Socio-cultural Perspectives on Object-oriented Learning

Ola Berge, Annita Fjuk

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Abstract. One of the central objectives of project COOL is to explore critical aspects associated with learning (and teaching) object-oriented concepts. This objective will be pursued by bringing forth the heritage of Kristen Nygaard and the Norwegian approach to object-orientation. The project will develop learning material based on this work and intends to make the material available to the object-oriented community in the form of reusable learning objects. This paper explores how social-cultural theories can inform design of learning objects and the learning environments they will be a part of.

Background

The three-year (2002-2005) interdisciplinary research project COOL (Comprehensive Object-Oriented Learning) is aimed at maintaining and further developing the Norwegian heritage from object-orientation. The project was initiated by Kristen Nygaard (C.f. Nygaard 2002), and addresses issues that provide insights into how object-oriented ways of thinking can be applied and further developed in a variety of problem areas and fields. One important aspect of this work is to explore the complex area of learning (and teaching) object-oriented concepts.

In object-oriented ways of approaching a problem area, fundamental concepts must be considered as tightly interrelated and cannot arguably be explained in isolation. Because the approach has a close logical relationship to physical worlds (with physical objects and their properties), some educational institutions find it rather trivial to design and organize qualitative learning activities (personal communication). Others, however, have proven this to be complicated activities (Kölling 1999a; b). In agreement with the latter view, we believe that it is not object-orientation in principle that cause the problems, but *the constellation of artifacts available to learn it.* In this context, artifacts are generally interpreted as ranging *from* learning material, pedagogical approaches and methods, scaffolding techniques *to* Information and Communication Technologies (ICTs). In agreement with an object-oriented philosophy, we strongly believe that the relationships between these artifacts are rather interwoven, implying that it is complicated, sometimes even impossible, to consider what artifacts that are *most critical* with respect to the learners' understanding of the object-oriented philosophy and corresponding concepts. In COOL, we will explore this complexity though an appropriate number of test cases, and further experiment with new approaches and examples that are inspired by Nygaard's emphasis on the *modeling aspect* of object-orientation.

In contrast to learning environments that simply transform organizational and pedagogical approaches from non-object oriented paradigms (C.f. project description[1]), COOL is aimed at incorporating the specific object-oriented characteristics and philosophy into innovative learning environments where ICTs have mediating positions. This objective is grounded in a number of case studies on net-based and ICT-mediated learning environments (Fjuk 1998; Fjuk & Ludvigsen 2001) that conclude that an ICT-mediated learning environment is a product of complex interconnections between several aspects, such as: theories of learning and instruction, subject domains, delivery institution's educational practice and tradition, organizational and administrative arrangements, properties of ICT and available software, etc. The problem area of past research within this field is, however, that they mirror a partial thinking with respect to these aspects. Such approaches though do not provide directions for designing learning environments that are relying on its' own specific conditions.

Outlined from earlier studies, we argue that *blended learning environments* are promising with respect to learning complex problem areas and subject matters. Blended learning is a fairly new term (Kahn & Linquist 2002), but the concept has been around for decades in areas like distance education (Holmberg 1995). As practiced in distance education, the blend is described through supplemented use of classroom and assistance of technology (in a wide sense, i.e., ranging from letter correspondence to advanced ICTs) (Smith 2001). In the context of COOL, the core concern is to *utilize* the specific conditions manifested in a *combination* of available ICTs, pedagogical approaches, didactical techniques and various learning resources so as to offer the students meaningful environments for knowledge construction.

In line with Nygaard's vision of producing didactical modules that should be made available across institutional traditions, courses and ICT solutions, COOL aims at designing and organizing the learning content in terms of *digital* and *reusable learning objects*. This paper gives priority to this latter issue, and discusses the potential of using *socio-cultural* theories to understand and design the format of the learning objects. Concerning the specific content, this is discussed elsewhere (C.f. Groven, Hegna & Smørdal 2003).

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[1] http://heim.ifi.uio.no/~kristen/FORSKNINGSDOK_MAPPE/F_COOL1.html

The next section gives a short introduction to the concept reusable learning objects and the standardization initiatives currently taking place in the e-learning industry. The underlying pedagogical approach is discussed in relation to the approach taken in COOL. This is followed by a presentation on socio-cultural perspectives - which is the theoretical foundations for the work described in this paper - and how these perspectives can be used for understanding design of reusable learning objects incorporated into learning environments resting on its own conditions.

Reusable learning objects

The fundamental idea behind the area concerning reusable learning objects (RLOs) is to break a larger block of electronic learning content into smaller pieces. Two of the main benefits of this modular approach are the easy updating of content, by swapping in new objects for outdated ones, and the ability to reuse content by using learning objects within other object-based content (Edmonds & Barron 2002). This is a concept familiar to practitioners of object-oriented programmers, and Wiley states "*Learning objects are elements of a new type of computer-based instruction grounded in the object-oriented paradigm of computer science*" (Wiley 2000). We do not find it apparent that there is a strong relation between learning objects and object-orientation as we know it in computer science. Discussion of this issue, however, is out of scope for this paper.

A learning object is constituted by the learning content and a set of metadata describing the content. The content can be any element usually associated with multimedia content: text, graphics, animation, sound, movie, or a combination of these. There is no generally accepted definition of a RLO. For example, NETg [1] defines it by three components that must be present: the object must have a measurable objective, it must have an activity that exactly matches this objective, and it must have an assessment. Wiley defines a learning object as "any digital resource that can be reused to support learning" (Wiley 2000). Some equate a RLO to a single graphic or video file, others equate a RLO to a small piece of instruction that targets a specific performance goal (Nichani 2001).

Reusable Learning Objects are at the core of the standardization processes that are currently carried out in the e-learning community. These processes are represented by initiatives such as Instructional Management Systems Project [2] from IMS Global Learning Consortium, the EU project ARIADNE [3], AICC [4] from the aviation industry, the Advanced Distributed Learning Initiative [5] initiated by the American Department of Defense, PROMETEUS [6], an open initiative supported by EU, or the work done in sub-committee 36 of ISO /IEC JCT1 [7] and the IEEE Learning Technology Standards Committee [8]. Generally, these initiatives focus on three main issues:

- **Metadata descriptions**: Definition of bibliographical data, keywords describing subject matter, target groups, learning objectives, level of difficulty, etc.
- **Content structures**: Recognizable structures are perceived as a prerequisite for interchange of content between various Learning Management Systems. One example of such a structure is found in SCORM, which is constituted by the three levels *Asset*, S*harable Content Object* (SCO), and *Block*. An *Asset* is the basic element of content, such as a section of text or an illustration. An SCO contains two or more *Assets*. A *Block* is a hierarchical representation of several SCOs (or other *Blocks*). By the help of a Content Structure Format one can aggregate the learning content into a comprehensive unit such as a course, a module in a topic, etc.
- **Interoperability**: Standardization to ensure that content and other data such as log data and status information to be exchanged and shared by separate Learning (Content) Management Systems.

By standardizing the format of the modules, or learning objects, the learning material becomes more robust with respect to *changes* in underlying infrastructure, and one makes interoperability across various Learning Management Systems (LMS) or Learning Content Management Systems (LCMS), courses, ICTs, etc. Generally, the purpose of a LMS is to simplify the administration of learning/training programs within an organization by improved delivery and tracking of content. A LCMS combines the administrative and management dimensions of a traditional LMS with functionality from Content Management Systems (Edmonds & Barron 2002).

The use of RLOs is regarded as an adequate approach, as a standardized approach to development of RLOs aspires to providing learning material that can be reused across various ICT-platforms, educational institutions, courses, L(C) MS', etc. There are, however, some problematic issues that need to be addressed before such an undertaking can be accomplished.

The standardization initiatives seem to be anchored (more or less consciously) in a cognitivistic perspective on learning. In this view, learning "*becomes the process by which the problem solver acquires a proper representation on a problem space. Instruction, then, consists of activities designed to facilitate the acquisition*

of such representation by the learner" (Koschmann 1996, p. 7) and the redemption of missing or incorrect knowledge. One indication of this underlying perspective on learning is the emphasis on tests and mechanisms to express prerequisites for accessing a learning object. Another is the assumption that a learning material belongs to a course (or a similar structure). The cognitivist perspective on learning tend to rely on a pre-defined syllabus and regard the learning material as the primary – if not sole – means for knowledge construction. Applied in design of learning objects, the objective becomes to integrate well-defined plans for what to do when, ended by a test for measuring the effectiveness of the content (Hoel 2003).

Typically the e-learning industry targets learning situations where the learning objective is related to skill acquisition, for example how to operate a Xerox machine or how to configure a network router. These are quite different from the learning situation students of object-oriented concepts are facing. In project COOL, we seek to explore the potential of using socio-cultural perspectives as guiding framework for understanding and designing learning environments directed towards this particular subject domain and its characteristics.

Socio-cultural perspectives and directions for designs

Socio-cultural perspectives (Vygotsky 1978; Cole 1996; Wertsch 1998; Leont'ev 1978; Engeström 1987; Cole & Engeström 1993) constitute rich frameworks for studying different forms of practices as developmental processes, with individual and social issues interlinked at the same time (Kuutti 1996).

Vygotsky (1978) was among the first to recognize the importance of the societal dimension in the educative process. He therefore sought to define those aspects of social engagement that concern the development of mental processing (McMahon & O'Neill, 1992). A key issue in his research is that intellectual development takes place on two levels. First it appears on a social level, through *interpersonal* processes. Then it appears on an individual level through *intrapersonal* processes. In COOL context, social interactions are understood in a variety of ways, - ranging *from* collaboration between peers *to* problem solving under guidance of a tutor or a more capable peer. Kristen Nygaard emphasized that object-orientation represents a philosophy in which the principle multiperspective reflection - the consideration of the phenomena from many different perspectives - is essential. We argue that collaboratively oriented learning approaches are particularly well suited for organizing this principle and negotiation of opposed alternatives and meanings (Fjuk & Dirckinck-Holmfeld 1997).

It is the interwoven relationship between artefacts, activities and human development that make socio cultural theories so powerful with respect to design of learning environments where various ICTs have central positions. Through their studies of past research, Fjuk & Ludvigsen (2001) conclude that the tendency is that the activities mediated by ICT constitute a unit of analysis themselves, rather than additional and interconnected aspects that are manifested in the ICT environment. Socio-cultural analysis[2] expands the unit of analysis beyond the context of one given activity system, but as a complex mix of various interconnected activity systems (Fjuk & Ludvigsen 2001). In an activity system there are potential *contradictions* or tensions between all components of the systems (Engeström 1987). Contradictions are used to indicate 'misfit' within elements of an activity, and between different developmental phases of a single activity. Contradictions manifest themselves as problems, breakdowns, clashes, etc., within the system itself or in relation to other systems (Kuutti 1996). An individual learner's actions will be affected by three major factors: the tools used, the environment she/he belongs to and its explicitly or implicitly expressed rules and, the division of labor within that community. When the unit of analysis expands to the interaction between different activity systems, the complexity that we are dealing with increases.

Used in COOL, socio-cultural analysis provides the following important issues, illustrated in Figure 1: The learner's activities directed towards construction of knowledge on object-orientation is mediated by a constellation of artifacts, including a variety of ICTs and learning objects. The learner's relationship to the blended learning environment is mediated by certain didactical principles and scaffolding techniques as well as predefined pedagogical approaches. Furthermore, the learner's commitment to the learning environment is also mediated by the roles embedded in the social interactions (e.g., the power each yields, tasks each is responsible for, etc.).

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[2] Parts of the text used in this section, is first presented and discussed in Fjuk & Ludvigsen (2001).
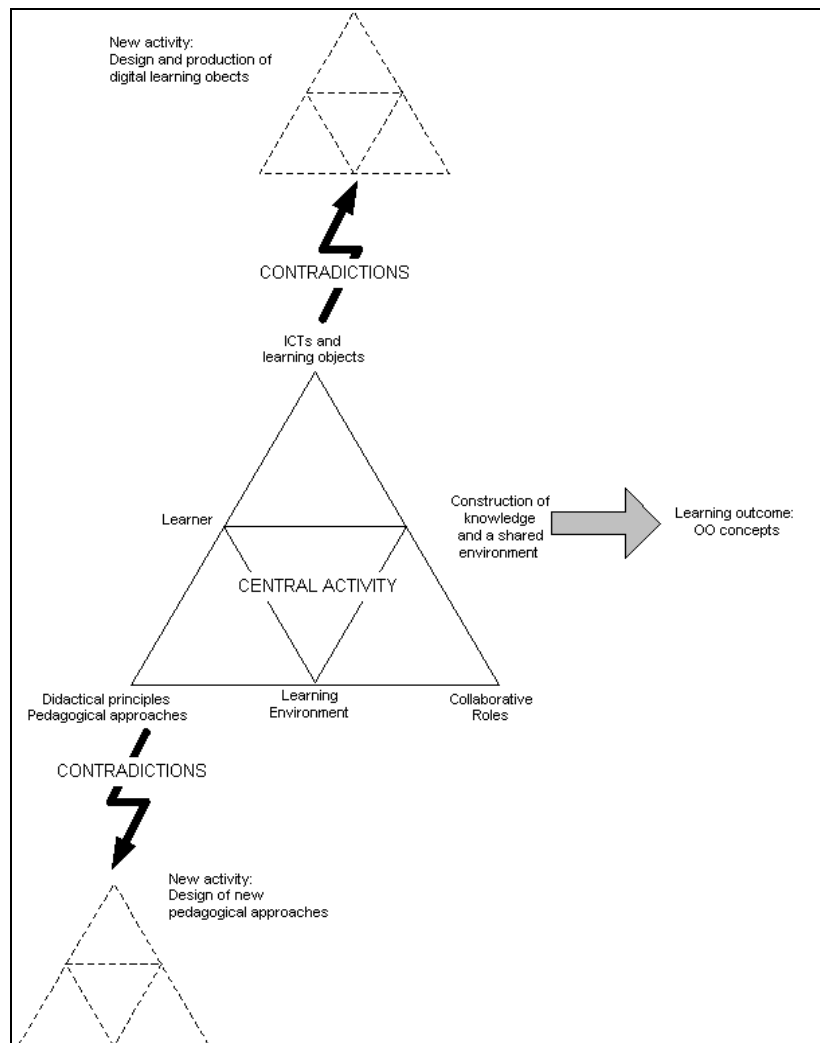
Figure 1: Activity system[3]

Important aspects to consider are contradictions that manifest themselves in a practice of introducing digital learning objects. The figure illustrates the importance of looking for possible contradictions that manifest themselves through application of traditional didactical principles and pedagogical approaches (for example anchored in a non-objective paradigm and/or in traditional face-to-face situations). Based on past research (Fjuk 1998), we argue that new approaches that incorporate the specific conditions of the new learning situations are a critical activity.

Furthermore, socio-cultural analysis provides with a consciousness on considering the role of the artefacts used. An artefact has a two-sided, but mutually dependent, role: 1.) as the mediator of the communicative aspect of an action, that is, the way knowledge is constructed about the phenomenon of question, and 2) the chosen tools that mediate the operational aspect of the same action. Let us illustrate this issue with a well-known example: A word processing program is the operational means for the individual act of writing, and writing is a communicative means for reflection and interpersonal interactions. The outcome of the action is framed by the embedded conditions of the artefact (Leont'ev 1978).

Considering digital learning objects as artefacts, the theoretical position provides guidelines for considering contradictions associated with the following research- and design areas: How should the constellation of learning objects be designed with respect to the duality between the communicative and the operational aspect of human actions? First, this implies how the content should be presented to support knowledge construction. Second, it implies the conditions metadata and standardization put on the content and how it is presented. One central question is if the dominating standards and standard proposals are applicable for learning objects designed for use in learning situations based on a socio-cultural perspective on learning. Closely connected to these issues, is:

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[3] The figure is inspired by (Engeström 1987).

How and to *what* extent should the pedagogical approaches be incorporated into the designs? It is clear that learning situations based on the cognitivist perspective are different from those based on the socio-cultural perspective. This difference has a profound impact on the design of learning environments, but it is not obvious that this is true for design of the learning material. The role of the learning material is different in the two traditions, but does it follow that they should be designed differently? This means considerations on whether the designs should incorporate the pedagogical philosophy and as such, direct the use of the learning objects. Furthermore, it also means a consideration on an opposite approach, i.e., to focus on the object-oriented content and leave the pedagogical philosophy to the organizational design. In this way, the focus of the research become to study one particular constellation of learning objects and exploring its effects within various pedagogical approaches and institutional constraints.

Concluding Remarks

This paper applies a socio-cultural perspective on the area of learning object-oriented concepts. We have raised a number of issues concerning design of learning objects and learning environments for knowledge construction in this field. Project COOL explores these issues by studying current practices as well as by experimenting with new constellations of artifacts. Early activities include the development of courses that introduces learners and practitioners to fundamental object-oriented concepts through approaches such as "models first" and "objects first". The courses will be developed evolutionary, where experience from the first courses, planned to be held in Oslo in the summer of 2003, will provide insights for further improvement of the subsequent activities.

The socio-cultural perspectives give directions for design of how tools (e.g. KarelJ or BlueJ) and other ICTs should be incorporated in the learning activity. Concerning the latter, it challenges how existing and new learning material should be implemented as learning objects in ICT-based learning environments. Last, but not least, it provides guidelines for how to understand the meaning of social interaction with respect to learning.

About the Authors

Annita Fjuk is Dr. Scient in Informatics, from University of Oslo, and is currently employed by Telenor R&D and Intermedia, University of Oslo. She is project leader of COOL. Her research interests are particularly directed towards design of ICT-based learning environments, an area she has worked in since the late 80'ies. Socio-cultural perspectives and activity theory have had an important position in her work.

Ola Berge is a PhD student at Intermedia, University of Oslo (funded by the COOL project). His primary research interest is on reusable learning objects in learning situations based on a constructivistic approach. Ola Berge has worked with ICT and learning since 1997, most recently as a research scientist at Telenor R & D.

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