

Wollok: language + IDE for a gentle and industry-aware introduction to OOP

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Abstract—Students often have difficulties in learning how to program in an object-oriented style. One of the causes of this problem is that object-oriented languages require the programmer to be familiarized with a big amount of non-trivial concepts, to write even the simplest programs. For several years we have been teaching introductory OOP courses using an *incremental learning path*, which starts with a simplified OOP model consisting only of objects, messages and references. We observed that the use of programming languages and tools that differ greatly from those used in the IT industry weakens student interest, and also hampers the application of the learned concepts and techniques in subsequent labor experiences.

In this work we describe Wollok, which encompasses both an educative language and a specialized integrated development environment (IDE) conceived for learning OOP in a way that supports our pedagogical approach, and facilitates at the same time the transition to industrial environments. Equally important, we describe our teaching experience with these tools and the motivations for their design.

I. INTRODUCTION

Teaching how to program has revealed itself a difficult task [4], [16]. We have individualized three specific aspects present in many initial programming courses that hinder the learning process: a complex programming language, the need of introducing too many concepts to produce a first working program, and a programming environment not conceived for the specific needs of an initial student [15].

There have been several proposals to address the difficulties in introductory OO courses. Some of them define a specific language which provides a simplified programming model such as Karel++ [9] and Mama [7]; others even provide a whole programming environment specifically designed to aid novice programmers such as Squeak [3], Traffic [13] and BlueJ [8]. The great differences between these programming languages and environments show that they have to be analysed in the light of the pedagogical approaches behind them. The tools are of little use without their respective pedagogical view.

Previous works from our team [2], [1], [6], [12] have described a novel path to introduce OO concepts focusing first on objects, messages and polymorphism while delaying the introduction of classes and inheritance. A reduced and graphical programming environment supports this path, allowing to build OO programs without the need of classes. This environment is an adaptation of the syntax and class browser of Pharo Smalltalk. After introducing classes, the course switched to the standard Pharo development tools.

This way of organizing a course provides a more gentle learning curve to students, so that they can write completely working programs from the first course weeks.

While this approach proved to be successful in providing the students with a more profound knowledge of OOP at the same time as raising pass rates, we feel that there is still room for improvement in three areas: (a) the difference between the experience in the classroom and the reality in (most) professional environments, both in the language as in the development tools. (b) the gap between the simplified and the classical programming models, mostly because of the differences among the development tools (c) the adherence to a preexistent, general-purpose language that limited pedagogical decisions.

As a result, we decided to conceive both a programming language and an accompanying development environment that closely follow the pedagogical approach we advocate for an initial OOP course. The main goal of this paper is to describe Wollok¹, the tool we created that reunites language and environment.

Wollok combines some characteristics that are typically present in academical environments with others that are more easily seen in industrial ones. Its most noticeable characteristics are: (1) the possibility of using self-defined objects to support an introduction to the topic that postpones the introduction of the concept of class, (2) the possibility of combining self-defined with class-based code objects in the same program, (3) the decision of offering an IDE with edition and code management capabilities that are fine-tuned for unexperienced programmers and (4) that both the language as the IDE share similarities with their industrial counterparts, in order to soften the later transition to the professional tools.

II. WHY WOLLOK?

One cause behind the difficulties in learning OOP is the use of industrial languages, which require the student to understand several concepts before being able to run his first program [11]. Figure 1 shows an example of a possible first program, written in Java [10]. To get this program running, the student has to walk through a minefield of complex concepts:

¹ <http://www.wollok.org/>. Source code and documentation can be found in Github (<https://github.com/uqbar-project/wollok>). Wollok is open-source and distributed under LGPLv3 License (<http://www.gnu.org/copyleft/lgpl.html>).

packages, classes, scoping, types, arrays, printing to standard output and class methods; just to have a first object and send a message to it.

```
package examples;

public class Accumulator {
    private int total = 0;

    public int getCurrentTotal() { return total; }
    public void add(amount) { total += amount; }

    public static void main(String[] args) {
        Accumulator accum = new Accumulator();
        accum.add(2);
        accum.add(5);
        accum.add(8);
        System.out.println(accum.getCurrentTotal());
    }
}
```

Fig. 1. Sample initial Java program which diverts student attention from the most important concepts.

Courses tend to spend too much time concentrated on the details of programming constructs of a specific language, leaving too little time to become fluent on the distinctive characteristics of OOP. Moreover, frequently the students do not have proper tools that could help them to overcome all the obstacles. Hence we advocate the use of a pedagogically conceived programming language that allows to build simple programs from a *minimum* of concepts, along with a programming environment specifically tailored for the needs of novice programmers.

We have also detected that sometimes, students who seem to understand the main concepts and can apply them in interesting ways to create medium to complex program have a hard time translating this knowledge to their professional activity. We think that bringing the activities in the course as close as possible to professional practice could help mitigate this problem. For that matter, we aim to incorporate industrial practices such as unit tests, adapting them to the possibilities of students with little or no programming experience.

Wollok is designed to give support to our pedagogical approach: it allows to define both classes and standalone objects, includes an industrial-like, simplified IDE, and provides a simple syntax to define unit tests as well as a graphical interface to run them.

While neither the language itself nor the programming environment contain novel features that are unseen in industrial tools, the assemblage of selected features, each one carefully selected due to its educational value, is not found in other previous programming environments, neither educational nor industrial. Therefore, the distinctive characteristic of our solution is the search for a programming toolset which (a) supports our pedagogical approach, (b) feeds the student with a set of tools which are adequate to his current knowledge and (c) gently prepares him to be using industrial-level tools. This approach constitutes a novel way of dealing with the problems of OOP teaching.

A big amount of effort in our research has been put in looking for solutions that can solve the apparent controversy between the objectives (b) and (c). Often, the rich set of tools an industrial language or programming environment offers cannot be exploited by an inexperienced programmer or even worst they confuse the inexperienced student. On the other hand, we think that poor programming environments fail to help students to make their first steps in programming, which in turn trims the possibilities of introductory courses. Therefore, there is much to gain from a language that has the exact features a teacher desires to teach and a programming environment which provides the exact tools a student can take advantage of at each time of his learning process.

III. THE WOLLOK LANGUAGE

Wollok is a brand new languages built to specifically give support to our pedagogical approach [2], [1]. Wollok provides an extremely simple programming model which allows the students to create programs containing objects, messages and polymorphism without the need for more abstract concepts such as classes, inheritance or type annotations. Later in the course, Wollok allows the incremental introduction of more abstract concepts, providing a smooth transition into a full-fledged OO programming model.

The example in figure 2 shows an example first program in a Wollok-based OO introductory course. Syntax has been reduced to a minimum and the basic constructs of the language match exactly the concepts we want to transmit, *e.g.*, `var` is used to define variables and `method` is used to define methods. The accumulator object is defined as a stand-alone (*i.e.*, it has no visible class), automatically instantiated and *well-known* (*i.e.*, globally accesible) object (WKO).

```
object accumulator {
    var total = 0
    var evens = 0

    method getCurrentTotal() { return total }
    method add(amount) {
        total += amount
        if (amount % 2 == 0) { evens += 1 }
    }
    method evenCount() { return evens }
}
```

Fig. 2. Sample initial Wollok object definition.

The first tool we introduce to try out a program is a *read-eval-print-loop* (REPL). Running a program in the REPL brings all defined objects to life and allows the user to interact with them sending messages, as shown in Fig. 3. The REPL handles all I/O and the student is only required to send the desired messages to a *domain object*.

In this way, we avoid the discussion of I/O related features at the beginning of a course, and in particular, the introduction of a habit (namely, the use of a poor I/O mechanism as `System.out`) that should be *unlearned* later on.

Shortly after in the course, we introduce unit testing which slowly replaces the REPL as the main form of interacting with objects. Figure 4 shows a sample test for the previous program.

```

Wollok REPL Console
Wollok interactive console (type "quit" to quit):
>>> accumulator.add(2)
>>> accumulator.add(5)
>>> accumulator.add(8)
>>> accumulator.getCurrentTotal()
15
>>> |

```

Fig. 3. Sample usage of the accumulator object in the REPL

```

import accumulator.*

test "adding 2+5+8 should give 15" {
  accumulator.add(2)
  accumulator.add(5)
  accumulator.add(8)
  assert.equals(15, accumulator.getCurrentTotal())
}

test "accumulator starts with 0" {
  assert.equals(0, accumulator.getCurrentTotal())
}

```

Fig. 4. Sample test Wollok program.

Again, Wollok is fine-tuned for our pedagogical objectives. In particular, the test runner guarantees that there is no interaction between tests: the messages sent to the accumulator in the first test will not affect the state of the accumulator in the second test.

Furthermore, tests have to be written in a separate file. A simple form of the **import** directive allows to refer to the objects (and later on, classes) defined in other files. In this way, some basic knowledge of modularization is subtly introduced early in the course².

Another simple feature that is very helpful in the initial steps of the course is the presence of literals for lists (e.g., [1,2,3]) and sets (e.g., #{1,2,3}). This allows us to use collections and, therefore, increase the complexity of examples that we can build before introducing classes. We even briefly introduce *closures* at the initial stage of the course. For example, our accumulator object can be implemented as shown in Fig. 5.

```

object listBasedAccumulator {
  var history = []

  method getCurrentTotal() {
    return history.sum()
  }
  method add(amount) { history.add(amount) }
  method evenCount() {
    return history.count({n => n % 2 == 0})
  }
}

```

Fig. 5. Another accumulator implementation, using a list.

Next in the course, we introduce classes. Once more, Wollok helps us in the transition: any pre-existent stand-alone object can be converted into a class by just chang-

²The assimilation of the **import** directive, as early as in the second week, was not problematic in our experience using Wollok for first-year programming courses.

ing the keyword object for class in the first line³. E.g., changing object `listBasedAccumulator` by class `ListBasedAccumulator` makes the code shown in Fig. 5 to turn into a class definition.

Figure 6 shows how the three previous definitions of accumulator can be used polymorphically. Also, it shows the usage of more advanced list messages and closures⁴. A special mention has to be made about the fact that stand-alone objects are used in the same program and even they are polymorphic with class-based objects.

```

import accumulator.*

test "adding 2+5+8 should give 15" {
  const accumulators = [
    accumulator,
    listBasedAccumulator,
    new ListBasedAccumulator()
  ]

  accumulators.forEach { accum =>
    accum.add(2)
    accum.add(5)
    accum.add(8)
    assert.equals(15, accum.getCurrentTotal())
  }
}

```

Fig. 6. Simple polymorphism example.

IV. A CUSTOMIZED PROGRAMMING ENVIRONMENT

The features that influence the experience of the learning programmer are not limited to the programming language used. The *tools* used to write, analyse and evaluate the code have a paramount relevance for this experience, and therefore for the success of the programming courses.

We decided to embed the Wollok language in an integrated programming environment, whose features are designed having in mind the specific needs of novice programmers. The visual appearance and graphic structure of the Wollok IDE are similar to those of several Eclipse distributions. In turn, the set of tools it provides is, mostly, the result of a selection from the broader collection standard to mainstream industrial IDEs like Eclipse, Visual Studio or the Idea series, and a subsequent adaptation of some features to enhance their value to early course attendants. In this way, we aim to make both the programming experience more appealing to the students, and the transition to later courses and work environments softer; while giving adequate support to the learning process through the same tools.

In addition, we decided to include two tools which are not bundled in standard industrial IDE distributions. One of these is the REPL that we already described in Section III. The other is the automatic generation of *static diagrams*, cfr. Fig. 7, that are highly customizable in terms of which elements

³As a matter of fact, we will also change the name, as our code convention mandates lowercase names for objects and uppercase names for classes

⁴In our approach, we introduce polymorphism and closures *before* classes. For reasons of space we skipped those intermediate examples here.

(classes/objects, methods, attributes) include, and also their spatial distribution.

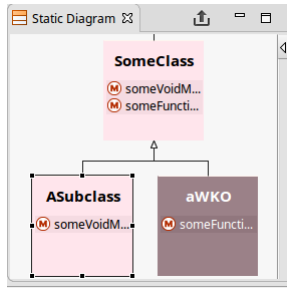


Fig. 7. Static diagram.

We briefly mention some standard features bundled in the IDE:

- A powerful **code editor**, with syntax highlighting, proper indentation, and automatic insertion of closing delimiters. The editor offers also smart *content assist* in several situations, e.g. `super` and `self` sends and messages to be sent to a WKO.
- Automatic **detection of errors and warnings** integrated into the IDE, focused on situations that novice programming tend to experience. Some examples: unused or never-assigned variables, instantiation of abstract classes, absence of matching methods for messages sent to WKOs, `super` and `self` sends. In some cases, automatic fixes are suggested.
- Visual **test runner** for the tests that are part of Wollok syntax, described in Section III.

V. EXPERIENCE AND PERSPECTIVES

Several hundreds of students have been used Wollok in courses along several universities of the Buenos Aires metropolitan area, since 2015. In this experience, both the language and the IDE have successfully supported the incremental learning path described in Section II. The combination of the minimal syntax required to define a WKO, the quick interaction that the REPL enables, and the features included in the editor, allows to greatly shorten the time needed by a standard student to get her first object definitions work, right from the first lab session.

We also remark that: (a) The transition from WKOs to classes was remarkably smooth. (b) Students get used to write unit tests from the first course weeks. (c) The tools and features bundled in the IDE effectively empower students, helping them to avoid simple syntax errors, and to quickly discover other potential sources of problems.

In turn, the experience of some students in a later course in which Java is introduced, suggests that the industrial-like appearance of the IDE and the language syntax ease the transition into work-like environments. Hence the use of Wollok in the first course seems to promote the effective use of the basic concepts and techniques learned there, in their successive experiences.

The main focuses of attention for the Wollok IDE development team are the detection of programming errors and bad practices, and the provision of quick fixes, content assistance and refactorings. A cornerstone to achieve these goals is the *type inferer*, which is one of our current main objectives. Still, providing a type inferer for a language such as Wollok has many subtleties, which deserve an independent study [14]. Also, we plan to include an *effect system* [5].

On the other hand, in our opinion *teamwork* should be a subject covered in programming courses from as early as possible. We note that the success of object-oriented languages is partly due to their advantages in group projects. Hence we plan to give support to teamwork in Wollok, by adding a simplified interface to *code repositories* like Git or SVN.

There are also initiatives to build *Web-based* or lighter versions of the IDE and the interpreter, in order to broaden the availability of Wollok.

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