Case Methods, Pedagogical Innovation and Semantic Technologies

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Abstract. This paper describes an approach to conducting research leading to technological development that is grounded in detailed empirical research and participant engagement. We describe our initial findings about the diverse conceptualizations of cases and their use that exist in a number of higher education settings and match this to considerations of the potential of semantic technologies to support these teaching and learning activities. In this way we develop the argument for developing technologies in parallel with empirical research about current practices and engagement of participants in educational settings in order to realize the full potential of semantic technologies to support case-based learning.

Keywords: case methods; problem-based learning; case-based learning; higher education; technology enhanced learning; semantic technologies

1. Introduction

In technology-enhanced learning (TEL) research, new technologies have often inspired new solutions to old problems, and initial assessments of the semantic web or at least the semantic technologies (applications, standards and services) were for the most part positive [1, 2]. Semantic technologies appear to offer an architecture that aligns well with current educational tenets of active, problem- and case-based, and collaborative and distributed learning that respond to changing realities in educational provision as well as workplace demands. The provision of access and retrieval of resources (esp. authentic data) guided by consistent ontologies and taxonomies, the ease of combination and re-combination of these, and the much improved interoperability that results, have promise in supporting learning in rapidly changing domains where dealing with complexity is seen as indicative for expertise.

The Ensemble project ("Ensemble: Semantic Technologies for the Enhancement of Case Based Learning") is exploring the potential of semantic technologies to support and enhance teaching and learning in a variety of settings in higher education: specifically advanced undergraduate courses at the University of Cambridge and postgraduate and professional courses at City University, London. The work of the project is focused on settings in which complexity, contestation or rapid change makes some kind of case based learning the pedagogy of choice. As well as substantive research settings in which learning with cases is the focus of attention, a series of pilot projects and technical demonstrators has informed the work of the main project and served to engage potential participants. Members of the project team are also undertaking more wide ranging work on digital repositories, knowledge

representation in different fields, visualization of complex data and the role of semantic technologies in student assessment.

The project is using a participatory research approach that includes teachers and learners in the co-interpretation of evidence associated with practices. We have set out to involve participants in the identification of the relationships between educational dimensions of case-based learning and features of semantic technologies, and aim to describe these relationships as a set of affordances. This participatory approach is empirical and practice centered in that it involves the study of existing practices of learning with and from cases, an area with considerable lacunae with regard to descriptive characterizations. We have drawn on the literature on the "Case Method" [3] and on problem-based-learning (PBL) [4] for initial interpretations of practices, but we also move beyond in order to include a broader range of commitments and practices that involve learning with cases that have not yet been characterised.

In contrast to attempts to develop generic design specifications to match an ideal model of case based learning, our findings encourage an eclectic, pragmatic and participatory approach. They indicate that learning with cases consists of a core of commitments to learner autonomy, engagement with authentic data and a representation of 'reality' (through this engagement authentic data, 'real world problems', simulation or role-play), while its adaptation to domains, tensions in institutional goals (e.g. vocational vs. academic), education levels, teacher (e.g. where, for example the teacher is also an active researcher) and student identities (including projected ones), and the curricular environment (e.g. CBL accompanied by lectures rather than as the sole method), results in highly differentiated enactments of learning with cases. This range of observed practice requires an adaptive technology design approach that takes place in parallel with the engagement of teachers and students and involves them in collaborative design activities.

The paper develops the argument for the necessity of this participatory approach to design and the specification of the affordances of the semantic web, by describing in detail our engagement with four different learning settings and how case-based learning is enacted in each: a Masters' course on Maritime Management where 'teaching cases' are used alongside lecturing; an undergraduate course in Plant Sciences where traditional lecturing was recently complemented with an active, student-centered case-based learning module; a seminar on Ceramics within an undergraduate course where objects are at the basis of introducing students into research in Archaeology; and the general course-wide activities of students in a postgraduate course in International Journalism. We identify overlaps between other practices using teaching cases and the management course, PBL and the module in Plant Sciences, but show that in the Ceramics module, cases are emergent from the complex interaction between several educational dimensions. Finally we conclude with a discussion of the implications of these variations for design, development and implementation of semantic technologies.

2. The Semantic Web for Education

The Semantic Web is conceptualised as "an extension of the current Web in which information is given well-defined meaning, better enabling computers and people to work in cooperation … data on the Web [is] defined and linked in a way that it can be used for more effective discovery, automation, integration, and reuse across various applications." [5] The flexibility of key Semantic Web technologies allows the integration of user-generated content with that from digital repositories, web services

and ‘non-semantic’ data such as ‘legacy’ databases. They offer the user advanced search tools and a range of representations and visualisations of data. They also support ‘social software’ functions such as reviewing, rating and collaborative annotation. This means that these technologies can provide a framework capable of supporting the individual and collective engagement in a variety of teaching and learning environments and through a range of software applications.

The realisation of an ‘educational semantic web’ is, however, a space ‘open to be filled with meaning’ [6]. In a teaching and learning environment in which the potential of semantic web technologies had been fully realised, teacher and learner engagement would be fluid, flexible and generative [1]. In this respect, the ‘Educational Semantic Web’ is at a stage in its development comparable to the Internet prior to the Web Browser, when the Internet too was realised primarily as a means of accessing or disseminating information, but its potential as an expansive learning environment or means of collaboratively constructing knowledge was becoming apparent.

The range of different technologies, services and applications that make up this broad vision of a semantic web provides both a challenge and an important opportunity. On the one hand, it means that the project is not introducing a single technology or application into what Lankshear et al. [7] and Edwards and Usher [8] call “spaces of enclosure”, to see how it ‘lands’; instead, following studies such as those by Suchman [9] and Ciborra [10, 11], it is undertaking the more challenging task of exploring how technologies are integrated (or not); made sense of (or not) and selectively appropriated by individuals and groups in a more fluid environment of opening and disruptions. The opportunity this provides, however, is that of engaging with continuing discourses in dynamic settings with the potential to learn from and contribute to pedagogical, technological and theoretical discourses.

This sensitivity both to existing practice and to the potential differences in understanding of, and engagement with, learning technologies means that the project makes no assumptions about which factors will act as predictors of adoption or outcomes. We reject notions of ‘technology-rich’ and ‘technology-poor’ disciplines, or of teachers and students as ‘digital natives’ or ‘digital immigrants’, instead exploring with participants how specific technological affordances align, intersect or conflict with existing and emergent practice. This underpins the intensive, participatory and multi-modal research undertaken with teachers and learners in research settings that is reported in the following sections.

3. Case Methods, Problem-based Learning and Case-based Learning

Cases or, more generally, accounts of real-world events or situations, can be found more or less frequently in a broad variety of educational environments. We approach the study of these teaching and learning practices with the recognition that the use of cases has spread quite widely into areas previously outside the classical case-based-learning areas of management, medicine and law. While institutions with vocational orientation adopt explicitly a case-based-learning-oriented discourse, cases are also used in more academically oriented institutions where they can be found as valuable complements to teacher-led instruction. This spread into other institutions and subject areas was and is influenced by concerns on the effectiveness of conventional curricula in preparing learners for work (e.g. [12, 13]).

Our approach is empirically grounded, though the existing literature on case- and problem-based practices provides ways to frame our observations, certainly in the initial period of the project. This literature reports a highly diversified and rich landscape of cases in educational setting. But a few practices with strong traditions and theoretical bases exist. So, for example, the 'Case Method' aims to convey a sense of reality through cases [14], but also emphasises the process of learning, the learners' thorough engagement with the case and the role of the facilitator. Further, in this and other settings, cases are mediators of the continuing interaction between educational institutions and industry, because they embody the latest and most actual challenges of the world of work. Problem-based learning, in contrast, aims to teach basic scientific knowledge within a concrete context [4], and bases its highly structured design and instructions on a predominantly cognitive model. It also emphasises active, student-centred learning [15], but limits its instruction to a highly selective set of reasoning processes [16]. These and other methods, such as anchored instruction [17], emphasise also the role of cases in stimulation student interest and motivation. The landscape of methods using cases is thus varied, with different learning goals and underlying theories and models, and with some roles of cases shared across 'families' of practices, as well as some very distinctive uses of cases.

Common amongst the various practices is the commitment to enact forms of 'authenticity' and 'realism' in a formal educational setting. So, for example, PBL medical students learn with 'patient cases' that are essentially raw descriptions of symptoms, lab results, etc.; and driving the use of authentic data is the aim to familiarize students early on with the data and reasoning processes that are constitutive of a doctor's work. Business and management schools use rich narrative accounts of events about situations a company has faced or plans it wanted to implement, and the events that followed the implementation; these situations are deemed to represent authentic 'slices of reality' [3] and provide students with windows onto the 'work reality'.

However, a look at the practices of CBL supports our argument about the necessity of an empirical and eclectic research approach. This more practice-oriented education is also realized through specific forms of teaching and learning, and, maybe more importantly, authentic learning material may only be the initial base for highly dynamic learning processes. Indeed, various CBL practices emphasise specific teaching and learning activities where the learning material is often merely a foundation, albeit an essential one, for those activities. This is prominent, for example, in management schools where cases are the basis for facilitated discussions and where the thorough exercising of generic skills, such as critical argumentation, communication and even persuasion are highly valued. In more science-oriented case-based learning, activities such as developing hypotheses (or, in the case of medical PBL, diagnoses) or explanations are actively promoted. Thus, while the provision of 'authenticity' and more connections to the real world through flexible access and up-to-date information is certainly important, it is to be considered only one part of an overall pedagogical strategy.

The recognition of the importance of the teaching and learning activities/processes associated with CBL opens though a wide variety of possibilities for supporting these in a targeted manner. For example, teaching with cases involves a much more active engagement by the students than traditional lecturing: actively developing understanding, and identifying learning issues and misconceptions is encouraged and highly valued. This view of CBL would see the student-teacher engagement as the central locus of learning, and, in order to provide a better provision of CBL, technology support would also need to focus on that very place. Within a similar lens, small-group discussions, sometimes not facilitated, are very common in CBL because

their open-ended and collaborative nature mirrors to a degree the workings of practitioners when they are faced with real-world problematic situations. And also these activities may be supported to realize the learning goals of CBL. Indeed, cases engender a problem space (the many issues related to it as well as the many ways to understand it) exploration through which needs to be guided by, for example, constraining the access to information or by promoting a more description-oriented search of resources. Thus, studying CBL-characteristic learning activities may be one more opportunity for semantic technology.

Our work has progressed to a degree where we can locate our findings on cases and case-based-learning within the fragmented and rich world of similar practices with increased confidence. However, we are going beyond a mere comparison process at the end of which the cases and practices found in our settings would be pigeonholed into existing categories (and would then inform specific technological approaches to their support and enhancement), but propose a new look at case-based learning. In this, we embrace theoretical approaches drawn from recent developments in social science research where people and technology are seen as being intimately related in producing what are normally thought of a being stable practices, learning objects and 'acquired knowledge' [18, 19].

The characteristics of cases and CBL and the resulting concerns have guided our research on the educational settings, and our work has progressed to a degree where we can envision semantic technology to support the generic learning goals as well as a better provision of authentic data. But we are also aware that the study of practices and especially the focus on teaching and learning activities may unearth opportunities as yet not evident from a review of the literature.

The next sections describe the settings in detail. We focus on those characteristics (such as teacher's learning goals and the kind of data used in class) that align with functionalities of semantic technologies. In the last section, we speculate about further research as well as potentials of semantic technologies.

4. Research Settings

We have chosen to research a variety of different settings in order to get a wide view of the way in which cases are used in higher education. We have engaged with participants at two institutions with quite different characteristics. The University of Cambridge describes itself as a 'community of scholars' and a 'leading academic centre', which uses distinctive and long-established teaching methods. At City University, London, the emphasis is placed on professional business and industry links that are reflected in the experience of the teaching and research staff. We are working with lecturers of postgraduate and professional courses such as the Maritime, Operations and Management course and the School of Journalism. At the University of Cambridge we are working with members of the Department of Plant Sciences and the Faculty of Archaeology and Anthropology, who teach advanced undergraduate courses. Our choice of research settings has also been greatly influenced by our need for a high level of engagement with participants. Members of the project group have used their personal and professional contacts to initiate connections between Ensemble and teaching staff at both institutions. In all potential settings, further engagement was initiated with scoping interviews that were held with initial contacts such as lecturers or course organizers.

The Ensemble research group has members from a diverse range of backgrounds, including educational researchers, social scientists, cognitive scientists and computer

scientists, who have experience of teaching, learning and researching in many different environments. This diversity helps to make our research group a site for learning where knowledge is shared, reconstructed and reconceptualised to form new understandings [20]. We are using a participatory research approach with the aim of including participants in the research settings in this process of co-interpretation and collaboration that will influence our research as well as participants' teaching and learning practices. This shows a practical intention to realize educational values in action that aligns with Elliot's [21] view of 'educational research' rather than 'research on education'. An important element in this type of research is that critical reflection is integrated into the research process. Having an interdisciplinary and participatory research group that is constantly questioning, assessing and modifying research practices stimulates this critical reflection. Regular large and small group project meetings, workshops, seminars, conference attendance and a virtual research environment all contribute to supporting our collaborative research.

Because of the diverse nature of the settings that we have studied we have developed and adapted our methods accordingly, although a commitment to series of interviews, multimodal data collection of naturalistic settings and focused co-interpretation activities is characteristic. In this paper we will describe the subsequent research and engagement processes that have taken place in four of the settings, what we have seen and understood about cases in each one so far and the potential application of semantic technology to support teaching and learning.

4.1 Marine Operations and Management (MOAM)

In this Masters level course at City University, London, experienced mariners (sailors), some having reached the peak of their career, are prepared for their move into management positions in the marine industry. We consulted the course syllabus, interviewed one of the teachers and observed a weeklong module on Maritime Management and Technology. In the course a variety of cases are used, from small teaching cases discussed in small groups for about one hour, to larger scenarios that demand a design solution taking into considering discipline-specific constraints. In these latter cases, solutions are developed over four or more days, involving the consultation of manuals and selection of design components from lists.

The cases serve multiple purposes: the teaching cases are narrative accounts of representative problem situation often drawn from the teacher's own experience. Here the case is a way to bring a snapshot of the real world into the classroom and confront students with its messiness and complexity. The larger scenarios, in contrast, are designed to give students a sense of the many disciplines, specialisations and roles involved in the industry, and the intricacies involved in collaboration between different practitioners.

Teacher interviews gave us insights into the role of cases and the rationales for choosing case-based learning. One of his aims is to prepare his students to become practitioners and he defines a practitioner's knowledge in contrast to the one of an expert: "a practitioner does not need in-depth knowledge, like an expert, but he needs broad knowledge and he needs to know how to put the jigsaw together". He exemplifies the future of his students as, "a practitioner is somebody who can jump on a ship and drive it, or run a fleet of ships and complying with legislation, keeping the balance sheet right and know who (which expert) to ask".

The scenarios are certainly realizations of this learning goal: they provide opportunities to experience working as a practitioner together with other practitioners in a very diversified field. The task is to design a ferry servicing an archipelago off

the coast of Cornwall, and students play the roles of different domain experts (e.g. economist, safety engineer, technical designer) and present and defend their design to a panel of experts. Interestingly, this exercise does not aim to train ship designers (none of the students is planning a career in that area), but addresses the stated purpose of the course "to get across what is in the industry, the whole combined areas". The teaching cases, in contrast, are designed to be the bases for exploring, in a discussion, situations deemed to be representative for situations future managers will be facing. So, for example, one of the cases describes a company's aim to upgrade their software. This case engenders questions such as how to deal with legacy software, and how to put into place a management structure and plan that integrates existing employees' competences and new responsibilities.

Thus, though the two kinds of cases realize an overall similar learning goal, they differ in learning material as well as in teaching and learning activities. So, in the design task students sift through a large amount of data that are essentially only listings of, for example, engine types, or manuals on safety regulations. Their main cognitive challenge is to choose components of the 'virtual' ferry in dependence of the increasingly complex solution and the many regulations existing in the industry. Improving the access to authentic data as well as giving students the opportunity to combine and recombine them to formulate a design may support this practice.

The teaching cases, in contrast, are not resource-rich but instead are designed to engender the application of codified knowledge as well as relatively unconstraint exploration of issues. Indeed, the analysis of one of the case-centred discussions showed us that students rely on lecture material to develop understandings of what the situation is about, but also explore issues in dependence of their personal interest and experiences. It is these activities that realise the teacher's aim to help students 'reason like managers' and to provide them with 'conceptual' thinking tools for their future. This form of case-based-learning demands an approach to think about technology support that is very different from merely improving access to authentic data.

4.2 Plant Sciences

The Department of Plant Sciences at the University of Cambridge has been working with external and internal educational researchers for a number of years in order to reflect on and support their teaching practices. Recently the teaching coordinator and lecturers at the Department identified the need for a change in the structure of the course for third year students to allow for the integration of a more student-centered approach to learning as an alternative to traditional lectures.

The teaching coordinator and an experienced plant sciences lecturer (currently seconded to an institutional teaching and learning role), worked with Ensemble researchers to design a new case-based course that would enable students to gain expert knowledge about a real-world issue, whist developing professional skills; such as, working collaboratively, analysing authentic data, working with experts, reflecting on practices, using technology, giving presentations and writing reports. The course was structured around the theme of using algae as a source of biofuels. The students were split into three groups, each of which had a different theme to investigate; either cell walls, lipids or hydrogen. The students were set the task of researching their theme to build a case for the use of algae, and present it in the form of a report, a group presentation and a final discussion with experts. Ensemble researchers were involved in all stages of planning, designing and running the new course. The course was supported by a number of academic mentors and consultants who were available during group meeting times to provide advice and guidance about the project and the

area being researched. In addition a Virtual Learning Environment (VLE) was provided that featured a number of collaborative (but non-semantic technology) tools. The VLE allowed announcements to be made to the student group, files could be stored online, a timetable showed the course structure, a wiki environment was set up for student groups to publish their reports, and a blogging tool allowed students to reflect on their research and share ideas outside of group meeting times.

This plant sciences case building exercise aligns well with the investigative case study approach that is a variant of problem based learning [22]. The open ended and investigative nature of the task makes it more authentic and complex than 'problem solving' but there is a pre-formed structure to student's work and outputs. Evidence from journal articles, news papers, commercial webpages, presentations, and consultants was used to build cases that were viewed as being dependent upon a series of related and often contradictory other cases. Evidence was utilised in a number of contexts including the synthesis of new relationships between previously unrelated observations; the prediction and testing of solutions to new problems; and the re-interpretation of previous work. Students recorded all their group meetings and initial analysis of this data shows that in their effort to find solutions and reach decisions through discussion, students sorted out factual data, articulated issues, reflected on their relevant experiences, and came to conclusions. Activity in the VLE was monitored to gauge its use. The students appeared to make the most use of the online file store, by accessing recommended paper to start their research and also posting new papers online that they had found and wanted to share with others. In the wiki they wrote their group reports but they did this in a fairly static way by posting final versions of the text in the last few days rather than collaboratively editing throughout the course. The blogging tool was used a lot by some students who wanted to share excerpts of papers they had read outside of meeting times or links to online articles, presentations or videos. However, there were a number of students who did not post any blogs or make any comments on other student's blogs.

A focus group was held with students after the course was completed to ask them: who they collaborated with and how, what kinds of sources they used and how they found them, what they thought of the VLE, and what additional support could be provided? The feedback from this focus group indicated that the students needed more online support for sharing resources and continuing discussions outside of group meetings and between each group. Having the separate file storage, wiki and blogging tools made the connections between resources and collaboration disjointed and awkward. Semantic technologies may be able to help make these links and allow for the collaborative analysis of patterns, omissions and relationships amongst a variety of resources. Post-hoc discussions with the course organizers highlighted the need for students to retain the links from the statements and conclusions they made in the case presentation and report and the original resources that support them. The presentation of the final cases using a semantic visualization tool (such as those demonstrated by SIMILE at MIT) could be supported with tools that allow for clearer links to original data and academic sources. The students also felt that they would have benefitted from starting with a larger number and richer variety of resources that were recommended. This shows a need for scaffolding of undergraduate student case building that could be integrated into semantic technologies in the form of expert recommendations and pathways through data sources.

The high level of engagement that Ensemble have with the Department of Plant Sciences has allowed us to integrate technology design and development into the concurrent development of a new case-based course. Our aim is to involve students and staff in the integration of semantic tools and services to support the algal biofuels course for next year's students.

4.3 Archaeology and Anthropology

A complex network of Faculties, Departments, Museums and Institutes influences the teaching that takes place at the Faculty of Archaeology and Anthropology at Cambridge. Our initial contact was made with the Deputy Director of the Museum of Archaeology, who also coordinates the MPhil Graduate course on museums and lectures on the History of Science for undergraduates. Many of the lecturers involved with teaching Archaeology students also work at one or more of the nearby research institutes or museums. This adds a professional and interdisciplinary slant to the teaching that takes place, which is supported by the practical knowledge and experience of lecturers. Cambridge offers a three-year course (Tripos) in Archaeology and Anthropology during which students specialise in one of the three disciplines of the Faculty: Archaeology, Biological Anthropology or Social Anthropology.

Scoping interviews with lecturers led us to observe an MPhil Zooarchaeology seminar, 'World of goods' undergraduate lectures and undergraduate Ceramics Practicals, to help us understand the nature, role and scope of cases in Archaeology. Our observations, especially of the ceramics practicals, have shown us new ways of using cases that diverge from classical case-based learning practices. Case studies were explicitly used to look at how sites, materials and artefacts are classified, and how scholars have examined, recorded and published particular sets of excavated material. An important element of teaching on the ceramics course is that artefacts are physically present for students to experience their visual and tactile elements. These artefacts are also often used to demonstrate expert 'ways of seeing' or of interpreting ceramics. The lecturer describes their observations and explains their interpretations in order to pass on knowledge and interpretive skills to the students. This may be another type of case whereby the object itself constitutes a case by representing a story and demonstrating the complexity of real life.

This pedagogic approach represents a significant challenge for the development of any semantic technologies. The knowledge base for the ceramics course has foundational and stable elements and there are examples of 'real-life' data that could be integrated into a semantic tool. However, expert accounts of research practices in the field are an important element of teaching that represents the additional complexity and contested nature of knowledge. A semantic tool would have to allow for multiple interpretations of artefacts to be developed and progressively elaborated with support from expert 'points of view'.

We have followed up our observations of teaching and learning environments with feedback interviews with several lecturers to allow co-interpretation of the use of cases in teaching Archaeology. We have encountered a variety of opinions and perspectives on the pedagogical reasoning behind teaching practices that reflect the diverse background and experience of teaching staff. We also plan to discuss the use of cases with Archaeology students to assess the effects of case studies and the physical presence of artefacts on the way in which students learn, and what they learn. This will give us more guidance about the most important elements of teaching with cases that should be incorporated into semantic technologies to support Archaeology.

4.4 Journalism

In this Masters level course at City University, London, cases are frequently used throughout many modules, though the teachers do not recognize their courses to be primarily case-based. Rather, narrative accounts of journalists' experiences are interwoven into other teaching practices, and primarily used to teach 'lessons'. In this

setting, thus, we encountered similar uses of teaching with cases as in other settings (MOAM, A&A). However, two characteristics of a journalists' work that have been integrated into this course are particularly interesting: first, students are taught how to 'tell stories' including the intricacies to develop a narrative and supporting it with facts. This activity relies on very large sets of resources: the various factual accounts of an event, its interpretations and reporting in other news outlets, the reliability of sources, considerations on the impact of the story in the cultural, political and social environment etc. Our continuing engagement in this setting will thus study journalists' use of technology to search for, evaluate and archive resources.

Second, the course offers an unusually high number of technology-related modules (online journalism, databases) because technology of many forms, including for social networking, pervades a journalists' work. The course is thus oriented not only at using technology *for* teaching and learning, but especially at teaching how to carry out work *with* technology, giving us a unique opportunity to study how a practice relies on technology as well as being changed through new technology.

5. Teaching, Learning and Technological Enhancement

If we review data collected in the research settings in section 4 it is evident that not only is there a variety of teaching and learning with cases but also that there are different opportunities for the integration of semantic technologies as summarised in Table 1 below. This table is not intended to suggest particular predictors of the uptake of semantic technologies. In fact no single factor (such as existing levels of technology use in teaching and learning, or the use of technology in related professional practice) can be reliably used to predict the nature or level of engagement with new technologies [23]. For example 'high end users' of existing technologies may be unwilling to abandon well-established technologies already embedded in their practices and discourses.

The project will, therefore, use a range of participatory design methods that will further explore the potential enhancements of teaching and learning made possible by the use of semantic technologies. The commitment of many teachers to introduce authentic data into teaching and learning environments, or to support modelling of authentic disciplinary practices appears to align well with the opportunities to access, select, interrogate and represent data offered by semantic technologies. But at the same time, there is need (highlighted by both teachers and students in the research settings) for the scope of searching and the boundaries of the cases constructed to be circumscribed and contained. This too could, of course, through the application of ontologies, pre-and post-search filtering and machine reasoning, also be enabled by implementation of appropriate semantic technologies.

This leads to a final important issue which has been highlighted by the intensive work in settings described above: namely the potential for students to construct cases from data, or to reconstruct cases presented by teachers, in individual and unpredictable ways. This is to be expected, given the complexity of learning domains, and the experience and perspectives that students bring to these complex settings. Once again, this suggests a necessarily participatory and flexible design and development process: one in which different elements and facets of semantic technologies are brought into play in order to support processes of case data identification, case construction and case reconstruction on the part of both teachers and students.

Teaching and learning environment, (location & students)	**Character of case knowledge**	**Characteristic teaching and learning activities involving cases**	**Current use of learning technologies in T and L environment**	**Use of technologies in current professional practice**	**Potential areas for semantic technology development**
Marine Operations (City PG)	Experience-based "lessons", "stories" and "challenges"; requiring practical reasoning across domains	Illustrative cases with a lesson; broader scenarios with design task; unguided, no facilitated engagement	Low, generic applications	High, specific applications	Meaning-driven access to authentic data; guiding open-ended processes through selective access to resources.
Plant Sciences (Cam UG)	Changing knowledge base from a lecturer to a student focus; includes real-world complications; evolves along with academic research publications	Semi-structured problems within broader scenario involving collaborative building of a case	Moderate, generic applications such as a VLE and online literature searches	High, specific applications	Mediated access to resources that retains links to original data. Support for collaborative analysis.
Archaeology (Cam UG/PG)	Complex knowledge; socialisation; interdisciplinary; evolves alongside academic research practices	Emergent cases drawing on acdemic research practice, with more structured activities 'embedded'	Moderate, specific applications	Moderate, specific applications such as databases and statistical analysis software	Integration of authentic data integration, including expert accounts of research practices
PG Journalism (City PG)	Experience-based "stories and "lessons"; templates for developing "narratives"; fast moving; controversial, complex	Emergent cases drawing on teacher practice, developed by students; ubiquitous story-building with rich resource use	High, generic applications	High, generic applications	Access to and archiving of resources based on the ‚story' of a narrative; support for ‚case/story building'

Table 1: a summary of our research settings displaying the variety of current case-based practices, existing technology use for learning and work, and potential semantic web technology deriving from and adapted to the setting.

So the purpose of the next phases of engagement with participating teachers and students is not to explore whether 'the semantic web', or groups of semantic

technologies have the potential to support teaching and learning with cases in a given setting; rather it is explore how, under what circumstances and to what ends, teachers and students might wish to mobilize particular semantic technologies in order to support practices that are themselves emergent and evolving.

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