A pedagogical approach to the design of Learning Objects

Emanuela Busetti, Giuliana Dettori, Paola Forcheri, Maria Grazia Ierardi

A pedagogical approach to the design of Learning Objects

E. Busetti[1], **G. Dettori**[2], **P. Forcheri**[*,1] and **M.G. Ierardi**[1]

[1] IMATI CNR, Via De Marini 6, 16149 Genova, Italy
[2] ITD CNR, Via De Marini 6, 16149 Genova, Italy

In this paper we describe an approach to the design of learning objects (LOs) suitable to support learning in complex domains at university level. Our proposal is centred on a costructivist approach where learning is viewed as resulting from personal activity and comparison with the activity of others. Our pedagogical approach to knowledge acquisition and to the use of technological tools is realized by means of didactical units which can be implemented as Learning Objects (LOs) with a variety of structures and aims. In this framework, we address the issue of supporting students' learning in ways that differ according to the requirements of each situation. Based on an analysis of the literature, we devise possible types of support that students may need in different learning situations and show how they can be realized by means of our pedagogically-oriented LOs.

Keywords Learning objects; pedagogical approach; scaffolding; coaching; modelling.

1. Introduction

In an active approach to learning, oriented to the acquisition of non-trivial knowledge, to the solution of complex problems and to the development of self-regulation abilities [1-4], students build new knowledge based on their previous one, by means of personal reflection and social interaction [5-7]. In this framework, an important role for the teacher consists in supporting the students through this process, increasing their motivation, promoting initiative and control, guiding them in the process of knowledge exploration and organizing the use of tools that ease this process. Following this theoretical characterization, learning is seen as developing from activities of three different kinds, that is, individual, teacher-guided, and in collaboration with peers. Technology can play a meaningful role in all kinds of activities by offering non-trivial working tools and individually adaptable hypermedia learning materials, easing communication and collaboration with peers, supporting self-assessment, as well as by performing some functions which were traditionally of teachers, such as scaffolding and problem posing.

The increased possibilities of effectively implementing such an active and articulated approach to learning, due to the current development of ICT, turns out very useful when the object of study are complex domains, as for instance mechatronics education at university level. The design of robot control, as a matter of fact, requires a particularly strict integration between methodological and operational competence. Actual work on the real tools is crucial for suitable learning in this field, and the use of simple simulation programs can not be sufficient. For economical reasons, however, labs with different equipment are spread across several universities. This motivates the need to develop tele-presence environments, including the development of a rich and articulated range of abilities, such as technical, instrumental and methodological competence, meta-cognitive and self-regulatory abilities, as well as relational abilities so to be able to perform collaborative work on complex tasks [8].

In order to meet the needs of this application, we designed an educational framework where Learning Objects (LOs) are the central tool used to keep a strict connection among theoretical, methodological and operational competence. This is obtained by defining a typology of LOs. In a previous paper [9] we detailed the characteristics of these LOs, together with the different kinds of tools that we devised as necessary to integrate their correct and effective functioning. In this paper we concentrate on the issue of suitably supporting students' learning in ways that differ according to the competence of the students and the characteristics of the tasks addressed. Based on an analysis of the literature, we point out different

[*] Corresponding author: e-mail: forcheri@ge.imati.cnr.it

types of support that students may need in different learning situations and show how they can be realized by means of our pedagogically-oriented LOs.

2. Pedagogically-oriented LOs

In order to model and implement a view of learning apt to cope with the requirements of complex domains, we devised a variety of LOs and tools [9], so as to reflect the articulated organization of educational materials and activities that experienced teachers usually employ in their work. This correspondence is shown in Fig.1.

This gave rise to defining LOs of two different types, that is, Structured LOs and Functional LOs, together with a set of working tools with different aims (such as communication, manipulation, object sharing), necessary to develop the various phases of learning. The first class, i.e. Structured LOs, corresponds to the educational modules teachers usually build to address some topic, and constitutes the backbone of the students' activity. These LOs can take different forms according to the pedagogical approach they embody. The second class, i.e. Functional LOs, includes support materials of different kinds that teachers generally use as reference material to complement their lessons.

Structured LOs are articulated in:

- Guided LOs, devoted to introduce some topic under teacher's guidance, and suitable for leading inexperienced students in the initial exploration of some new topic;
- Problem LOs, leaving students space to use their ability and creativity on topics where they already have some experience;
- Mixed LOs, based on a combination of these two types.

Functional LOs, on the other hand, contain complementary material, such as glossary, templates, presentations, guidelines for the analysis of results, etc., and are articulated into sub-classes named after their function, i.e., Glossary-LO, Template-LO, Tutorial LO, etc. They can be context-dependent or context independent according to their application range.

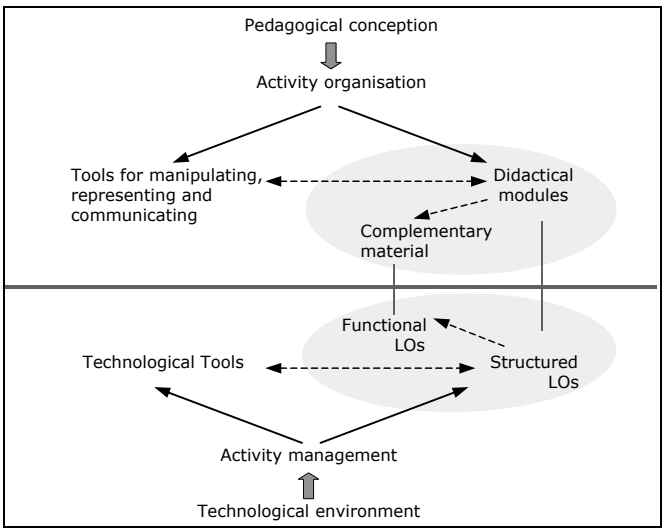

Fig. 1 Correspondence between our pedagogical conception and the technological environment designed

3. Supporting the learning process

From a theoretical point of view, speaking of educational support to the learning process refers to the interactions that take place within an educational context and give rise to learning. It is sometimes called "scaffolding", with an overloaded term which can be used to refer both to support in general and to a particular kind of it, as specified in section 3.3. The term scaffolding was first introduced within the

constructivist framework in order to metaphorically represent effective interactions [10]. The idea of scaffolding is related to Vygotsky's studies on the "zone of proximal development", which is the area of learning where students are not able to proceed by themselves but can do it under expert's guidance [7]. Distinctions within this concepts were later introduced, emphasizing different points of view on the supporting activity and consequent differences in the didactical planning, as described below.

3.1 Modelling

The term *Modelling* refers to the kind of support that guides the students to acquire expert behaviour in problem solving. In this case, attention is focused on the analysis of expert's results, on what knowledge they use, on what cognitive and meta-cognitive processes they carry out during a problem solving activity. Modelling includes the analysis of meaningful cases, and implements an approach to educational support which is problem-oriented and guided by the teacher.

A particularly interesting aspect of modelling is the study of strategies apt to support the user in the development of expert reasoning models, and consequently the definition of Structured LOs guiding this kind of activity. The didactical aim of LOs implementing modelling is thus to lead students to spot and reflect on the differences between how they tackle problems and how teachers do.

3.2 Coaching

The term *Coaching* refers to the teacher's activity supporting students' efforts to solve some task. In this case, the emphasis is on students' work. Here, the teacher follows and regulates students' activity, by analysing it and providing feedback and suggestions. This kind of support, hence, develops during the activity and entails a high degree of interaction between students and teacher. It is not necessarily limited to class activity, though, since distance communication tools, such as e-mail, CMC platforms or videoconferences can be used to allow coaching in ICT-based environments.

In our pedagogically-oriented framework, coaching is realized by structured LOs entailing a direct intervention of the teacher or containing links to Functional LOs and communication tools.

3.3 Scaffolding

The term *Scaffolding* refers to any incentive or help, adapted to the student's ability level, intentionally given in order to help a student to perform some task [11]. In this case, the focus is mainly on knowledge to be acquired and tasks to be tackled, taking into consideration the systemic factors that may affect performance. A distinctive characteristic of scaffolding is to decrease over the time and finally disappear. It can include also some activities which are typical of modelling and coaching, provided they are implemented so as to progressively decrease while the learners acquire the ability to work on their own.

From the point of view of application, scaffolding can be subdivided into categories taking into account the requirements of the educational situation at hand [12, 13]. It is hence possible to talk of motivational, procedural, cognitive, meta-cognitive and strategic scaffolding. In our pedagogical approach, it can be realized through the interaction among student, teacher and peers, mediated by Structured LOs.

4. Choosing the right kind of support

It is clear that none of the mentioned types of support can be considered the best one for any case, since each of them have potentialities which make it more or less suitable in different educational situations. They should, hence, not be considered as opposite choices, but combined and integrated, even within a same activity. Figure 2 shows, as example, a guided LO focused on modelling expert reasoning, which makes use of the three mentioned kinds of support in different phases of the proposed activity.

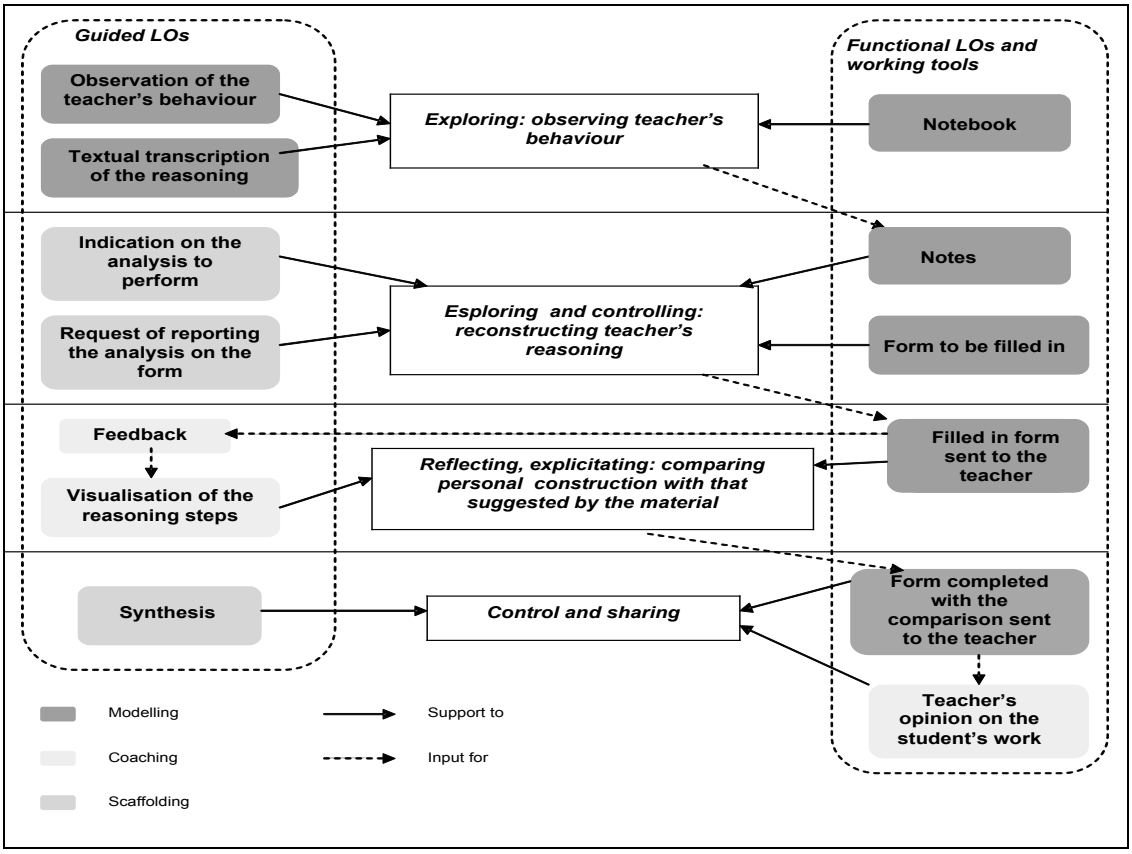

Fig. 2 Use of different kinds of support within a Guided LO

Creating an effective support is, in general, a complex task [14]. It is clearly difficult, as a matter of fact, to find a balance between the current development point of students and possible achievements. In order to effectively lead to actual learning, moreover, the support given should evolve over the time to follow the changes of the learning needs [15, 16], but unfortunately it is not easy to devise and implement rules to guide such evolution. Nevertheless, we can propose some general criteria apt to express at least partially the ever changing nature of an effective educational support, pointing out, for each of them, what kinds of LOs and tools of our pedagogical framework can be used for that end:

Develop a pedagogical approach integrating teacher-guided work with autonomous one, by gradually mixing activities of these two kinds, based on the development reached by the students in the considered topic. This kind of activities can by realized by means of Mixed LOs.

Include in an educational path moments in which personal activity comes before the analysis of the activity of others. This kind of activity, which aims at letting students try to figure out on their own individual ways to tackle problems, instead of replicating solving approaches of others, can be realized by asking them to hand in their results before accessing educational materials, such as:

- Best-cases worked out by peers, when the assignment consists in solving a problem or working out a project.
- Syntheses and overall considerations of the teacher, when the assignment consists in analysing some problem situation.
- Argued evaluation made by teacher's or peers', when the assignment is a self-evaluation task.

Allow students to get help from peers who are possibly on-line.

Use evaluation as an occasion of learning, including the possibility for the students to hand in a second time their work after a first evaluation, making use of the knowledge gained from the evaluation received and from examples of best cases.

Include the use of adaptable tools, apt to grant different kind of support based on the actions made with them. For instance, a collection of Frequently Asked Questions can be used as

coaching, if students use them to get the answers to implicit or explicit questions;

cognitive scaffolding, if students use them to rapidly refer to known procedures and methods which are functional to a task they are working on;

meta-cognitive scaffolding, if teachers ask their students to organize and update them.

Acknowledgements The work has been partially supported by the Italian Ministry of Education, University and Research , FIRB Research Project 'TIGER-Telepresence Instant Groupware for Higher Education in Robotics' and Project VICE- Virtual Communities for Education.

References

[1] Ausubel, D. (1963). The Psychology of Meaningful Verbal Learning, New York: Grune & Stratton

[2] Bruner, J. (1966). Toward a Theory of Instruction. Cambridge, MA: Harvard University Press

[3] Novak, J.D. (2002). "Meaningful learning: The essential factor for conceptual change in limited or inappropriate propositional hierarchies leading to empowerment of learners", Science Education, 86 (4): 548-571

[4] Piaget, J. (1976). The grasp of consciousness, Harvard University Press

[5] Dillenbourgh, P. (ed.) (1999). Collaborative Learning - Cognitive and Computational Approaches, Oxford U.K.: Elsevier Science Ltd.

[6] Jonassen, D.H & Land, S.M. ed. (2000). Theoretical Foundations of Learning Environments, Erlbaum Associates: New Jersey

[7] Vygotsky, L.S. (1978). Mind in Society. Cambridge, MA: Harvard University Press

[8] Fabri D., Falsetti C., Ramazzotti S., Leo T., (2004). Robot control designer education on the Web Robotics and Automation, 2004. Proceedings. ICRA '04. 2004 IEEE International Conference on, Robotics and automation, New Orleans,(USA), Apr. 2004, Volume: 2, Pages:1364 – 1369.

[9] E. Busetti, G. Dettori, P. Forcheri, M. G. Ierardi (2005). "Devising a typology of LOs based on pedagogical assumptions". In Advances in Web-Based Learning - ICWL 2005, Rynson Lau et al (Eds), Lecture Notes in Computer Science, Berlin: Springer Verlag, (in press).

[10] Wood, D., Bruner, J., & Ross, G. (1976). The role of tutoring in problem solving. Journal of child psychology and psychiatry, 17, 89-100

[11] Jonassen, D.H., Mayes T. & McAleese R. (1993), A manifesto for a constructivist approach to technology in higher education, in Duffy T., Lowyck J. & Jonassen D. (eds), Design environments for constructivist learning, Springer Verlag

[12] Winnips, J. C., McLoughlin, C. (2001). Six learner supports you can build. in C. Montgomerie & J. Viteli (eds), Proceedings of ED Media 2001: World Conference on Educational Multimedia, Hypermedia and Telecommunications, AACE, 2062–2068.

[13] Reiser B. J. (2004). Scaffolding Complex Learning: The Mechanisms of Structuring and Problematizing Student Work, Journal of the Learning Sciences, 13 (3) 273-304

[14] Rasku-Puttonen E., Eteläpelto A., Arvaja M., Häkkinen P. (2003) Is successful scaffolding an illusion? – Shifting patterns of responsibility and control in teacher-student interaction during a long-term learning project, Instructional Science, 31 (6)

[15] Fretz E. B.; Wu H-K., Zhang B., Davis E.A.; Krajcik J. S., Soloway E. (2002) An Investigation of Software Scaffolds Supporting Modeling Practices, Research in Science Education 32 (4), 567-589

[16] Masters J., Yelland N. (2002), Teacher Scaffolding: An Exploration of Exemplary Practice, Education and Information Technologies 7 (4) 313-321