

Devising a Typology of LOs Based on Pedagogical Assumptions

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Abstract. In this paper, we outline the pedagogical assumptions that underlie the design of a distributed web-based environment, presently under development, devoted to robotics education at university level. We briefly discuss, from an educational point of view, the approach followed to implement these assumptions. In particular, we focus our attention on the methodological choices underlying the design of the Learning Objects (LOs) to be used as didactical materials in the environment. These have been conceived so as to meet the complex requirements of the learning subject considered, and to model the didactical proposal based on a constructive view of the learning process.

1 Introduction

Educational technology offers new possibilities to education, since it puts at learner's disposal complex resources, including several which can be used at a distance. An interesting example of such remote applications is offered by robotics education. In this field, as a matter of fact, most universities put at students' disposal a laboratory where only experiments on some specific class of robots can be carried out. The possibility of sharing such resources at a distance allows students to avail themselves not only of simulation tools which are available in other universities, but also of the very robots located elsewhere, by means of tele-presence.

Exploiting this possibility is the basic idea of the TIGER (Telepresence Intant Groupware for higher Education in Robotics) project, which aims at building a web-based environment to operatively access robot labs distributed in several Italian Universities, hence providing for the students an educational context which transforms the potential of technology into a real opportunity to build up knowledge and experience.

The considered application field is very complex, and is characterized by the need to keep a particularly strict connection between theoretical knowledge and methodological competence necessary for the use of robotic laboratories [6]. Moreover, students need to develop good abilities of self-regulated work, and become able to fully avail themselves of the use of virtual environments on the web. To this end, we worked out the structure of an educational framework where Learning Objects (LOs) [3, 4, 9] are the central tool which keeps a strict connection among

theoretical, methodological and operational competence. This is obtained by defining a typology of LOs, apt to meet the variety of requirements which characterize education on robot control.

With our contribution, we aim to propose an approach to the design of educational environments which combine the learning object paradigm with the current pedagogical view of teaching in complex fields.

2 Educational Framework

From a pedagogical point of view, our proposal is based mainly on a constructivist approach to knowledge, where learning is viewed as resulting from personal activity and comparison with the activity of others. We briefly remind here that the constructivist approach relies on active learning, oriented to the acquisition of non-trivial knowledge and skills, to the solution of complex problems, to the focus on constructing knowledge rather than transmitting it, and to the development of self-regulation abilities [1, 2, 10]. In this view, new knowledge is built up, based on the previously acquired one, by means of personal reflection and social interaction, by analysing and combining experiences, by abstracting concepts and consciously applying them to the solution of new problems [5, 12]. Moreover, tools need to be provided and activities suggested, so as to help the learners develop meta-cognitive abilities, that is, awareness and regulation of cognition (which includes planning, monitoring and self-evaluation of learning) [7, 8]. Our view of learning, hence, is essentially learner-centred. Nevertheless, we think that teachers have an important role to play in it, introducing concepts and guiding their deepening, posing problems, organising the overall activity, coaching, monitoring, scaffolding, assessing and keeping up student's motivation. The picture which emerges from this characterization spots learning as developing from activities of three different kinds, that is, individual, teacher-guided, and in collaboration with peers. In this framework, technology can play a meaningful role in every component, 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 educational framework which arises from this articulated pedagogical view is summarised in Figure 1.

3 Implementing the Educational Framework

The TIGER project is developed within the general framework of current education at university level, in particular as concerns robotics education. The design of robot control requires a particularly strict integration between methodological and operational competence, as can be obtained by a learning-by-doing approach. The situation is, however, made particularly difficult by the fact that robots are delicate and expensive devices and students need to undergo a suitable preparation with exploratory activities on recognition of the environment's features before they can materially access the real tools. Moreover, for economical reasons, labs with different

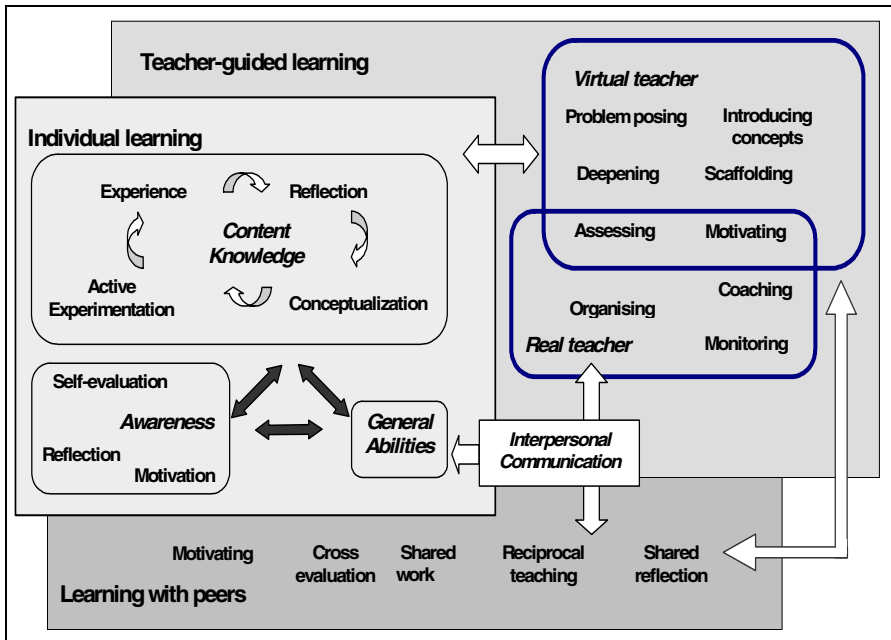


Fig. 1. Educational framework defined by our pedagogical view

equipment are spread across several universities. On the other hand, the physical availability of the laboratories is crucial for suitable learning of robot control, and hence the use of simple simulation programs can not be sufficient. This motivated 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, relational abilities so to be able to perform collaborative work on complex tasks [6].

Hence, in order to face the complexity of the considered educational situation, we decided to let the TIGER project put at user's disposal a variety of resources apt to help students to take initiative and control of their own learning, as well as to encourage them to interact with their peers and with the tutor. Moreover, we organised and structured the students' work by integrating individual activity with learning guided by the teacher and learning in collaboration, as well as by fostering the acquisition of abilities of autonomous learning. To this end, we devised tools and functions which could be apt to implement this process, and worked out a suitable organization for the educational materials by defining a typology of Learning Objects.

3.1 Devising Tools and Functions

We started from observing that a complex educational activity, though based on an overall design made by the teacher, leaves the students wide space of autonomous choice and conscious reflection on the work to be carried out. This entails that students should be in condition to take autonomous decisions on their work, as well as planning and controlling its development. In their activity, students need to be

supported in the acquisition of cognitive, meta-cognitive, collaboration and self-regulation abilities [13]. Moreover, they should be allowed to access the system’s functionalities from different points of view, so to be in condition to shape their own learning paths according to individual learning needs, and easily understand how to do so. Figures 2 and 3 show which tools and functions we selected to support and ease the educational activity and how they conceptually relate, pointing out, in particular, which belong to the planning and control phase and which to the development one.

As concerns the development phase, initially, student’s activity develops around some structured LOs proposed by the teacher, gradually enriched by including other learning material produced by the students themselves. The production of these new LOs requires the support of general-purpose tools such as notebooks, evaluation forms, shared working spaces, manipulation and simulation tools (Figure 2).

As concerns the control and planning phase, we included materials to plan content selection, to acquire awareness on the work to be done and on one’s own abilities, to support the recall of basic knowledge, to stimulate individual deepening, and to limit the difficulties connected with the use of the TIGER environment. We included also communication tools and facilities to obtain different points of view on content knowledge (Figure 3).

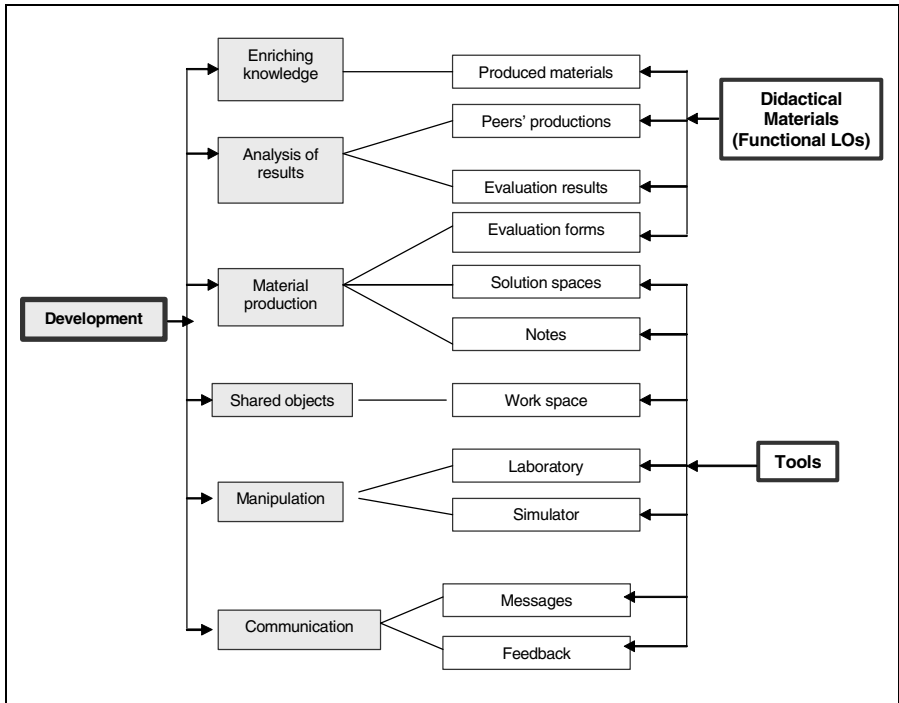


Fig. 2. Examples of tools and functional learning materials for the development of activity

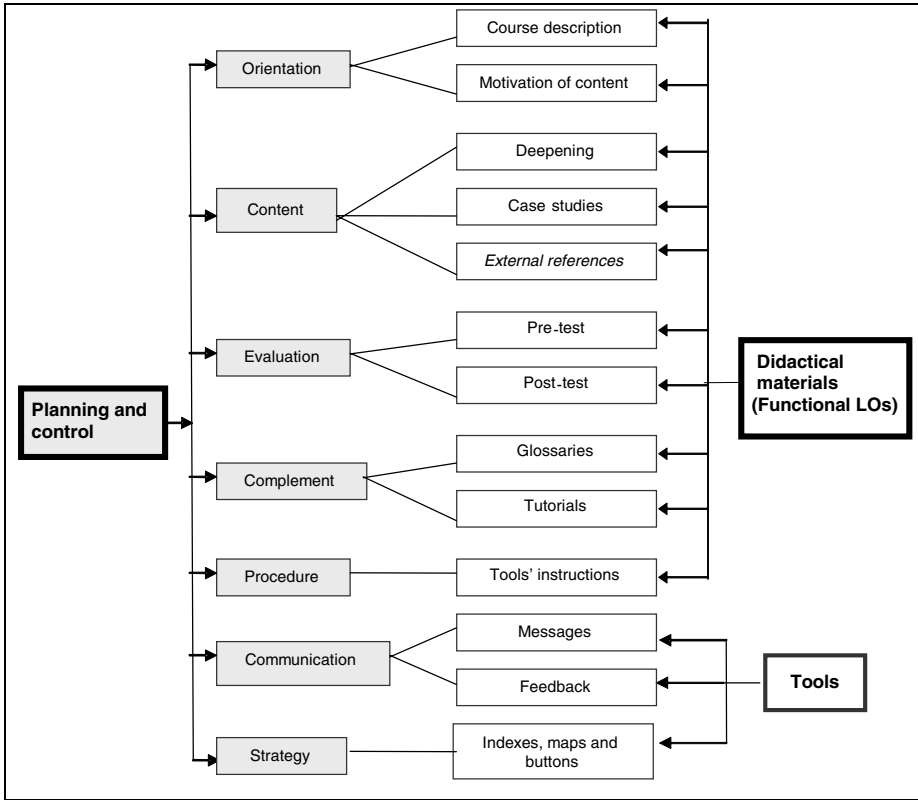


Fig. 3. Examples of tools and functional materials for planning and controlling of activity

4 Structuring the Didactical Activity

4.1 Educational Modules as Initiators of Constructive Learning Processes

Based on the educational framework outlined, we oriented our designing effort by considering Learning Objects from a teacher's point of view. We started from observing the behaviour of a teacher who designs some educational activity. Starting point of this process is devising an overall learning experience, based on previous educational work, as well as on new contents to be learnt and abilities to be acquired. Then, the teacher organises the overall path in a number of educational modules, each focused on addressing a specific topic, either theoretically or by means of some activity. These modules are actually initiators of learning experiences. Thus, they include a specific educational objective, and a pedagogical approach to it. They also make use of general-purpose complementary material, aiming to possibly give different orientations to the learning process they plan. They organise the use of tools so to be functional to the work development and to suggest the interactions among the actors of the educational experience. Following our pedagogical framework, each didactical module include or refer to a combination of the following resources:

- Individual or group activities;
- Simulation tools or actual access to the laboratory;
- Tools which are meaningful in relation with the module's content, so as to support collaboration, reflection and evaluation of the experience (notebook, portfolio, qualitative and quantitative evaluation forms filled in by teacher, peers and the student him/herself, etc.);
- Materials to support the development of activities (outlines of activities, proposed exercises, theoretical material, methodological indications, examples, guide to the use of the laboratory, suggestions of tools to use, etc.);
- Reports on experiences made by peers, if the teacher considers it suitable to make them available, as well as possibly existing materials related with the tools used, such as journal papers, web site of industries producing the tools, glossaries and notes of use);
- Assessment and self-assessment material;
- A pre-test aiming to help the students understand if they are prepared to tackle the module under consideration.

Each module includes a description of the work to be done, motivates its introduction, guides the student to acquire specific skills, encourages the development of self-regulation abilities.

4.2 From Educational Modules to Structured LOs

Learning modules are realized by means of LOs, designed so to structure and guide an articulated educational activity. We designed these LOs, which embody the modules, so that they can, in turn, make use of, or refer to, other LOs, with a different structure, corresponding to materials necessary to carry out the proposed activities. This organization implies having at disposal LOs of different types, depending on the characteristics of the educational modules they embody: 1) *Structured LOs*, based on a precise educational objective, characterized by a type which determines their structure and didactical function. 2) *Functional LOs*, which do not include a specific pedagogical orientation but have a general-purpose or context-related function. These correspond to auxiliary modules.

These two types of LOs are, in turn, divided into different subtypes, according to their structure and function. The hierarchy resulting from this characterization of LOs is represented in Fig. 4.

Functional LOs can take different types, according to the kind and function of their content. We distinguish, in particular, two general types, that is: 1) context-dependent ones, containing material which is relevant only in connection with some particular module; these include presentations, assessment modules, etc.; 2) general-purpose ones, whose content may be relevant for any module of a whole, articulated course; such as glossaries, templates, etc.. These two types of Functional LOs, in turn, are subdivided into several subtypes, according to their specific function. Hence, we give to each of them names such as *Glossary LO*, *Presentation LO*, *Template LO*, *Assessment LO*, etc.

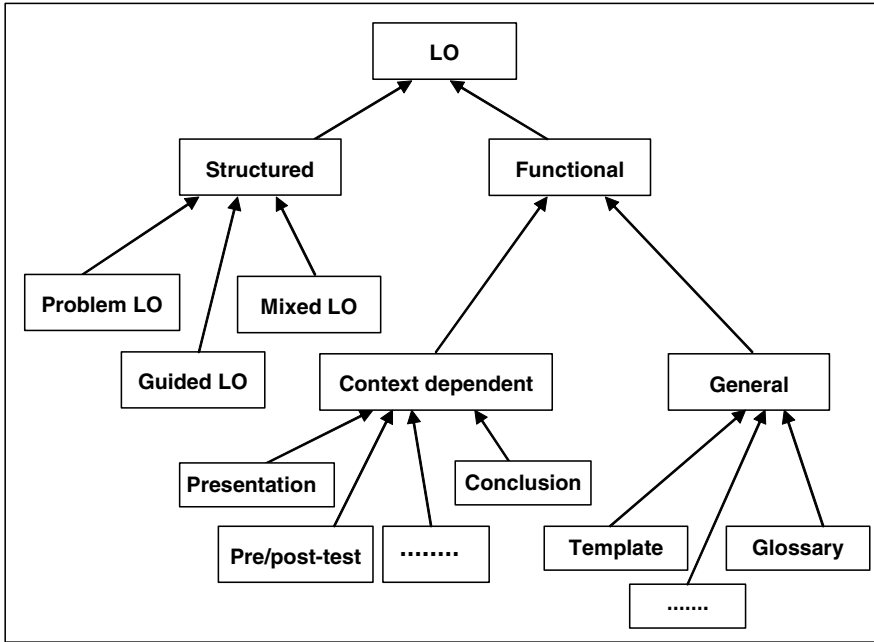


Fig. 4. Types of LOs devised in our proposal

Also *Structured LOs* can take different forms, depending on the objective of the correspondent modules. As a teacher can decide to apply a different educational approach in different phases of the overall learning path, based on the specific requirements of the situation (which depend on the students' competence and maturation level, and partially also on the nature of the topic addressed), we can devise different kinds of didactical modules. This possible diversification of modules led us to introduce a characterization of *Structured LOs* with different didactical aims, as shown in Fig. 5. We describe here briefly the three types we consider necessary for our purposes:

1. *Modules guided by the teacher.* In this case, the control of the activity, which initially relies mostly on the teacher, gradually passes to the students while they develop some abilities. Such modules aim to introduce content knowledge or some basic approach to problem solving. In this case, teaching and learning are very structured, though still based on the performing of activities. We call *Guided LOs* the correspondent of such modules.
2. *Modules oriented to autonomous exploration, where the control is strongly demanded to the student (or group of students).* In this case, a problem situation is proposed. The module includes groups of questions leading the students towards activities necessary to solve the given problem, as well as materials and tools relevant with respect to the task assigned. Here the evolution of learning can not be completely planned *a priori*, nor can it easily be evaluated with traditional methods. This approach is suitable for students who have already

acquired a basic preparation. It aims to develop high level cognitive abilities, as well as to support metacognition and autonomous learning. We call *Problem LOs* the correspondents of such modules.

3. *Modules based on a mixed approach, combining teacher guidance and autonomous exploration.* These can be formed by the combination of more than one LO of the previous two types. They correspond to *Mixed LOs*.

We wish to remark that both a *Problem LO* or a *Guided LO* may be suitably applied to support the learning of a same topic, but with different pedagogical aims, as illustrated by the examples in the next section.

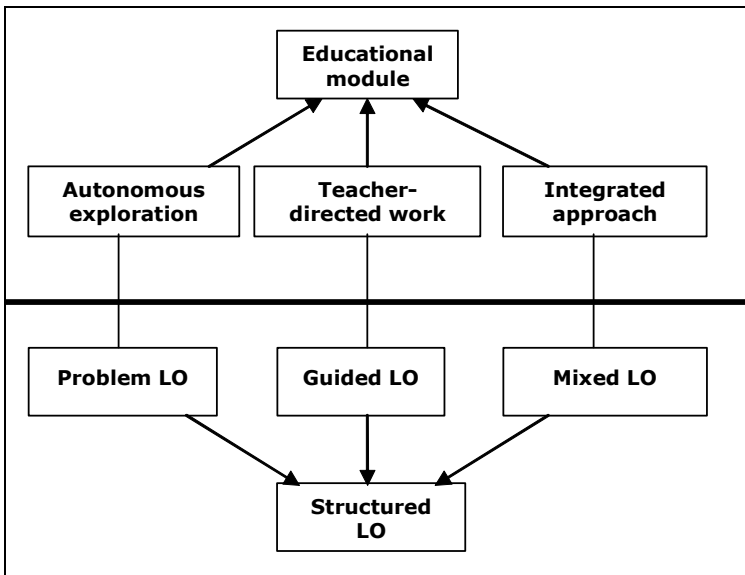


Fig. 5. Correspondence between different types of educational modules and LOs

4.3 Examples of Structured LOs

Guided LOs and *Problem LOs* can be used to tackle a same problem by applying different pedagogical approaches, which could be required by the characteristics of some educational situations. Let us see, for example, a meaningful problem among those considered within the TIGER environment, that is, how to analyse the unexpected behaviour of a robot.

To acquire this ability, it is necessary that students learn to analyse conceptually and understand several problem situations; they must learn to reflect on the variables of the problems and on the elements of the context that may influence their behaviour, on what tests should be carried out to verify such influence, on the order to follow when performing such tests. The complexity of this task depends on the characteristics

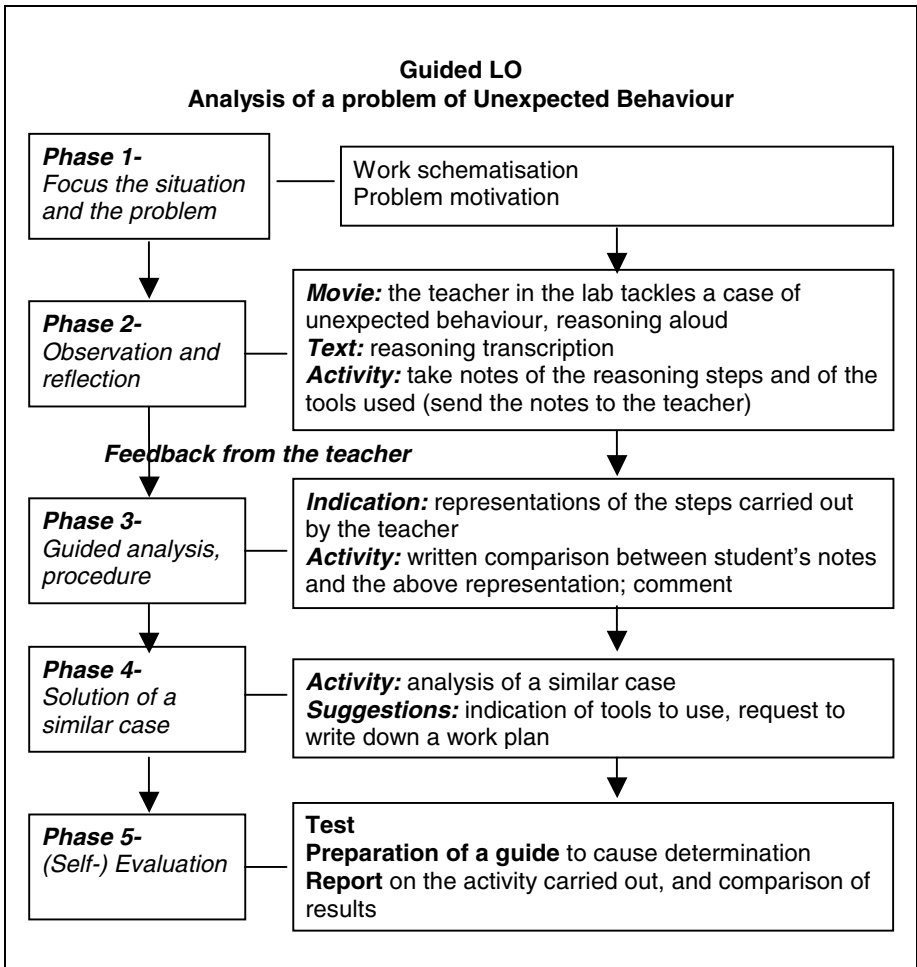


Fig. 6. The structure of a Guided LO for the “Unexpected behaviour” problem

of the problem at hand. This motivates the need to have LOs of different kinds on this topic, so to assist the students during the subsequent phases of their learning.

If the students are at the beginning of their work in this field, and have no practical experience, teacher’s guidance is necessary, to help them learn *by examples* how experts reason on this kind of problems; hence, we will make use of a *Guided LO*, like the one sketched in Fig. 6. We note that in this case the activity is articulated into 5 phases. First the teacher (real or virtual) gives a general idea of the situation and motivates the problem [11]. The second phase is still characterized by a central presence of the teacher, who shows how to reason to find the cause of the problem so to tackle it effectively; the focus is on developing analytical abilities, not on the acquisition of some procedure, since it is obviously not possible to figure out a priori all the possible causes of unexpected behaviour. The students start to become active

by recording the reasoning steps exemplified. A feedback from the teacher at this point aims to check if the students are approaching the task in the correct way. In the next step, the students are asked to analyse deeply the procedure applied, so to make sure they understand correctly all important steps, still supported by comments of the teacher. In the fourth phase, they are requested to solve (conceptually) by themselves a similar case and to sketch a work plan. Finally, they need to self evaluate their work, before being evaluated by the teacher. The self-evaluation phase, in particular, is very important for the students to improve their meta-cognitive abilities (which include awareness of what they know and don't know). This is an important pre-requisite for them to be in condition to proceed in their learning path.

In Fig. 7, on the other hand, we show the structure of a *Problem LO* on the same topic. Here the activity consists of only 3 phases, where the central and most important one must be carried out essentially autonomously.

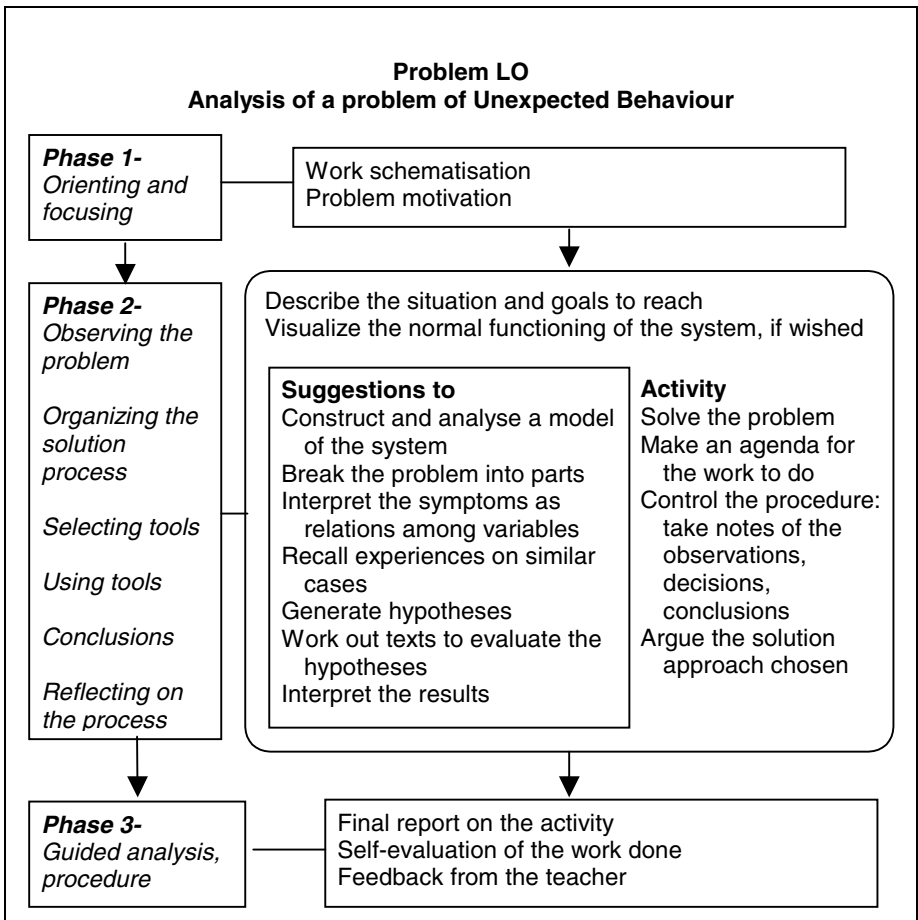


Fig. 7. The structure of a Problem LO for the “Unexpected behaviour” problem

The initial phase still consists in a focus on the situation considered, analogously to what happens in the previous example. The second phase points out the goals to be reached and offers the possibility to visualize the normal functioning of the observed robot. It gives also suggestions on what tools could be chosen and how they should be used to solve the problem, as well as recalls on how to organize the work from a conceptual point of view. Finally, a phase of self-evaluation and formal evaluation concludes the module.

5 Conclusion

LOs are currently considered a valuable tool to support web-based learning, since it allows to efficiently build courses at reasonable cost. However, there are a number of problems to solve in order to exploit this opportunity efficiently, mainly concerning the pedagogical aspects [4].

In order to overcome these problems, we propose a vision of LOs which models a teacher's behaviour while planning an educational activity. When we model this activity with a (structured) LO, we endow the LO with the same pedagogical approach of the correspondent didactical proposal.

Our approach, which is currently adopted within the TIGER project, has several advantages from the educational point of view:

- it gives an operative tool to help the teacher gain familiarity with the concept of LO;
- it enriches the expressive power of LOs by representing not only learning materials but also pedagogical approaches;
- it gives the possibility to shape templates based on different pedagogical approaches, hence providing materials which are easier to re-use in different educational situations rather than ready-to-use proposals;
- it gives indications on a possible approach to create LOs of constructive kind, hence capturing the essential nature of the didactical process, which is constantly in evolution.

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