# Modelling an eLearning environment for learning programming languages

Ricardo Queirós[1] and José Paulo Leal[2],

[1] CRACS & DI-ESEIG/IPP, Porto, Portugal
ricardo.queiros@eu.ipp.pt
[2] CRACS & DCC-FCUP, University of Porto, Portugal
zp@dcc.fc.up.pt

## Introduction

It is widely accepted that solving programming exercises is fundamental to learn how to program. Nevertheless, solving exercises is only effective if students receive an assessment on their work. An exercise solved wrong will consolidate a false belief, and without feedback many students will not be able to overcome their difficulties. However, creating, managing and accessing a large number of exercises, covering all the points in the curricula of a programming course, in classes with large number of students, can be a daunting task without the appropriated tools working in unison. This involves a diversity of tools, from the environments where programs are coded, to automatic program evaluators providing feedback on the attempts of students, passing through the authoring, management and sequencing of programming exercises as learning objects. We believe that the integration of these tools will have a great impact in acquiring programming skills.

Our research objective is to manage and coordinate a network of eLearning systems where students can solve computer programming exercises. Networks of this kind include systems such as learning management systems (LMS), evaluation engines (EE), learning objects repositories (LOR) and exercise resolution environments (ERE).

Our strategy to achieve the interoperability among these tools is based on a shared definition of programming exercise as a Learning Object (LO).

## Programming Exercises as Learning Objects

The concept of Learning Object (LO) is crucial for the standardization on eLearning [1]. The latest standard for LOs is the IMS Common Cartridge (IMS CC) [2]. An IMS CC learning object assembles resources and metadata described by a manifest. We developed an XML dialect called **PExIL**, standing for **Programming Exercises Interoperability Language**. The aim of PExIL is to consolidate in a single document all the data required in the programming exercise life-cycle, from when it is created to when it is graded, covering also the resolution, the evaluation and the feedback. PExIL documents can be used for authoring LOs containing programming exercises.

The generation of an LO is based on a valid PExIL instance as depicted in Figure 1. The Generator tool uses as input a solution file and produces automatically several resources (e.g. exercise description, test cases and feedback files) described by a valid IMS CC manifest and wrapped up inside a ZIP file.

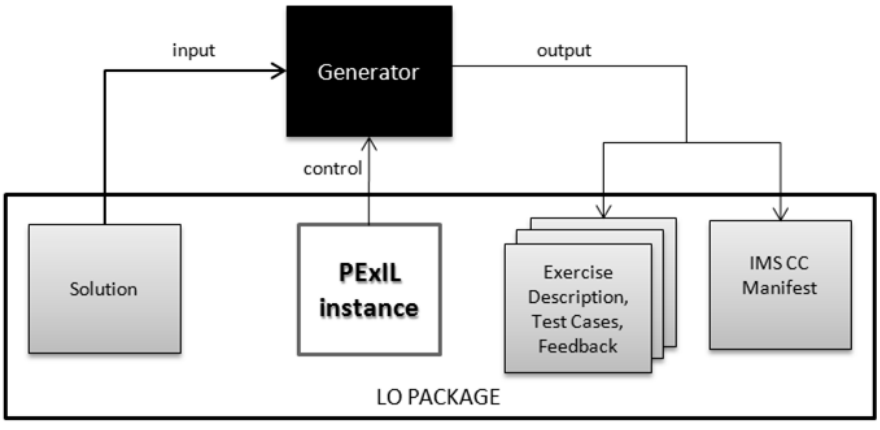


Figure 1 – Structure of a programming exercise as a LO

Nevertheless, the impact of PExIL is not confined to authoring since these documents are included in the LO itself and they contain data that can be used in its life-cycle, to present the exercise description in different formats, to regenerate test cases or even to produce feedback to the student.

## Environment for learning programming languages

The previous LO definition will be used in a learning process regarding the automatic evaluation of programming exercises. The evaluation of programming exercises involves the following types of services:

**Learning Management System** - to manage and retrieve the exercises to the learners. We chose the Moodle LMS since it is a free and open-source LMS with a significant share on the LMS market [3];
**Learning Objects Repository** - to persist LOs and related meta-information. We developed a specialized repository named crimsonHex [4] which currently stores more than 2000 programming exercises;
**Evaluation engine** - to evaluate and produce feedback on the learners' attempts to solve the exercise. We will use the Mooshak system as the evaluation engine based on a shared service [5];
**Exercises Resolution Environment** – to code the attempts of solving an exercise. We will use the Eclipse IDE since it is a free, widely used and open-source solution.

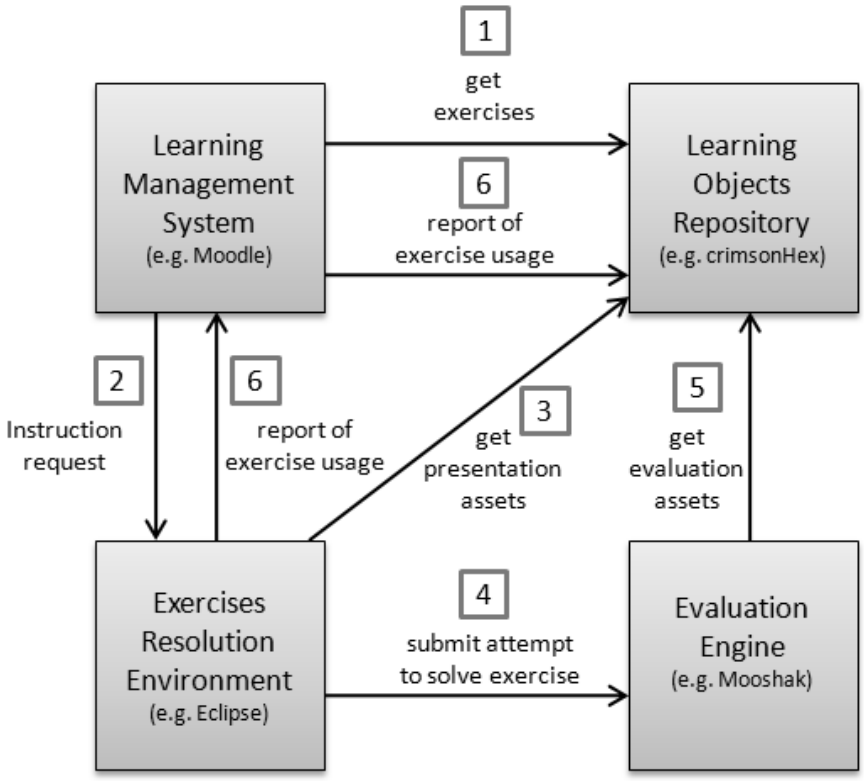


Figure 2 – Service integration in a pedagogical learning process [4]

Figure 2 shows the integration of these services in a pedagogical learning process. In this particular scenario the teacher starts by setting a number of activities in the LMS, including the resolution of programming exercises. To select the relevant programming exercises the teacher 1) searches for relevant exercises in the repository. Then, the learner 2) tries to solve the exercises set be the teacher using an Experimentation Environment (e.g. Eclipse IDE). The IDE 3) recovers exercises descriptions from the repository showing them to the student. After coding the program the learner 4) send an attempt to the Evaluation Engine. The Evaluation Engine 5) recovers test cases from the repository. The learner may submit repeatedly, integrating the feedback received from the Evaluation Engine. In the end, the Evaluation Engine 6) sends a grade to the LMS that records it and reports the LO usage data back to the repository.

## Future Work

We are currently finishing the development of the generator engine to produce a LO compliant with the IMS CC specification. The generator uses the PExIL definition to produce a set of resources related with a programming exercise such as exercise descriptions in multiple languages, input and output test files, feedback and a manifest file used to describe the programming exercise as a whole. This tool could be used as an IDE plug-in or through command line based on a valid PExIL instance.


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[3] Davis, B., Carmean, C. and Wagner, E.D. (2009). The Evolution of the LMS: From Management to Learning - Deep Analysis of Trends Shaping the Future of eLearning, Sage Road Solutions, LLC.

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