

A Conceptual Model for Scholarly Research Activity

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ABSTRACT

This paper presents a conceptual model for scholarly research activity, developed as part of the conceptual modelling work within the “Preparing DARIAH” European e-Infrastructures project. It is inspired by cultural-historical activity theory, and is expressed in terms of the CIDOC Conceptual Reference Model, extending its notion of activity so as to also account, apart from historical practice, for scholarly research planning. It is intended as a framework for structuring and analyzing the results of empirical research on scholarly practice and information requirements, encompassing the full research lifecycle of information work and involving both primary evidence and scholarly objects; also, as a framework for producing clear and pertinent information requirements, and specifications of digital infrastructures, tools and services for scholarly research. We plan to use the model to tag interview transcripts from an empirical study on scholarly information work, and thus validate its soundness and fitness for purpose.

Topics

Information seeking and use, Ontologies, Research methods, Scholarly and scientific communication, Digital humanities.

Keywords

Scholarly information behaviour, Conceptual modelling, Digital curation, Activity theory, CIDOC CRM, Cyber-scholarship.

1. INTRODUCTION

Research in the arts and humanities relies increasingly on the ability of scholars to discover, appraise, aggregate, organise

and use effectively an expanding mass of digital scholarly resources, ranging from primary data and documentary evidence to unpublished and published research, reference works and terminological resources. Current investments in institutional and thematic research e-repositories and digital libraries, and emerging plans for comprehensive digital infrastructures to support scholarly research [1-3] exploiting, among others, the promise of grid technologies, introduce a pressing need to establish a robust conceptual framework for scholarly research information requirements, based on an evidence-based specification of user needs in present and anticipated research work, which will ensure the current and future fitness for purpose of planned systems, applications and standards (metadata, process etc.).

This paper reports on work conducted in the context of *Preparing DARIAH: Preparing for the construction of the Digital Research Infrastructure for the Arts and Humanities*, a collaborative project co-funded by the ESFRI *e-Infrastructures* programme, aiming at providing the foundations (strategic, financial, legal, technological and conceptual) for the timely design and construction of the digital infrastructure requisite for scholarly research in the arts, humanities and cultural heritage in Europe [4]. The Digital Curation Unit-IMIS, *Athena* Research Centre is currently engaging in a two-pronged research programme within the conceptual modelling work-package of DARIAH, consisting: a) of an empirical study of scholarly work, based on the elicitation, transcription, conceptual encoding and interpretation of open-questionnaire interviews with humanities scholars [5], and b) of the formulation of a scholarly research activity model, based on an event-centric modelling approach, and intended to be useful for the formalisation of the analysis of the results of the empirical study.

This paper focuses on the scholarly research activity model developed as part of this project. A summary of earlier work, a definition of research rationale and of the approach adopted, a detailed presentation of the model, and a brief discussion of its utility and planned work are presented below.

2. EARLIER WORK

Earlier studies of research activity, touching upon information practices relevant to this study, range from ethnographies and theoretical syntheses from the field of social studies of science [6-9], which concern mostly the natural and pure sciences, to empirical studies from the field of human information behaviour (HIB) [10], often focusing in humanistic disciplines such as history [11-15] and art history [16-18], and on interdisciplinary research typical in the humanities [19]. A comprehensive overview of concepts, issues, practices and problems related to “scholarship in the digital age”, providing a broad framework for conceptualising the relationship between disciplinary practices in the humanities, documents and data, and technological infrastructures and tools, is provided by Borgman [20].

Conceptualisations of scholarly activity, in the form of schematic models and classifications, evolved in tandem with empirical research on information behaviour. Ellis, based on a grounded theory analysis of research practice across the natural, social and human sciences (including economic and social historians, archaeologists, prehistorians and English literature scholars), proposed a classification of research activities composed of six processes, common across disciplines: *starting, chaining, browsing, differentiating, monitoring* and *extracting* [21], to which Meho and Tibbo later added three further processes: *accessing, networking* and *verifying* [22].

The notion of “scholarly primitives” was introduced by Unsworth in 2000, in the context of the then emerging digital humanities field, with reference to the information processes employed by literary scholars [23]. The related concept of “research method” was the focus of the AHRC Methods Network in the UK, which has developed a thesaurus of ICT research methods typically employed by researchers (“Methods taxonomy”), and also a series of brief reports on the needs and plausible scenarios for the current and future scholarly use of ICT in fields such as history, art history, and archaeology [24-26].

Brockman and associates presented a broadly based conceptual framework of the information nature of scholarly work, accounting for processes of *reading, collaborative networking, researching and searching*, and *ways of writing*, and emphasizing the differences in information work in the humanities *vis-à-vis* other disciplines [27]. On the other hand, a study aimed at defining appropriate infrastructures and services at the Minnesota University Libraries [28], was based on organising “scholarly primitives” into four groups of scholarly information activities (*discover, gather, create, and share*). Most recently, Palmer and associates defined five broader “scholarly activities”: *searching, collecting, reading, writing, collaborating*. These, as well as a bucket of “cross-

cutting primitives” are further refined to a more detailed list of twenty granular “scholarly primitives”, of which *browsing, collecting, re-reading, assembling, consulting* and *notetaking* were found to be particularly common in the humanities, while *chaining, accessing, assessing, disseminating* and *networking* were seen as equally applicable to all disciplines [29].

Complementary conceptualisations, mostly focussing on *information seeking* behaviour, have emerged from LIS, focussing on the motivations and sequential actions of researchers as they seek information (from the stage of initiation, to selection/exploration, formulation, collection and, finally, presentation) [30], on the process, factors and mechanisms affecting information seeking, including notions of context of information need, psychological, role-related and interpersonal factors, social learning, and search strategies [31,32]; on information seeking as problem solving, employing notions of goal-directed behaviour, resolving an “anomalous state of knowledge”, or reducing uncertainty [33-36], or, on everyday life information seeking as sense making [37]. An overview of information seeking behaviour work up to 2002 is provided by Case [38]; an integrative model of information behaviour synthesising problem solving, sense making, information foraging and modular thinking approaches, was later proposed by Spink and Cole [39].

These models view information behaviour primarily as process; consequently, the world of information objects, data, and documents, remains in them as a rule implicit. Exceptions include Ingwersen’s cognitive model, informed by information retrieval system design, and viewing the information seeking universe as a set of cognitive transformation and interactive communication relationships between *information objects*, an individual user’s *cognitive space* (and social-organisational environment), and an *IR system* [40]. Also, Saracevic’ model of stratified interaction (distinguishing between *surface, cognitive* and *situational* layers) conceptualises information use via a sequence of interactions between *environment, situation, user knowledge etc., query characteristics, interface, computational resources, and informational resources* [41]. Finally, an implicit conceptual model is provided by the Minnesota study in the form of an extensive graphical diagram “track[ing] relationships between a) *primitives*, b) common *tasks*, c) support from *data*, and d) potential *tools* and *services* that would address scholars’ needs” (p. 47, our emphasis) [28].

3. RESEARCH RATIONALE AND APPROACH

As presented above, there is already a multitude of conceptualisations of scholarly information activity, or information behaviour in general, including useful classifications of specific scholarly activities and research methods, and macro-analysis models of human information behaviour, accounting for motives, goals and research strategies, and/or for sequential structure of information practices. These conceptualisations:

1. Are concerned predominantly with practices of information seeking, or searching, rather than on the whole life-cycle of scholarly information use, including curation activities (structuring, annotation, processing) typical of actual scholarly practice.
2. Focus mostly on the use of scholarly objects – research works, publications – from a library service perspective, and only implicitly on primary evidence (data, documentary sources) and hybrid, secondary archives, which, in fields such as history, art history and archaeology [42-44,27], constitute a central object of scholarly engagement in the research process.
3. Privilege process over object modelling, and thus account predominantly for factors (psychological, socio-technical, environmental) governing human information behaviour and relations thereof, and/or sequential/procedural structure of the information seeking process, rather than for the universe of entities (material, informational or conceptual) involved in information work.
4. Delineate collectively a broad domain of diverse entities of interest in the research process (such as “primitives”, research activities, methods, goals, motives, strategies, data and computational objects of various kinds), but such entities are only informally or extensionally defined in individual studies; in fact, there is no single model representing formally entities involved in the research process and relations between them.
5. Have mostly the status of explanatory schematisations, linking together specific factors, theoretical perspectives and implicit relationships, rather than of formal conceptual models amenable to operationalisation through specific bindings to data structures and procedural logic.

Our objective is, thus, to establish a conceptually sound, pertinent with regard to actual scholarly practice, and elegant model of scholarly research activity, encompassing both “object” (structure) and “process/practice” (functional) perspectives, and amenable to operationalisation as a tool for:

- structuring and analysing the outcomes of evidence-based research on scholarly practice and requirements, and
- producing clear and pertinent information requirements, and specifications of architecture, tools and services for scholarly research in a digital environment.

Our approach is inspired by Leont’ev’s cultural-historical activity theory, used as a useful framework in diverse fields, including developmental psychology, the study of organisations, work and ergonomics, social aspects of technology, Human-Computer Interaction, and digital curation [45-48]. Its key concept is *activity*, understood as “purposeful interaction of a subject with the world”; an activity is always directed toward some *object*, a physical or conceptual entity (or entities). This object embodies, also, the fulfilment of some objective or *motive*, which in turn is intended to meet a specific *need* of the subject of the activity. Activity systems are composed as a hierarchy of *activities*, constituted by conscious *actions*, which in turn are constituted by sub-conscious *operations*; actions are designed to meet hierarchically structured goals. Subjects can be *individuals*, but also *communities* with shared needs and motives. Purposeful

interaction between subjects and objects takes place by means of *tool mediation*, whereby tools include not just physical things, but also procedures, computer programs, languages and signs [47].

Modelling the research process is informed by the preliminary findings of our empirical study of scholarly practice, as well as literature cited above. The study was carried out in the form of semi-structured conversational interviews, so far with 23 European arts and humanities scholars who may be classified as mainstream users of digital resources and tools [5]; a second round of interviews, currently under way, involves scholars who could be classified as innovators or early adopters *vis-à-vis* ICT use. Interviews were recorded, transcribed in machine-readable form, and tagged, using an initial corpus of tags derived from information behaviour and research methods literature [21,23,28,29], and adding further tags when dictated by the conceptual content of the source material. Candidate concepts, such as activity, procedure, method, tool, and information object, were abstracted from segmented interview transcripts and associated tags. Actual modelling of the scholarly research process was based on established conceptualisations of activity, such as the concept of activity in the CIDOC CRM cultural documentation ontology [49], and the concept of process in enterprise information models [50,51].

4. CONCEPTUAL MODEL

Consistent with the activity theory framework presented above, scholarly research is here understood as a *purposeful process*, carried out by *actors*, individuals or groups, according to specific *methods*. Research processes usually are complex, consisting of simpler *tasks*, which may be carried out in parallel or in series. Each task may be further analyzed, until we arrive at elementary tasks. The detailed structure of the research process, and way of working for each step, are specified by a corresponding *procedure*. Procedures have a normative character and convey what is believed by a community of practitioners to be good practice at any given time.

A research process can be considered as an enactment of the corresponding procedure, carried out at a specific place and time by a specific individual or group. To capture the purpose of a particular instance of research work and of the successive steps of the process, a structured representation of goals is needed. At the highest level, we wish to express what the research is after, and why, and to determine, probably in general terms, its felicity conditions. As we proceed to the tasks and sub-tasks of the research process, goals become more specific and can be associated with the performance of services designed to support the respective tasks.

Not being conceived as merely a structured set of events (*what, where, when was done?*), but rather being characterized by subject (*who did it?*), method (*how was it done?*) and purpose (*why was it done?*), allows the research process to be considered as a special case of the notion of *activity* of the CIDOC CRM ontology (formally, a subclass of the Activity class) [49]. There is, however, one significant teleological difference between that model and the one we are

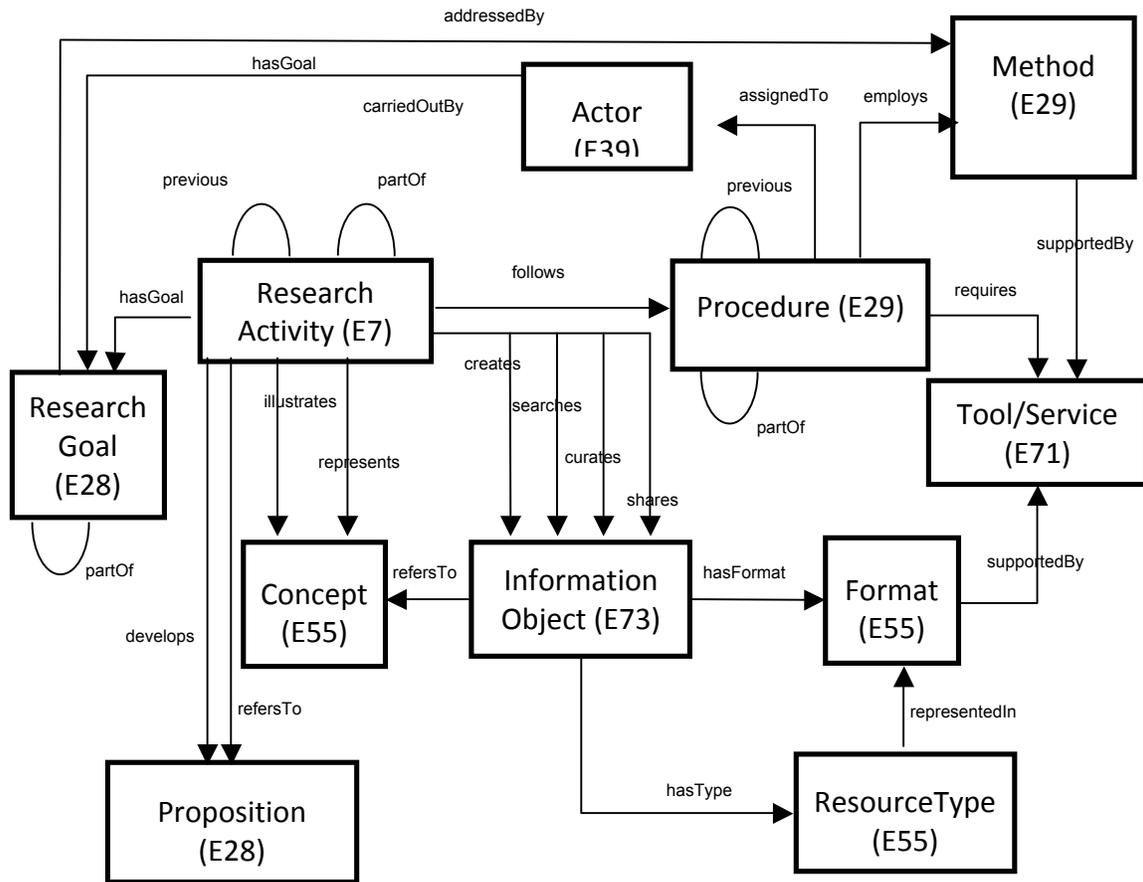


Fig. 1: Scholarly research activity

proposing here: the activity model of CIDOC CRM is meant for historical and documentary purposes. Our model of the research process is intended to facilitate the design and development of information repositories and services in digital infrastructures that support research in the arts and humanities. To this end the model should allow to represent the details of a particular research activity both at the level of planning (*how it should be done*) and of actual execution. This dictates the distinction between process and procedure while maintaining corresponding (though not necessarily isomorphic) descriptions of the two. This duality is commonly encountered in conceptual models of task-oriented systems, such as enterprise information systems [50,51].

A research activity involves a range of objects of different kinds: physical objects (natural or artificial), conceptual objects and information objects. *Physical objects* are those found, examined, stored, etc., or those used as tools in the course of the research process. *Conceptual objects* include concepts created, represented and illustrated, and logical propositions formulated, supported, countered, proved, disproved or refuted. The *information objects*, finally, are a special class of conceptual objects with corresponding physical information carriers, which refer to and represent physical and conceptual objects, and which are created, searched, shared, or even curated as part of research processes. Each of these categories actually gives rise to a representational facet of autonomous interest, related to the others through the rel-

evant research activity: the information objects are the contents of digital repositories; the physical objects are the original domain material; and the conceptual objects are the content of scientific theories. Our work focuses on the interplay between conceptual and information objects, so physical objects are not considered here any further.

We now turn to Fig.1 for a schematic presentation of the conceptual model of scholarly research activity. Next to the name of each entity in parentheses we note the code of an appropriate CIDOC CRM superclass. By property inheritance, the entities in our model share all the properties assigned to the respective CIDOC CRM superclasses and we decline listing those here, with one exception for illustration purposes.

The entity *Research Activity* is the basic construct for representing research processes. Being a subclass of the CIDOC CRM E7 Activity, this entity is endowed with all the properties describing E2 Temporal Entity, E4 Period and E5 Event (successive classes on the hierarchy path above E7) in addition to those of E7. Of particular interest in our case are: P4 (*has time-span*), P119 (*meets in time with*), P7 (*took place at*), P9 (*consists of*), P11 (*had participant*), P14 (*carried out by*), P16 (*used specific object*), P17 (*was motivated by*), P20 (*had specific purpose*), P21 (*had general purpose*), P125 (*used object of type*), P134 (*was continued by*). These are not shown in Fig.1 for the sake of clarity. Nevertheless, the prop-

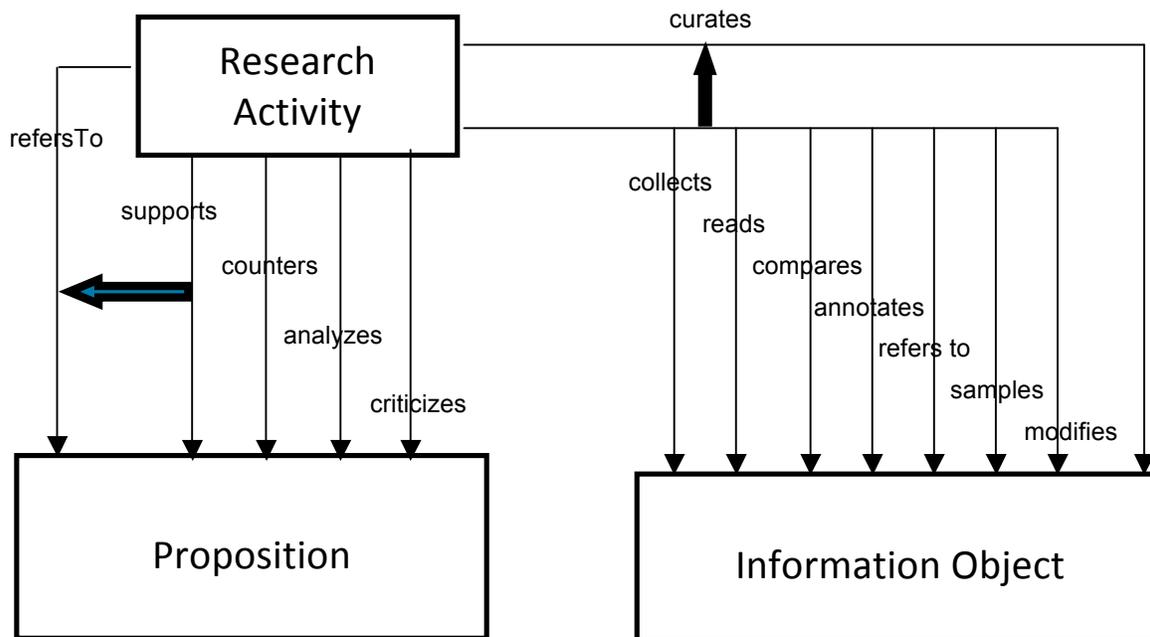


Fig.2: Modelling scholarly primitives

erties *previous* (sub-property of P134) and *partOf* (sub-property of P9) of *Research Activity* are shown in order to stress their prominent role in defining structure. This entity can be used for the documentation of accomplished as well as planned research processes through respective subclasses. Comparisons of corresponding property values allow inferences on the applicability of procedures and the actual use of resources.

The association of *Research Activity* with *Procedure* is the key element for recording normative aspects and planning. Besides having a similar structure with a research activity, a procedure is related to the *Methods* it employs and the *Tools* and software *Services* it requires. The latter can be a selection from the tools and services that support the respective methods. *Methods* may also be identified as useful in addressing particular research goals. The specification of a set of research goals with an appropriate internal organization (usually, but not necessarily, hierarchical) is captured by the entity *Research Goal*.

The *Proposition* entity represents all logical propositions, such as hypotheses formulated, inferences made, arguments raised for or against other propositions. The generation of propositions is represented by the *develops* property of *Research Activity*, while any other kind of reference to them is represented collectively by the *refersTo* property. Propositions refer to concepts and objects. *Concepts* are (or should be) represented and organized in appropriate thesauri. Objects are represented and documented by *Information Objects*. These are *created* in the course of research activities and populate digital repositories through which they can be *searched* and *shared*. Information objects of different types can be represented in specific *formats* which, in turn, require specific software *services* for access and processing. *Services* thus become an important mediator between methods, procedures and information repositories. From a functional per-

spective, affordances of digital scholarship are embodied in services available. From a teleological and methodological perspective, services evolve to better meet requirements.

Previous has authors have identified various sets of “scholarly primitives” as basic operations that take place in scholarly research and that can be used both to understand how a scholar works and which functions to support when designing tools for scholarly use. The model presented here provides a more general framework, in which scholarly primitives can be interpreted as specific operations on conceptual or information objects. Accordingly, they may be represented as specializations of properties relating *Research Activity* to *Proposition*, *Concept* and *Information Object*. Studies like those cited above, or like our own empirical study, provide the necessary substantiation on primitives which, together with an elaboration of research goals, enables developing a model of scholarly research processes specific enough to support development of appropriate digital services.

In Fig. 2 we present one possible specialisation of the properties (in RDFS triples style) $\langle \text{Research Activity}, \text{refersTo}, \text{Proposition} \rangle$ and $\langle \text{Research Activity}, \text{curates}, \text{Information Object} \rangle$. The proposed specializations of *refersTo* are: *supports*, *counters*, *analyzes*, and *criticizes*. These are genuine scholarly functions that actually refer to scholarly statements (*Propositions*), which can be mapped onto appropriate annotation functions operating on data objects containing the statements. On the other hand, the *curates* property is specialized into a set of properties that correspond to scholarly primitives that actually involve curating information objects: *collects*, *reads*, *compares*, *annotates*, *refers*, *samples*, and *modifies*. Clearly, different sets of primitives can be accommodated by the model in exactly the same way.

5. DISCUSSION

The conceptual model presented here aims to address a press-

ing need as we engage in the empirical elicitation, analysis, abstraction, and formal conceptualisation of information practices and needs in scholarly research. It has been developed as a complement, rather than as an alternative, to prior conceptualisations of information work, including classifications of scholarly activities and methods with which it can be interoperable. It provides clear definitions of constituent entity types and relationships, distinguishing, in particular, the cardinal concept of *Research Activity* from those of *Procedure*, *Method*, *Tool/Service*, and elucidating the relationships between *Information Object*, *Resource Type*, *Format*, and *Concept*. It also provides, by way of illustration, specialisations of the relationship between *Research Activity* and *Proposition*, and that between *Research Activity* and *Information Object*, mapping to empirically attested operations in research practice.

With the important proviso of the need to maintain a distinction between (empirically attested) process, or activity, and (goal- and task-driven) procedure, the model is fully expressed in terms of the CIDOC Conceptual Reference Model, a mature, internationally recognised standard for cultural information [49]. It is amenable to operationalisation, i.e., as a conceptual schema for the construction and population of a knowledge base with facts regarding information practices of humanities researchers, and corroborating documentary evidence, such as interview transcripts produced by our empirical study [5]. In the next stage of our conceptual modelling work in the DARIAH project, we plan to tag systematically all interview transcripts in terms of the model, and thus provide, in addition, a mechanism of validation of its soundness and fitness for purpose.

At the same time, the model is meant to act as a descriptive framework for better discovery, summarisation and understanding of relationships between specific scholarly activities, research goals, information objects, methods, and tools/services at the instance level. It may, therefore, be useful as a conceptual structure – or information architecture – for better communication among stakeholders (such as policy makers, archivists, repository managers, technologists and scholars) and institutions involved in the specification of requirements and affordances of digital repositories, services and tools intended to support scholarly research work.

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