portals' or directories. Data are often used in illustrative ways, rather than being extensively explored. May involve consideration of the ways that data is used to represent concepts and cases and evaluation of the reliability and granularity of the data, and of social and political factors at work in its collection and representation.
- (c) Extensive work with data, involving its manipulation in an online environment such as Exhibit, GapMinder or other data analysis software which may involve working with heterogeneous data, critically evaluating data and sources, and explicitly considering the data practices around its collection, categorisation and representation.
- (d) Generation of new original data and linking to other sources that may take different formats. This involves engagement with microformats, metadata and taxonomies and how this will affect knowledge representation and algorithmic treatments of the data.

Looking at these we can see how each can be understood in terms of a number of dimensions:

- Boundedness: closed worlds with selected data (a) or open global data space (b, c, d)
- Familiarity of Technologies: technologies that are stable and well-understood (a,b) and those that are emergent and poorly-understood (c,d)
- Production: students as consumers (a,b,c) or producers of data, analyses and interpretation (b,c,d)

Each example we have discussed, and the digital literacies associated with it, can be understood as being at the intersection of some or all of these dimensions, along with additional intersections with pedagogical and curriculum frameworks, and student preferences, expectations and concerns. What our experience of engaging students with sophisticated data-driven microworlds and external online data resources also demonstrated was the importance of the mediating role of the teacher in supporting critical engagement with data and resources: most obviously in encouraging students in type (b) scenarios to critically explore whether data categories are socially constructed and politically 'neutral'.

Our contention is that development of critical digital literacies, understood in this way as a set of sociomaterial assemblages is essential in the face of the changing experiences of students and workers and the pressures they face to constrain the kinds of inquiries that they undertake both in highly datafied educational and workplace settings. Such digital literacies and the data practices that they support have the potential to encourage a disposition towards critical inquiry and are important elements of the kinds of transformative networked learning described by Jandrić (2016). Jandrić, drawing on arguments from Giroux (1992) and Parchoma and Keefer (2012) argues that this networked learning should be conceptualised as the production of transdisciplinary (rather than multidisciplinary or interdisciplinary) knowledge. Transdisciplinarity, which involves personal "border-crossing" rather than simply bringing individuals from different disciplinary traditions together to solve problems "prompts teachers and students to raise new questions and develop models of analysis outside ... officially sanctioned boundaries", in turn transforming disciplinary knowledge and practice. We have seen examples of such personal transdisciplinarity in the course of the Ensemble project and its successors: teachers and students have become designers and data scientists; performers have integrated emergent technologies into their practice; and researchers have become application developers.

However, what is of particular note is that working with linked data, either as a critical 'consumer' or as a 'producer' offers specific opportunities to engage in politicised inquiry. Jandrić suggests that: "transdisciplinarity ... questions the existing systems of knowledge and domination and acquires genuine potentials for emancipation and social change" (2016; 176). What the availability of open data and the

opportunities to link, aggregate and visualise data from diverse sources allows, is a means of enabling and focussing such questioning. It makes it possible for researchers who have identified an issue of concern or a point of departure not only to contextualise their own inquiries, but, critically, to engage with and understand how issues are conceptualised within alternative and dominant discourses. Critical digital literacies therefore can provide means by which the inquiring student or teacher can engage in what Alquati (1994; 37) describes as 'counter-research', informed by subjective experience but able to locate, evaluate, critique and reconstruct data in order to develop alternative interpretations, frame new inquiries and establish emancipatory trajectories.

Pre-service teachers and students of education (currently the focus of our own work) are in a key position to effect the future of education and their critical digital literacies related to data are central to this as a means for supporting counter-research. But at the same time, the marketisation and datafication of education encourages them to focus their inquiries on limited and performative topics, including their own, quantified, competencies. This needs to be challenged through questioning disciplinary boundaries, as well as current notions of educational professionalism. What open data provides is an environment in which professionals can become investigators, researchers and activists, using open data to frame inquiries, working with others to gather new data and construct case studies, and contribute new knowledge and interpretations to open knowledge networks. This is not simply discipline-hopping (teacher as data scientist) but rather a reconceptualising the teacher as activist. This repositioning of students leads back to views of the role and purpose of higher education for society. Rather than reducing higher education to a training ground for the production and consumption of students as products, the University can be a place where criticality is modelled and fostered. Higher education can be radical and emancipatory by enabling a community of critical thinkers to come together. The material, digital and networked assemblages of the University can support collaborative investigation where students are co-researchers and co-producers of new knowledge effecting educational policy and practice.

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