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Evaluating hypermedia structures as a means of improving language learning strategies and motivation

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Abstract

By providing access, data and new forms of literacy and communication practices, it is widely accepted that networked technologies have done much to promote learner autonomy. However, in practical terms, the lack of resources, expertise and research investigations into learner interaction have all too often meant that autonomous learning is conveniently likened to teacher-independent learning, largely relying on the success and assumed intuitiveness of the World Wide Web (web) for its learner driven delivery. This situation affecting foreign language teaching and learning has been further aggravated by the recent trend, at least in UK universities, to conceive languages solely as communicative tools, further severing them from their academic base and cultural roots, often reducing learner autonomy to poor repetitive interaction. On this premise, this paper proposes to focus on how to make better use of the interactive potential of the web in order to maximise independent language learning online. From a Human Computer Interaction (HCI) design perspective, it intends to shed further light on and increase our understanding of hypermedia and multimedia structures through learner participation and evaluation. On the basis of evidence from an ongoing research investigation into online CALL literacy, it will seek to identify crucial causalities between the user interface and learner interaction affecting the learners' focus and engagement within their own learning processes. The adopted methodology combines a task analysis of a hypermedia prototype underpinned by an activity theory approach and participatory design based on user walkthroughs and focus groups. By looking at the relationship between action and goal as well as between activities and motives, it attempts to provide a framework for evaluating online hypermedia interactivity based on identified activities, design tasks and design criteria.

1 Introduction

Hypermedia interactivity, by linking together multimedia data with hypertext links, is ubiquitous, particularly so since the advent of the web, based on the document metaphor and developed using hypertext web technologies in the form of the Hypertext Markup Language (HTML) and the Hyper Text Transfer Protocol (HTTP).

The seeming and attractive simplicity of creating web pages with the available range of dedicated authoring tools, the now easy and fast access to online information and the low learning curve for using a web browser have all been important contributory factors in making the web successful. Likewise, courseware development in general and online Computer Assisted Language Learning (CALL) applications in particular, have benefited from an interactivity which not only made better use of the increasingly available network technology but which was also seen as being ideally suited for autonomous learning. Indeed, the original hypertext link, invented by Ted Nelson in 1965 to generate 'non-sequential writing', was easily perceived as giving users the electronic access, means and control to exploit online learning material better and to adapt it to their needs. However, in spite of this perceived potential, online learning supports on the web or on UK universities' intranets too often provide information bases with little navigational architecture and poor interactivity, leaving autonomous learners to their own devices and personal initiatives to find the necessary motivation and give shape and direction to their learning process. At the root of this problem lies the fact that the designers' model of how their electronic environment ought to behave is not matched by the learners' mental model of interactivity on the web and how this can help them achieve their learning goals (refer to Norman's framework: Norman, 1988). Indeed, if hypertext links are relatively easy to create with the help of appropriate authoring tools, the resulting interactive architectures are not sufficiently well conceived to enhance the learning process or, even, to reflect the learners' needs and expectations. Furthermore, the design process suffers still from a dearth of usable and reliable evaluative data since hypermedia courseware is difficult to evaluate given the dynamic and individual nature of its learner centred interactivity.

Thus, this study proposes to bring closer together represented models observed and identified through previous evaluation of hypermedia interactivity, in terms of patterns of use, and conceptual models implemented by courseware authors in an attempt to bridge the problematic gap between evaluation and theory (see for instance the design model presented by Colpaert, 2004: 135). More specifically, it will seek to ensure that evaluation better feeds back into the design process by facilitating hypermedia representation through an object-oriented design approach adopting the standardised Unified Modelling Language (UML) notation to depict models and behaviours diagrammatically, whilst highlighting the dynamic and contextual nature of its interaction through the use of activity theory (AT). Ultimately, it intends to play a part in improving the learning potential of hypermedia interaction by looking at its operational meaning at the level of activity, considered as the basic unit of analysis (Kuutti,1996: 25), and by suggesting better means of translating this fundamental dialog data into the iterative engineering loop, embracing both user-centred design considerations and object-oriented development. On this basis, the paper will initially explain the theoretical approach and parameters which will underpin the desired framework, before presenting hypermedia as an interactive concept from an object-oriented perspective, highlighting in the process language learners' mental models, the learning context and its goals, in order to facilitate the conceptualisation and subsequent development of hypermedia for learning.

2 Learning activities in hypermedia: adopting appropriate design methods

Unlike multimedia (which is a computed entity displaying different discrete media supporting a range of complementary representations for specific or expected interaction by information seekers), hypermedia, as an online learning resource, is virtual media which is only given shape and meaning through learner interaction. Nielsen (1995: 13), for instance, compares the difference between multimedia and hypermedia with that between 'watching a travel film and being a tourist yourself'. Indeed, it is this very sense of engagement on the part of the learner, at the root of hypermedia interaction, which makes it so relevant to the autonomous learning process. Without revisiting the significant debate on learner autonomy which would be outside the remit of this paper, it is generally accepted that the learning process is more efficient and effective when autonomous learners are focused and engaged, suggesting that the more committed they are through their interactive activities the more motivated they become (Little, 2002). On this premise and in theory in any case, hypermedia can be perceived as providing the ideal interactive electronic environment for autonomous learning. Indeed, through its architecture, it has the potential of offering meaningful purpose and learning goals whilst the students can be given full control over their interaction and the tools to monitor their progress and evaluate their effectiveness. Therefore, by promoting the students' own accountability and responsibility in the learning process as well as their freedom to stimulate individual initiatives, the hypermedia interaction should generate engagement.

However, in practice, very little evidence exists to support and verify this assumption, precisely because hypermedia can be unexpectedly problematic to design and, as a corollary, difficult to evaluate. Particularly so since its goal driven and contextualised interactive specificity make it almost impossible to ensure a satisfactory match between the model of how it ought to work at the conceptual level and the way it is actually used at the operational level. Indeed, goal directed behaviours such as those created in hypermedia are particularly difficult to represent using traditional task analyses, such as those provided in HCI (see for instance Diaper & Stanton, 2004), as they do not take into account sufficiently the dynamics of the activities undertaken (Kaptelinin, 1996: 60), crucial in the hypermedia-based learning process. Furthermore, even when relevant data is captured from the evaluation of resulting learner interaction, it is equally difficult to translate this information and filter it back into the design process, due to the lack of an adequate representational framework. Given these problems, it is therefore proposed to focus on the conceptualisation of hypermedia and, more specifically, on activities, at the micro level, with a view to providing better means of understanding the dynamics of interaction and to convey their representations back into the design cycle. To this end, the notation defined by the Unified Modelling Language (UML) designed to standardise object-oriented development (see for instance Jacobson *et al.*, 1999), has been adopted primarily to identify user interaction scenarios (see section 2.1) more easily at macro level but also in an attempt to establish a common ground for designers and developers alike. This approach which views information systems as a collection of interacting objects modelling features and behaviours will be used initially to represent the structural model, or architectural concept of hypermedia design. The second and main focus of this study seeks to better understand user interaction at the activity level affecting functional models.

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Hence, the earlier decision to resort to interaction design to address the design of goals through represented models (Cooper & Reimann, 2003; Norman, 1988; Preece *et al*., 2002) as well as activity theory (AT) to present a more flexible, evaluative framework for hypermedia.

2.1 Identifying behaviour with UML use case and collaboration diagrams

Use case diagrams (Booch *et al*., 1999; Cushion, 2005; Fowler & Scott, 1997) are primarily drawn during the elaboration phase of the design process in order to facilitate the overall and detailed capture of the system's interaction on the basis of identified user goals. If other methods such as task analyses exist in HCI to gather user requirements, these UML diagrams offer the added advantage of being easy to understand and interpret by both user interface designers and developers. Moreover, they have proved to be useful in the formative and summative phases of the evaluation by enabling a closer mapping between the designer's and the users' structural models through projected and tracked scenarios of user interaction. Thus, at the macro level, a use case diagram can be used to identify projected activities and indicate how the system would behave to allow the actor, depicted in the diagram by a self explanatory stick figure, to access all use cases within the given activity. Beyond this representation of the global structure of the system, but also beyond the scope of this paper, each identified use case would logically be further described as a sub-system with additional detailed information including activity and sequence diagrams. One of the advantages of use cases resides in the way they facilitate the identification and subsequent grouping of different behaviours, which will impact on the system's structure and user interaction, by specifying two broad types of inter-relationships. The 'include' relationship indicates a dependency explicitly incorporating the behaviour of the main base use case whilst the 'extend' relationship depicts an optional dependency, which only implicitly comprises the behaviour of another use case indirectly linked by the extended use case. Thus, in use case diagrams using UML notations, connecting lines indicate an interaction between the user and a user case. A dotted line with an arrow connecting two use cases points to a use case, which is 'included' or 'used' as a part of the main use case. Alternatively, an 'extend' relationship, with its dotted line pointing to the main use case, suggests that further iterations are possible leading to other use cases outside the major use case being considered (see Figure 1).

If use case diagrams can provide useful conceptual descriptions of a system's planned hypermedia interaction at the macro level, collaboration diagrams offer valuable visual support, at the micro level, for sketching out screen-based scenarios, thus highlighting links between screens, sequences and interactive progression. Even if this micro approach to interactive design still remains largely conceptual, it has proved to be particularly effective when attempting to compare user interaction in the form of storyboards with the system's behaviour for evaluation purposes.

2.2 Activities as perceived through activity theory (AT)

Traditionally and in HCI studies in particular, human cognition has been and still is largely perceived as the study of discrete mental representations and behaviours,

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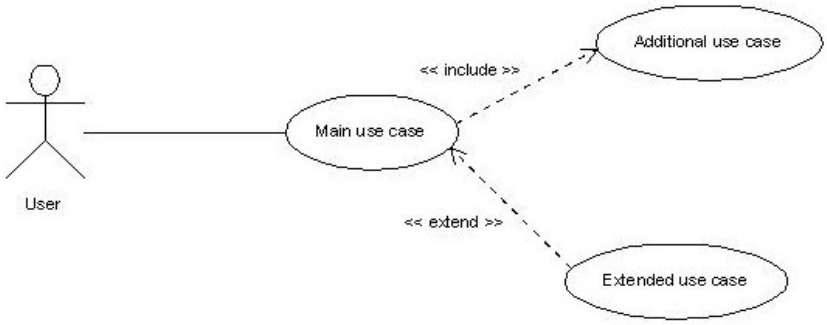

Fig. 1. Basic relationships between use cases.

abstracted from the social and physical contexts in which the cognitive processes take place. In contrast, activity theory (AT), which derives from the work of Vygotsky (1978, 1981) and developed by Leont'ev (1981) predicates that artefacts mediate thought processes and, by extension, human activity (Nardi *et al*., 1996). More specifically, it is argued that artefacts in the larger sense, including machines, instruments, sign systems, methods, procedures and work organisations, as well as established practices affect, through a process of internalisation, resulting mental processes. Therefore, if HCI is primarily concerned with gaining information on user characteristics, cognitive resources and procedural knowledge, AT crucially focuses on individual and collective consciousness as situated phenomena, which evolve dynamically with practice and are transformed in the process by artefacts like 'functional organs' (Zinchenko, 1996). Therefore, whilst AT does not offer 'ready-made techniques and procedures' for research (Nardi, 1996: 8), its perception of human activity and prevailing concepts to describe its nature are considered to be particularly pertinent and relevant when applied to the evaluation of hypermedia learning environments.

2.2.1 The structure of an activity

The main *raison d'être* or motivation of an activity rests on transforming the object of the activity by the subject into an outcome. Thus the basic structure of an activity highlights this process of transformation, realised through a relationship between subject and object and mediated by a tool enabling and defining its development. Furthermore, to include a meaningful collective context into individual activities, this basic systemic model is complemented by a third community component, thus completing the activity triangle (see Figure 2) by forming two additional relationships between the subject and the community, mediated by rules, as well as between the community and the object of the activity, itself mediated by the organisation of the community (Cole & Engeström, 1991).

Ultimately, the connections and combinations between all these activities become intricate parts of real-life situations. However, beyond this macro-level, structural model, shedding new light onto transformation processes through the clearer identification of components, mediating artefacts and objects, it is AT's focus on the multi-level process needed for an activity to transform its object into outcome, which

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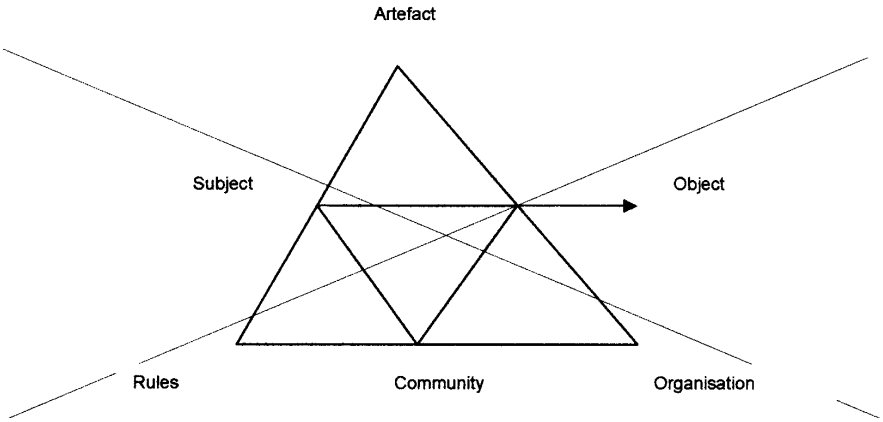

Fig. 2. An activity triangle adapted from Cole & Engeström, 1991.

has been seen as being particularly relevant to facilitate and inform the evaluation of hypermedia interaction as explained below.

2.2.2 The three-level process of an activity

AT provides a descriptive framework based on the study of contextualised activity. At the root of this approach lies the concept that an activity is uniquely identified as a unit of analysis by its collective motive, thus making activities distinguishable by their differing motivations and classified on the basis of three hierarchically defined levels: the *activity level,* the *action level* and the *operation level*. In essence, an activity is realised by means of an aggregated number of mediated actions, which are themselves realised by low-level operations becoming largely automated with time and practice. By the same token, activities derive from motives generating goals themselves affected by the conditions faced when performing the necessary operations. In other words, the *activity-motive* level is interpreted as being 'the why', the *action-goal* 'the what' and the *operation-conditions* 'the how' (see Figure 3). Since activities are dynamic entities, this system of thought has a hierarchical structure whereby, as users keep on learning with practice, actions over time become automated and are brought down to the level of operations and, likewise, activities themselves can also simply become actions, depending on the circumstances.

What is thought of as being particularly useful to hypermedia interactive learning environments is the notion that activities can be subject to transformation through

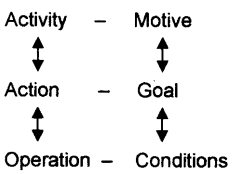

Fig. 3. Hierarchical levels of an activity.

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practice and through potential contradictions or disturbances which, when identified and understood, are themselves perceived as sources of development (Kuutti, 1996:34). Engeström (1995, 1999) in particular compares such contradictions to drivers for what he terms *expansive* or collective learning with its cycles of internalisation, reflection and externalisation. Thus, dynamics and contradictions are intricately linked. Engeström identifies four such contradictions: *primary contradictions*, which are found at the operational level and which will manifest themselves within an activity as a result of a faulty mediating artefact or a lack of corresponding skills leading to poor or erroneous use; *secondary contradictions* when a breakdown between actions realising the activity occurs, due for instance to the incompatibility or clashes between multiple goals; *tertiary contradictions* when new motives force an activity to be reshaped or redirected and *quaternary contradictions* suggesting conflicts between co-existing activities.

In essence, AT's strength and relevance rest on its ability to present a structured view of an activity, which comprises its context, internal dynamics and contradictions.

3 Towards an object-oriented conceptualisation of hypermedia

3.1 The semantics of hypermedia: architecture as a user interaction concept

The term hypertext, based on the Greek prefix *hyper*, initially described an important metatext application presenting a multi-layered text management format, thus enabling the user to navigate through extended textual data in a non-linear manner. Interestingly, the concept itself was introduced by Vannevar Bush who, in his now famous seminal paper 'As we may think' (1945), defined the human mind as operating by thoughts organised on the basis of associative links. By enabling other media extensions, such as sound, animation and video, to be incorporated and interlinked as discrete frames, hypermedia gave the hypertext environment greater design and interactive scope as well as the potential for representing and structuring the relevant knowledge base more closely mapped onto natural interpersonal interaction. Soon, its main design strength was quickly captured by its ability to generate hierarchical and non-hierarchical structures within the information space. The resulting interactive control exercised by users became therefore at the crux of the main interlinking function of hypermedia seen as *virtual* media, as opposed to *multi*media, because of the deep and rich nature of its *hypersource* of information whose full potentiality was conditional upon full and meaningful user interaction (Fisher & Mandl, 1989: 9). This symbiotic interactive relationship contingent upon the *stimulus attributes* of the *hypersource* and the *responder attributes* of the *user* raises an important conceptual duality inherent in hypermedia. On the one hand, it intrinsically links the domain-specific data and media input with the range, scope, accessibility and interactive potential of embedded user tasks and achievable goals. On the other, it recognises and therefore highlights the need for a satisfactory mapping between the system's interactive potentiality and the user's ability to react to it. Such a *virtual* role makes hypermedia the most logical vehicle to convey and present the multimedia information base within a structure controlled by the user. Nielsen (1990), who defines hypermedia as the natural technique providing the necessary interlinking between multimedia-based frames, corroborates this point. Beyond the multimedia modularity, hypermedia provides and supports information,

communication and exploration. Indeed, the meaningful user interaction generated by the dynamic semantic structure of the information base and its satisfactory manipulation by the user is the hallmark of hypermedia insofar as it represents its main strength. It is also, ultimately, its weakness due to the potential complexity of information structures and resulting user interaction. Therefore, one of the crucial conceptual problems of hypermedia lies in designing an interactive environment which can suit the semantics of the information across frames, as well as the structural potentiality of the content supported by the necessary functionality within frames.

3.2 Interaction as a functional model

The basic hypermedia syntactic concept is characterised by a frame-link paradigm (Nielsen, 2000) highlighting the crucial structural importance which frames, as computational modules of information, have as basic units of data interrelated by means of embedded links. Artefacts linking these frames will generally take the shape of word strings, icons, different colour patterns, changing cursor or mouse-pointer designs, pop-up windows, reference fields and viewers. Frames vary in size, although the information they contain is often limited to a single screen, hence, their common comparability with the computer screen or metaphorical pages, HTML pages and, misleadingly, web pages, as these go through some form of server-side processing. See for instance Arneil and Holmes (2003), Conallen (1999) or Nielsen (1995, 2000) who, whilst emphasising the frame's capacity to hold and display information data, make the distinction between frame-based and window-based systems. Interestingly, even if frames are often identified as screen displays, their format and size do not necessarily facilitate convenient screen adaptations. In design terms, data might have to be displayed over several frames in order to comply with the limited nature of the physical interface, or might incorporate a scrolling device to view a large information field. By carrying discrete fragments of information, and being connected and interrelated by links, the frame acts like a module in a modularised environment. This concept of modularity, crucial in object oriented theory, is quintessential in hypermedia, inasmuch as it encompasses access, navigation and, more generally, usability. Therefore, a coherent and manageable frame input into such a modularised framework is determined by the type, size, organisation and purpose of the information to be presented. At the macro level, frames fragment this information within an identified structure based on context of use, content, objectives and learning strategies. At the micro level, frames break the information down into representational sections, which are displayed on screen.

3.2.1 Links

Links interconnect frames providing access and navigation, thus implementing their internal structure. They allow users to navigate through the hypermedia information base by means of special or customized buttons or embedded anchors. The link specificity includes attributes such as directionality, type, size, position, display and function depending on how they either provide or refer to information and how intrinsically connected they are to the structure of the frames. Grabinger and Dunlap (1996) identify contextual and support links as being the two broad types existing in

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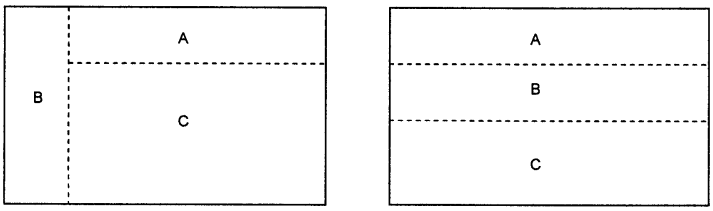
hypermedia. According to this categorisation, contextual links provide access to the information base and are, themselves, subdivided into two categories: sequential and relational links. Conversely, support links are 'metalinks' insofar as they provide permanent on-line access to support material and help facilities related to operational and structural aspects of the modular environment. Adopting a similar approach, Haas and Grams (1998) suggest that a hypertext link taxonomy should be based on four categories: navigation, expansion, resource and miscellaneous. More conceptually, de Rose (1989) proposes that hypertext links can be better identified as being either extensional, therefore providing a more explicitly tactical progression, or intentional, implying a more implicitly structural and deductive interaction. More recently, with the increasing standardisation of web page design, affecting navigational practices, Miles-Board *et al*. (2002) have introduced a taxonomy of hypertext links established on structural implementation and location on the web page, segmented into smaller micro pages or framesets (see Figure 4). Of the two types which are generally identified, navigational links highlight the primary structures of a web site and define high link density functional areas by being grouped together, listed and ordered. By contrast, associative links, such as reference links, keyword links and structural links to content-related pages, are to be found in the content of the interactive space and are instrumental in shaping the semantic thread through knowledge construction within the informational architecture. Table 1, drawn from the above identification and categorisation processes, sums up the main architecturally relevant link attributes.

4 The hypermedia language learning environment in context

The hypermedia learning environment, promoted by the success of web-based interaction and its potential for exploratory learning, is increasingly perceived by the Higher Education (HE) language community as a natural and logical e-learning support. After all, acquiring a foreign language implies that learners are already implicated in the real environment within which the language is spoken. In other words, by dint of contextualising the language learning process itself, learners should be encouraged to establish a useful relationship between context and use designed to facilitate and support the understanding and communication of meanings. In theory, therefore, language competence is achieved when language constructs, which are “embedded” into



A: static frame with no links; B: high link density functional area displaying ordered lists; C: content area with associative links embedded within textual material.

Fig. 4. Illustration of standardised framesets in relation with links.

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Table 1. *Taxonomy of link attributes*

	Associative	**Navigational**
Structual links	Intentional / C	Relational /B
Reference links (data)	Intentional / C	Intentional (web pages) / B
Keywords (deep links)	Extensional / C	
Interactive Exercise links	Intentional / Sequential /C	
Support links		Extensional /B

situational contexts, are satisfactorily "disembedded" from their situated representation with appropriate teaching methodologies (Laurillard, 1993). In practice, however, this contextualisation of situations has led to widely differing interpretations on how hypermedia could replicate "real situations". In its worst manifestation, this is achieved artificially by means of technologically driven solutions best exemplified by the systematic use of animations, which, to a student population, can be more counterproductive than useful in enhancing the language learning process. One of the main problems of this approach, aside from its design shortcomings, is in the narrow minded understanding of what the context for language learning should be. Instead of reproducing an unattainable electronic vision of the real world, hypermedia should and can more easily be instrumental in projecting a virtual reality of the language learning context based on the learning experience, existing teaching methodologies and the proper embedding of language within culturally relevant material.

4.1 The language experience seen within a real, existing hypercontext

The language learning process in HE involves students in acquiring the language and its culturally-related content within the broader confines of the university environment which can be seen, according to Barrett (1994), as a *hypercontext* with its real-virtual presence generated by its various sites such as the library, the classroom, the language and computer laboratories, home-based activities etc.. Teaching in this artificial context is tantamount to achieving a fine balancing act in order to provide the right amount of information, exposure and monitoring enabling students to process, manage and digest knowledge appropriately. Interestingly though, such a context still largely relies on a traditional presentation of information, sources, and visual supports generating exchanges and feedback, written assignments and corrections within the classroom which would be expected to be complemented by independent study and autonomous

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learning. In language teaching in particular, even if a more communicative approach is increasingly adopted, methodologies are largely explicit, with clear objectives, and still, almost unavoidably, prescriptive, particularly at the lower levels. It is, essentially, a top-down, structured approach generated by the teacher providing expert knowledge for language learners in an artificially interactive learning environment. In this respect, this hypercontext, triggering such an interactivity, in terms of input and output, could be likened to providing an institutional teaching and learning framework within which a variety of guided, exploratory and associative learning experiences take place under a large degree of teacher and learner control. However, paradoxically, few of the features and attributes of this hypercontext are replicated in the hypermedia language learning environment which, at one extreme, still proposes an overtly conventional electronic document simply simulating the well-known paper-based delivery, or, at the other end, presents a mainly unevaluated learner controlled interaction promoting the idea of constructive learning.

4.2 Hypermedia as a contextualised learning construct

Hypermedia as a language learning construct is often perceived as being synonymous with constructive learning. Indeed, at the core of this learning theory lies the fundamental notion that the learning process is dynamic and free from coercive instructional orientations imposing knowledge structures. As such, its main principle stipulates that knowledge is constructed through interaction and not simply transmitted via the use of teaching strategies. On this premise the computer, supported by the hypermedia platform, is considered ideal to enhance the interactive process of learning as opposed to promoting the longer established but reductionist role of teaching arbitrary facts. In fact, a parallel can even be drawn between the evolution of and perceptions towards the technology on the one hand and that of language learning theories on the other. From the rigid unidirectional stimulus-response interaction at the root of the behaviourist school, the procedural drill and practice mode advocated by instructionists, to the user-centred constructivist position, it is claimed that learning theories have shown a close reciprocal link with the interface design (Laurillard, 1993). Therefore, hypermedia, by conceiving an information environment based on frames and links, feeds into the constructivist concept on the basis that learners can freely interact with it in order to construct their own knowledge and understanding. Inversely, constructivist learning, by prioritising and promoting a quintessential, individualised learning process, feeds into the design of hypermedia on the basis that there is a definite need for a more beneficial user-centred learning approach promoting knowledge construction as opposed to knowledge transmission. However, in practice, this approach with its high degree of expectation as measured against more traditional methods, its great reliance on technology to deliver, and the artificiality of its interface design, leaves a lot to be desired. On the one hand, the push for greater learner autonomy and engagement is taking place within an educational context which is still mainly traditional in its approach to language delivery, creating in its wake a destabilising dichotomy between the more instructionist methods commonly used in the classroom and constructivist orientations designed to stimulate independent learning. On the other hand, institutionally promoted learning technology initiatives seem to suggest that

e-learning developments are still too often technologically driven whilst providing little evidence that usability studies and adequate evaluation are being conducted to indicate and, indeed, confirm that resulting interactivity justifies the means and complements the existing learning experience.

4.3 Hypermedia as a means of contextualising language within its culture

Finally, beyond the learning experience and language teaching methodologies, the question of content must also be addressed to complete this contextualisation of language teaching and learning in relation to the hypermedia environment. Last but not least, one of the major problems facing foreign language teaching in HE in the UK lies in the fact that languages are increasingly reduced to being considered merely as a means of communication and not representational and critical exponents of their foreign cultures. Aside from the detrimental academic marginalisation such a general trend has begun to engender, this reductionist and short sighted understanding of the essence and relevance of foreign languages has also, unwittingly, led to the increased virtualisation of the language content being taught. Deprived of its traditional cultural and academic base, the adopted approach and progression becomes essentially and artificially theme and situation based, driven by the need to introduce the necessary new vocabulary and constructs. Moreover, the lack of adequate critical references tends to inadvertently promote what can only be regarded as an infantilisation process, often relying on one-dimensional and overtly descriptive presentations, only made worse by the untested use of the technology. Indeed, evidence from evaluation of hypermedia interfaces over the last ten years (Hémard, 1998, 2003, 2004) would suggest that hypermedia wizardry by itself cannot and will not generate increased motivation and engagement on the part of students.

5 Elaboration of framework based on previous evaluation of hypermedia interaction

5.1 Background

The protracted evaluation referred to here stems from a well documented CALL project at London Guildhall University (see in particular Hémard & Cushion, 2002, 2003; Hémard, 2003, 2004) whose main objectives were to design and develop a web-based

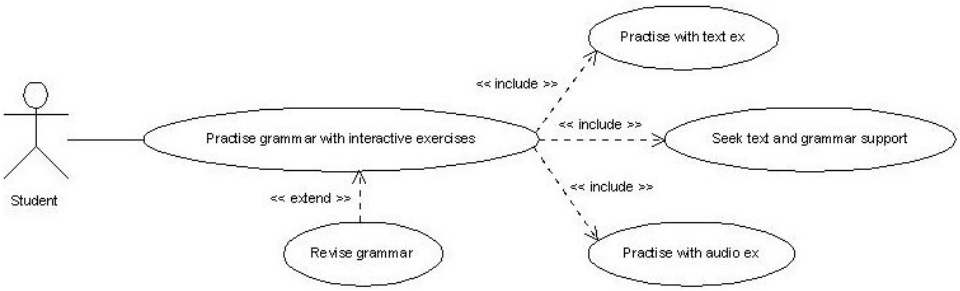

Fig. 5. Use case diagram of Learning Activity One: Learn by practising with interactive grammar

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interactive language learning environment, evaluate its usability amongst the university's language students and establish a benchmark in best design practice through an iterative design process. The designed interaction combined grammar-based interaction through interactive exercises, a grammar information base, a structured, theme-based, hypermedia environment and online assessment in the form of self-tests and formal "server-side" tests. Thus, the interactivity of the language learning environment was tested in different contexts of use, ranging from class-room situations to laboratory-based conditions and evaluated through a variety of methods, from questionnaires and user walkthroughs to directed interviews and focus groups. Whilst the main findings of this evaluation can be found in Hémard (2004), the main concern of this paper is to focus uniquely on the student interaction with a view to identifying and differentiating the students' structural models from their functional models of hypermedia in an attempt to compare the designer's model with the learners' mental models.

5.2 Identified activities in hypermedia as a language learning environment

As part of this study and on the basis of the evaluation undertaken (Hémard, 2003, 2004), four specific activities have been identified on the basis of motives, actions and operations, using the above-mentioned AT terminology. The first activity stems from the basic motive to develop a better grasp of grammar concepts through practice with

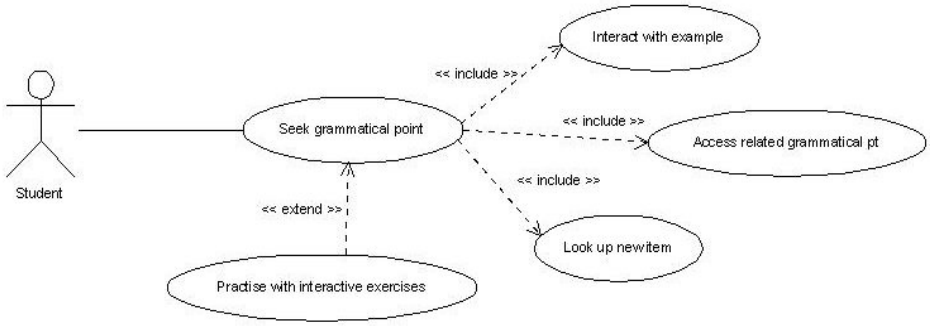

Fig. 6. Use case diagram of Learning Activity Two: Learn by exploring the grammar information base.

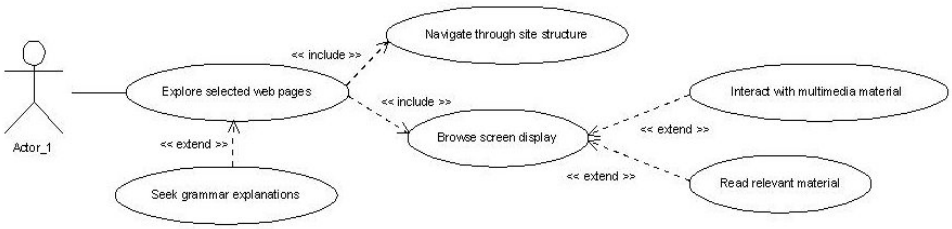

Fig. 7. Use case diagram of Learning Activity Three: Learn by seeking information embedded in a website.

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grammar-related interactive exercises. Thus, actions rely on a deductive approach of interactive drills applying grammatical rules, and operations comprise a linear back and forth navigation as well as relevant learner input processed and responded to with a meaningful output by the application. What the use case diagram (see Figure 5) shows is the typical interactive use case scenario as conceived in the design model. The student is meant to improve his/her knowledge of the grammar by selecting some identified grammatical point and practising with text-based and audio-based exercises, which are self supporting. Whilst in the interactive environment, the student also has the possibility of accessing the grammar information base, although this is outside the main activity.

The second type of activity more specifically encapsulates the motive of accessing specific information in the grammar information base, providing learners with appropriate explanations of grammatical concepts. In this case, actions are contingent upon matching the query with the appropriate answer and reading frame-based textual material, whilst operations are largely limited to hypertext links within the grammatical information base itself or between an exercise and the grammar. The following diagram (Figure 6) is a projection of a typical user interaction encapsulated by this activity: the student seeking information regarding a given grammatical point can access and read relevant explanations but can also interact with examples and decide to practise with related interactive exercises which are outside the remit of this activity (see Learning Activity One shown in Figure 5).

The third type is motivated by the need to seek related information embedded in different contexts. Its actions essentially consist of open-ended exploration within a relevant, multimedia-based website and its operations involve tactical and strategic clicking on hypertext links. The use case diagram (Figure 7) shows that actions revolve around navigating through the architecture of the site by clicking on appropriate structural links and browsing the screen display using tactical functions such as

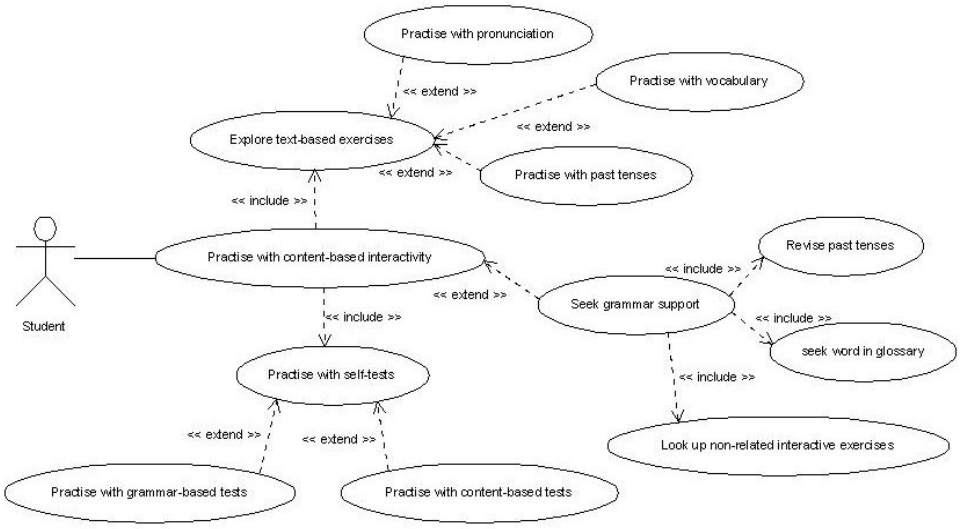

Fig. 8. Use case diagram of Learning Activity Four: Learn by practising with content-based interactivity.

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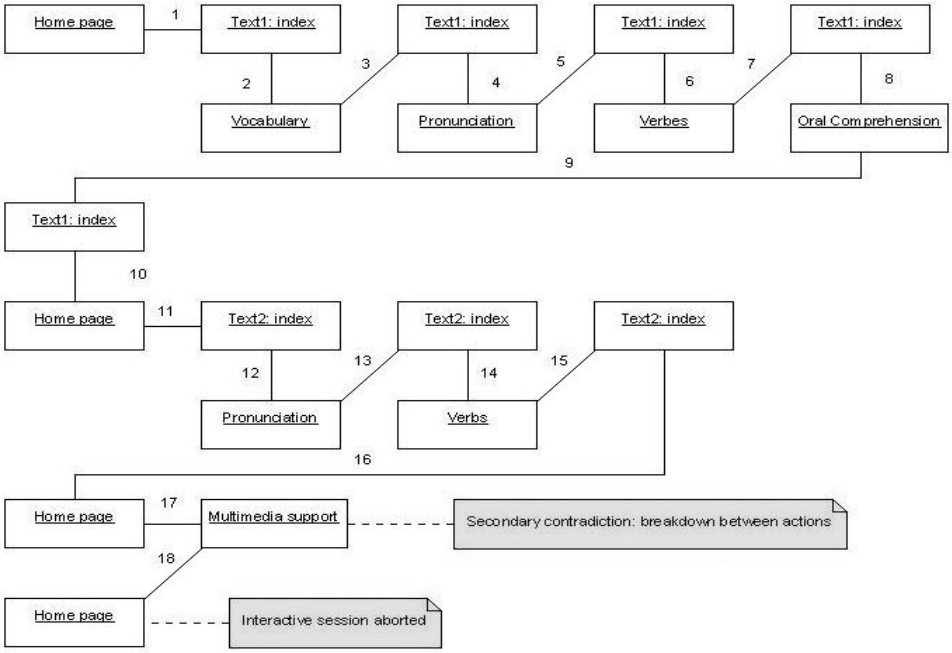

Fig. 9. Story board scenario expressed as a UML collaboration diagram.

keywords, multimedia extension links and scrolling.

Finally, the fourth type of activity relates to the motive of combining language with a cultural context related to the students' language degree programme of studies. Its interaction is designed to be circumscribed within its architecture of selected texts, themselves providing inter-related interactive exercises, additional multimedia support material and assessment in the form of self-tests and additional scoring exercises. Given the scope of the activity, actions are dependent on interactive scenarios adopted by the learner and present a variety of combinations indicating the approach taken and the degree of cross-pollination between language work, content exposure and self assessment. This is reflected by operations mainly predicated upon the use of associative links, be they sequential, relational or referential. The following use case diagram (Figure 8) yet again typifies the interactive remit of this identified activity: the student accesses a content-based interactive environment providing related exercises, grammar and self-tests. These actions can be taken in any given order, depending on the knowledge level, degree of practice and dynamics of the activity.

5.3 Dynamics and development of identified activities

Human practices cannot be looked at without considering their developmental and dynamic nature and related features. Using AT's activity hierarchy, which distinguishes activities from actions and operations, it becomes possible to identify relevant types of dynamics between these various levels of interaction, particularly at the level of the action-operation and activity-action dynamics. Action-operation dynamics indicate that,

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Table 2. *Application of framework for Level 2, post O and A level French students on the basis of transcripts of interaction and video recordings of user walkthroughs*

Activities	**Interactive exercises**	**Grammar knowledge base: explanation of grammatical concepts in information based presentation**	**Open-ended exploration based on additional material from selected websites**	**Content-based interaction built on architecture of selected texts, related exercises and additional multimedia support**
Interaction:	Essentially linear & finite, depending on context of use and language level	Mainly targeted, frame-based interaction	Navigational, exploratory: random + overwhelming frame scrolling	Mixed: structured navigation integrating interactive exercises within hypermedia context
Links:	Promotes sequential links and linearity. Need for more associative potential	Support / relational (associative)	Associative (structural) and navigational links to selected websites	Sequential links within clustered exercises, support links to grammar, associative links to content-based multimedia material
Learning context:	Directed, structured, autonomous	Explanation seeking, learning support, autonomous	Directed contextualisation / illustration	Directed, structured and open-ended: language & content combined through interactive contextualisation
Teaching strategy	Procedural drill and practice mode	Informational / constructivist	Communicative / constructivist	Mixed strategy involving instructional / constructivist / communicative
Language contextualisation:	Potential for targeting vocabulary and topics	Minimal, through examples	Main potential	Main focus on cultural context /language reinforcement
Learning goals:	Clear, easily defined, reachable	Enhanced when accessed (higher understanding / better completion)	Ill-defined: selected material but open-ended interaction	Multiple learning goals emphasising language or thematic context
Learning strategy:	Patchy attempts to use support links to grammar database	Very clear link between a grammar concept and its application	None observed on basis of student interaction: browsing + cursory reading of textual material	Logical progression through exercises and structure, suggesting a stronger structural model
Outcome:	Perceived as temporal tasks to perform, not referred to in focus groups unless exercises contextualised (see theme-based approach)	Greater completion rate of interactive exercises	Inconclusive – students needed clearer direction and orientation	When discussed in focus groups, students related well to the contextualised approach almost as though the language interaction was there to support it leading to noticeable recall and related exchange
Motivation:	Can be sustained, especially when students are paired, sense of engagement (see contradictions though)	Supports greater learner involvement and motivation in terms of understanding & thoroughness	Generated superficial interest and poor interaction generally	This combination of language and hypercon-textual content and variety of interaction led to greater motivation and fulfilment
Dynamics: (Functional versus Structural models	Context of use significant – practice leads to predictability (drills) – functional model is paramount, becomes too mechanical with time / practice	No noticeable changes identified due to patchy nature of interaction, although actions tend to override motives.	With practice, functional model supersedes structural model (disengagement / disorientation)	Greater sense with practice in general through a systematic progression reinforcing language through identified context
Contradictions:	Practice versus concentration, repetition version engagement, content versus context, validity versus artificiality	Usability versus applicability, static versus interactive display of support material	Open-endedness versus prescribed nature of interaction, content versus context	Range of interactivity versus interactive coherence, structured space open-endedness

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with practice, actions increasingly turn into automated operations as their execution becomes easier. In so doing, greater focus can be given to the action's goals, widening its scope in the process. The activity-action dynamics suggest that the motive of an activity is increasingly transformed into a meaningful structural model within which rational actions take place. For instance, the motive of a hypermedia activity can turn into the elaboration of finite goals such as seeking specific information, reviewing past interaction or clicking on specific links.

One of the advantages of this hierarchical approach is to provide a framework within which evaluation data can be better interpreted and processed. Thus, the following additional observations can be made to the existing evaluation from the previously mentioned evaluation results.

Judging by recorded data referring to the first activity, the activity-action dynamics were noticeable, particularly amongst the weaker students who, whilst gaining confidence with the interaction were also more likely to resort to the feedback provided to seek clues in order to facilitate their own input. In this instance, the original motive of the activity, that of learning through practice with the interactive grammar exercises, gradually turned into the action of practising itself, thus defeating the object of the activity. At a different level, the action-operation dynamics were more clearly observed amongst the more advanced students whose actions of practising with the exercises increasingly turned into automated operations and ultimately disengagement as their operational confidence led them to adopting a form of automatic pilot mode with random clicking, jumping links and exercises altogether. However, the action-operation dynamics were largely predominant in the second activity and related more to the degree of IT confidence students demonstrated than their learning involvement. It is interesting to notice that, in this particular case, the large majority of students who ventured into the grammar support in and out of exercises were generally more at ease and had more experience with computers and the web in particular. In the third case scenario or Activity Three, the activity was never felt to be strong enough to sustain meaningful actions. Therefore, the dynamic nature of the activity, across the whole spectrum of student interaction, was one which very quickly turned into simple operations, such as random clicking and scrolling, ultimately favouring mindless functionality over the development of noticeable structural models.

If the first three activities gave evidence of negative dynamics to varying degrees, in terms of use, engagement and learning process, generally leading to linearity, automation and random browsing over time, the fourth activity presented a more complex and interesting picture. Although students interacted and reacted differently to it, most did so by increasingly adopting a meaningful approach combining different actions together, such as practising with text-based interaction, multimedia supports and assessment, almost as if their unspoken structural model of the system was dynamically superseding their functional one. Remarkably, thus, the activity-action dynamics were reasserting the students' motive behind the activity. This, in turn, ensured that the action-operation dynamics were equally sustained with the appropriate implementation of specific goals, be they improving their score by going back to relevant information and interaction or attempting to know more by clicking on specific links, triggering more communicative actions between the participating students, thus encouraging them to be more pro-active when interacting within the activity. Of particular interest in this

case, the students' operations were increasingly helping them to generate actions aimed at making sense and strengthening the activity. This last point is particularly pertinent to hypermedia, setting its operational interactivity in direct contrast with most other activities, which, on the whole, will come to easier fruition and satisfactory conclusion when the action-operations dynamics lead to the scaling down of conscious operations. On the strength of the above mentioned observations, the reverse almost seems to be true for hypermedia activities as it is largely on the strength of the activity-action dynamics that the interaction really took shape and became meaningful, through actions increasingly generated by conscious-led operations.

5.4 Contradictions

According to the activity-theoretical perspective (see Nardi, 1996), contradictions are noticeable through the identification of their manifestation in the form of disturbances preventing the good running of an activity. In this respect, the identification of potential contradictions is closely linked to the development of an understanding of the activity's dynamics. This was particularly the case for the first three activities, dealt with above, whose dynamics were to a greater or lesser extent considered negative. The main disturbance or rupture (Kuutti,1996:34) noticed in the first activity of practising with interactive grammar exercises was inextricably linked to the repetitive nature of the interactive tasks and the degree of disengagement which ensued. Looking at recordings and transcripts, this translated into seeking cues from the system to speed up the process, jumping questions, feedback and exercises altogether. At a different level of interaction, another breakdown of activity was noticed when students with little ICT confidence consistently eschewed the use of grammar support when interacting with exercises for fear of disorientation. In the second activity, the most noticeable disturbance was, conversely, in the seeming lack of interactivity as perceived by the more advanced students who would have liked more reference links and generally complained about static pages and dead ends. In the third activity, which registered the worst dynamics, ruptures occurred when operations overtook actions or, in other words, when scrolling and clicking took a life of their own at the expense of exposure, reading and meaningful navigation. In the fourth and final content-based activity, a number of specific disturbances could also be noticed, although they did not seem to affect the overall dynamics of the activity. The breakdown of the fluidity of the interactivity was seen as problematic and resented by some, especially when a multimedia support, such as a map, was proposed as reference rather than as part of an interactive trail, therefore affecting the flow or praxis of actions. Another type of disturbance was also noticed at the structural level. Whereas, students were logically supposed to study or revise the grammar, practise with the exercises, get exposure and develop an interest through the selected content of the site and ultimately check their newly acquired knowledge in both, some students elected to use the material in a more anarchic fashion leading to confusion and frustration when test results were not what was expected. These are some examples of instances when the interaction did not go according to plan, highlighting the poor match between operations and intended action as well as between actions and activity. However, this hopefully will show how valuable such an identification process can be, not just in interaction design terms but also with a view to improving the

language learning approach, material used and interactivity. The following example (Figure 9), for instance, shows a UML diagrammatic representation of a random recorded user interaction by two level 2 French students during a user walkthrough session (see Hémard, 2003, 2004 for further details of evaluation). This screen-based presentation of a real user interaction, shown through a storyboard scenario approach using a Collaboration diagram can then be measured against the design model as projected by the earlier use case diagram for Activity Four: Learn by practising with content-based interactivity (Figure 8). As can be seen in this particular case, the interaction indicates an initial structured discipline through the first set of interactive exercises, which is not sustained thereafter when the students undertake to do the next set of interactive material. This could suggest that the activity has noticeable negative activity-action dynamics due to the way the interactive interface is perceived by the students. The diagram also shows that there could be a correlation between the breakdown experienced by the students and the sudden end to the session.

5.5 Framework for analysing evaluative data

On the strength of this dual object-oriented and activity theory approach to hypermedia, a framework can be devised in order to facilitate the transition from evaluation to theory, and the translation from evaluative data back to implementation. This involves cross-checking identified activities, informed by their context of use, structural and functional models as well as their dynamic representation. Whilst this is still work in progress, the following table will illustrate how such a framework, underpinned by both an object-oriented identification of activities and an activity theory approach, can be applied to existing evaluation data, thus facilitating their use and resulting exploitation.

6 Conclusion

In spite of the success of the web, with its numerous language websites, all benefiting from a recent aura of respectability bestowed upon e-learning delivery by HE institutions, hypermedia interaction in language learning is still too often flawed, poorly designed and largely relying on coercive instructed use. This paper sought to remedy some of these problems by focusing on evaluation but, more so, on better ways of approaching evaluation and exploiting its findings by dint of using a framework built on different but complementary design methods. The first one, being from the object-oriented design tradition, is seen as necessary and sufficiently intuitive to improve communication and understanding between designers and users at the macro level of structures and interaction. The second one, coming from user interface design expertise is thought to be particularly useful when looking at the interactive meaning of activities and how these evolve through user experience and the language learning process. Although activity theory does not present ready-made techniques and procedures, as previously discussed, it is argued that, in conjunction with an object-oriented approach, it offers real potential for analysing qualitative data and evaluating user engagement within the still elusive area of hypermedia for learning and online autonomous learning.

Ultimately, it is hoped that by generating greater design awareness of the dynamic nature of hypermedia interactivity, as well as facilitating its developmental

implementation, noticeable improvements can be made at the level of learner stimulation and motivation, reflective thinking and developmental learning processes.

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