UNIVERSIDAD
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# UNCode: Interactive System For Learning and Automatic Evaluation of Computer Programming Skills

**Felipe Restrepo-Calle**, **J.J. Ramírez Echeverry**, **F. A. González**
Universidad Nacional de Colombia

**PLaS Research Group**
***Programming Languages and Systems***
Contact: ferestrepoca@unal.edu.co

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# Outline

1. Introduction
2. Previous experience
3. UNCode
4. Results: qualitative comparison to other tools
5. Conclusions

# Introduction

## Motivation


Required skill for engineering students

**However:**

Learning programming is not easy:

- use concepts learned in class
- study and practice out of class

Evaluating programming assignments is not easy:

- Time-consuming
- Consider: syntax, semantics, efficiency, and maintainability

(Carter et al., 2003; Ala-Mutka, 2005)

**ICT support tools**

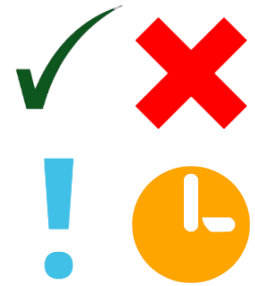
# Introduction

## Related Works

(Keuning, et al., 2016)

### ICT support tools for programming education

#### Automatic assessment

Source Code → Online Judge (Test Cases) → 

Ihantola et al. 2010
Caiza and Álamo, 2013
Guerreiro et al. 2006
Fernandez, 2011
Luo et al, 2008
Wang et al, 2016

- **Summative feedback**
- **Lack of formative feedback**

#### Learning environments

- Simple: Logo and Scratch
- Learning by examples
- Visualizations and animations
- Simulation environments
- Intelligent tutoring systems

Guzdial, 2003
Gomez, 2005
Le et al, 2013
Nesbit et al., 2015

- **Formative feedback**
- **Lack of summative feedback**

# Introduction

## Problem Identification

Automatic assessment

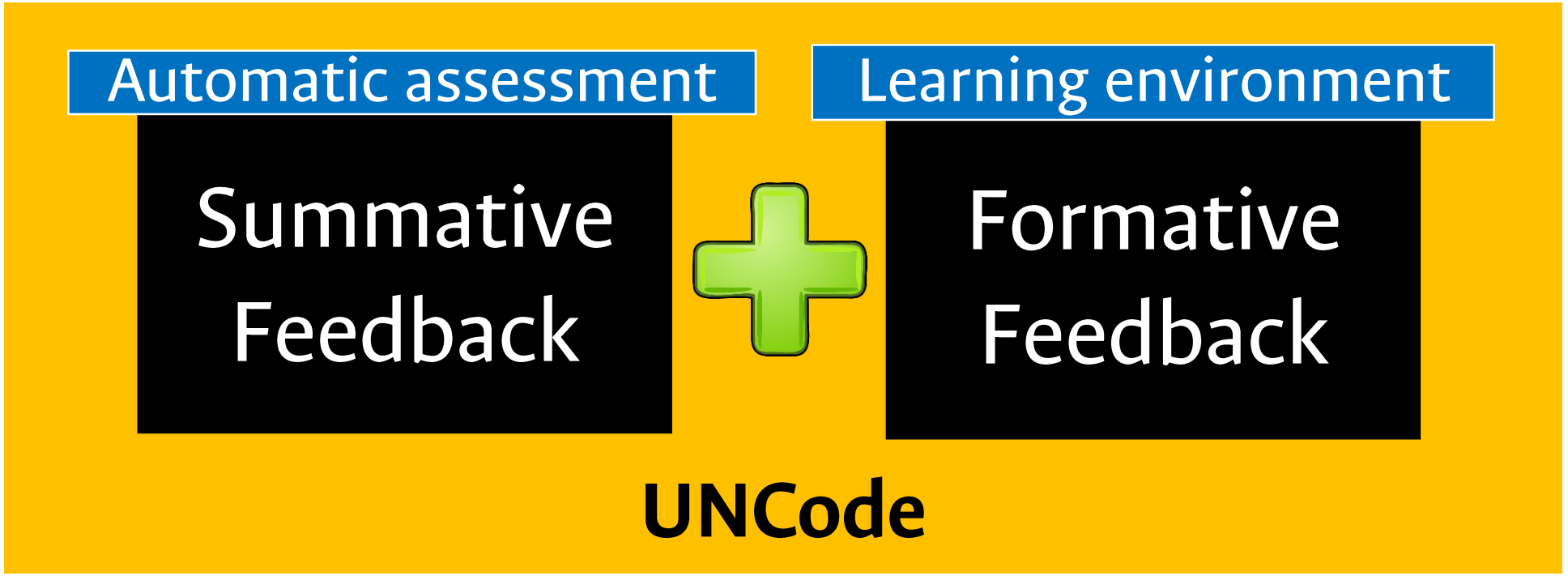
Summative Feedback

Learning environment

Formative Feedback

# Introduction

## Objective




Web-based educational environment for learning computer programming and for the automatic assessment of programming assignments

# Previous Experience

## Universidad Nacional de Colombia (UNAL)

**Automatic assessment**

**Summative Feedback: DomJudge**

Since 2013 at UNAL:

- Algorithms
- Data Structures
- Programming Languages
- …

https://www.domjudge.org/

### Pros:

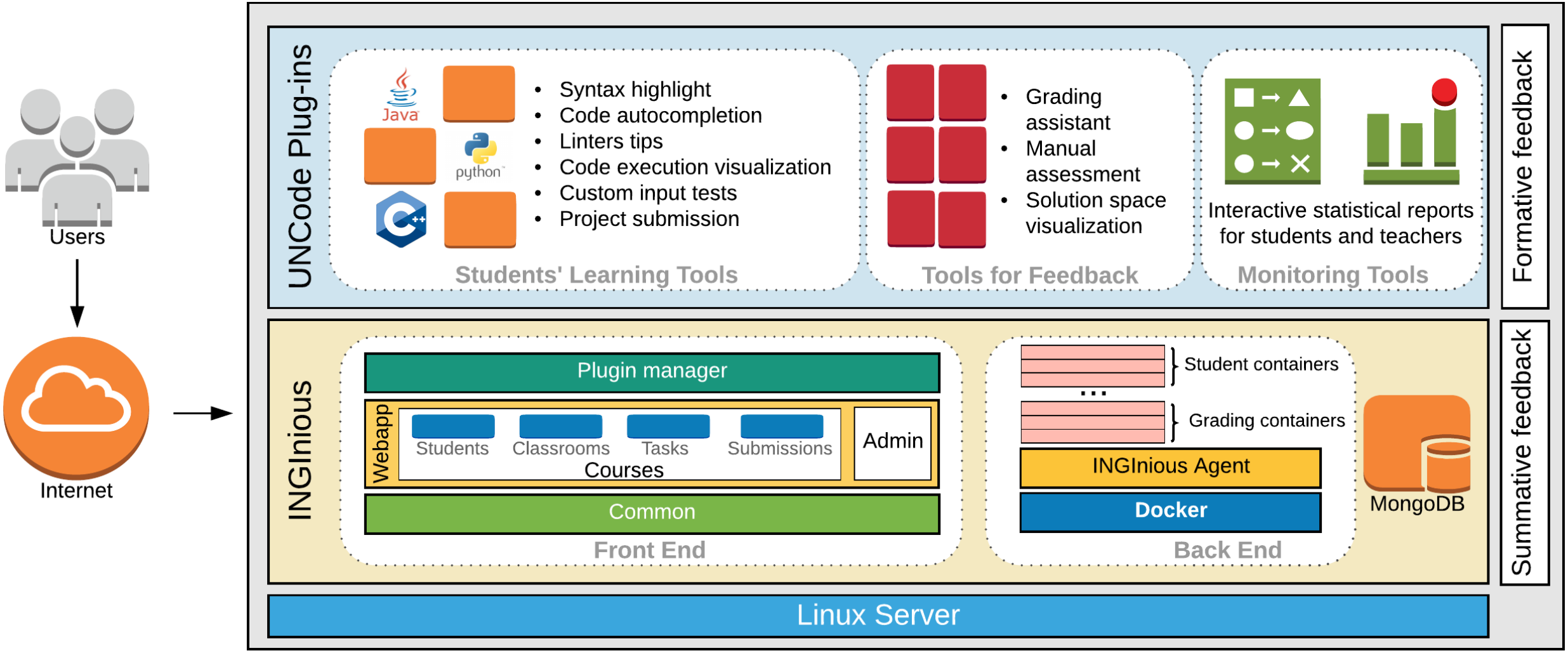
- Grade large amounts of programs
- Immediate summative feedback to students
- Excellent motivation for some students

### Cons:

- Very limited summative feedback
- Lack of formative feedback
- Anxiety and self-efficacy for learning have strong influence on students' academic performance - consequence of the evaluation method? (Ramírez Echeverry et al., 2018)

# UNCode

## UNCode Architecture



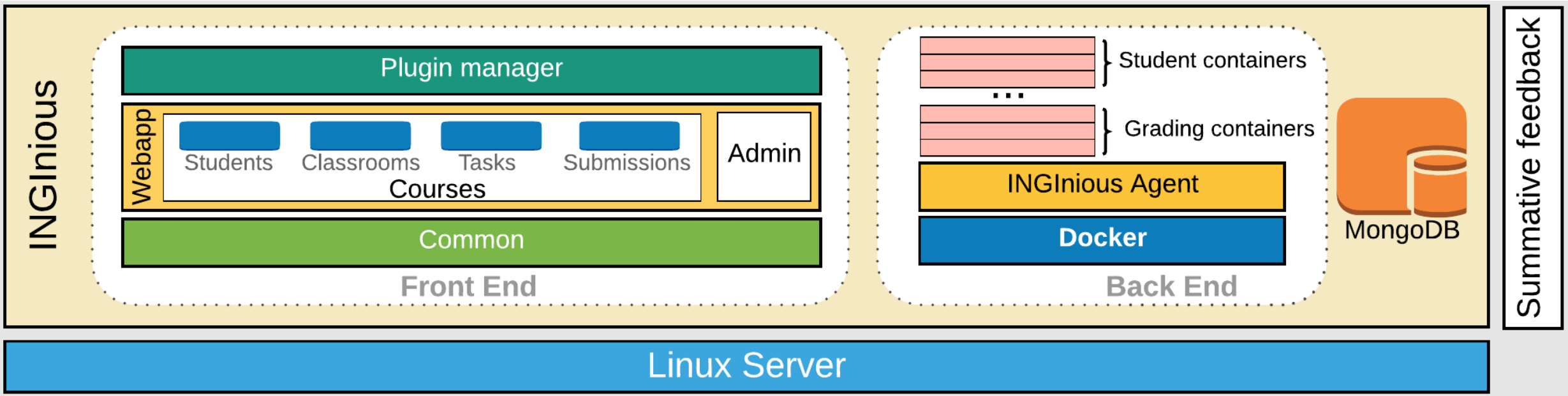
# UNCode

## UNCode Architecture: INGInious

- Automatic grading system for programming exercises
- Flexible, secure, scalable and extensible
- Oriented to educational environments, instead of competitive programming contests

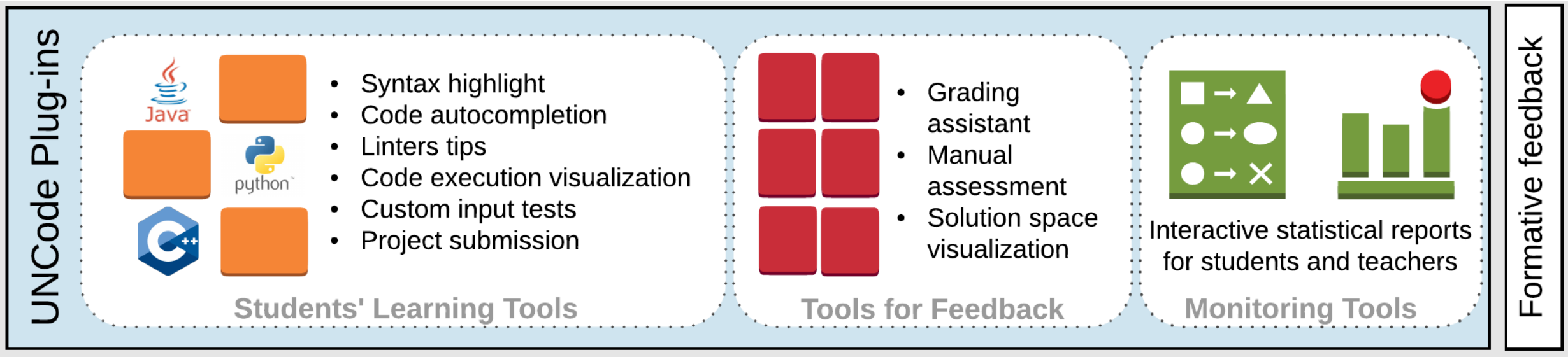
Derval, G., Gégo, A., & Reinbold, P. (2014). INGInious [*software*]. https://github.com/UCL-INGI/INGInious

Derval, G., et al. *Automatic grading of programming exercises in a MOOC using the INGInious platform*, In the Proc of the European MOOC Stakeholder Summit - EMOOCs 2015. pp. 86–91. 2015



# UNCode

## UNCode Architecture: UNCode Plug-ins




**Students' learning tools**

**Tools for feedback**

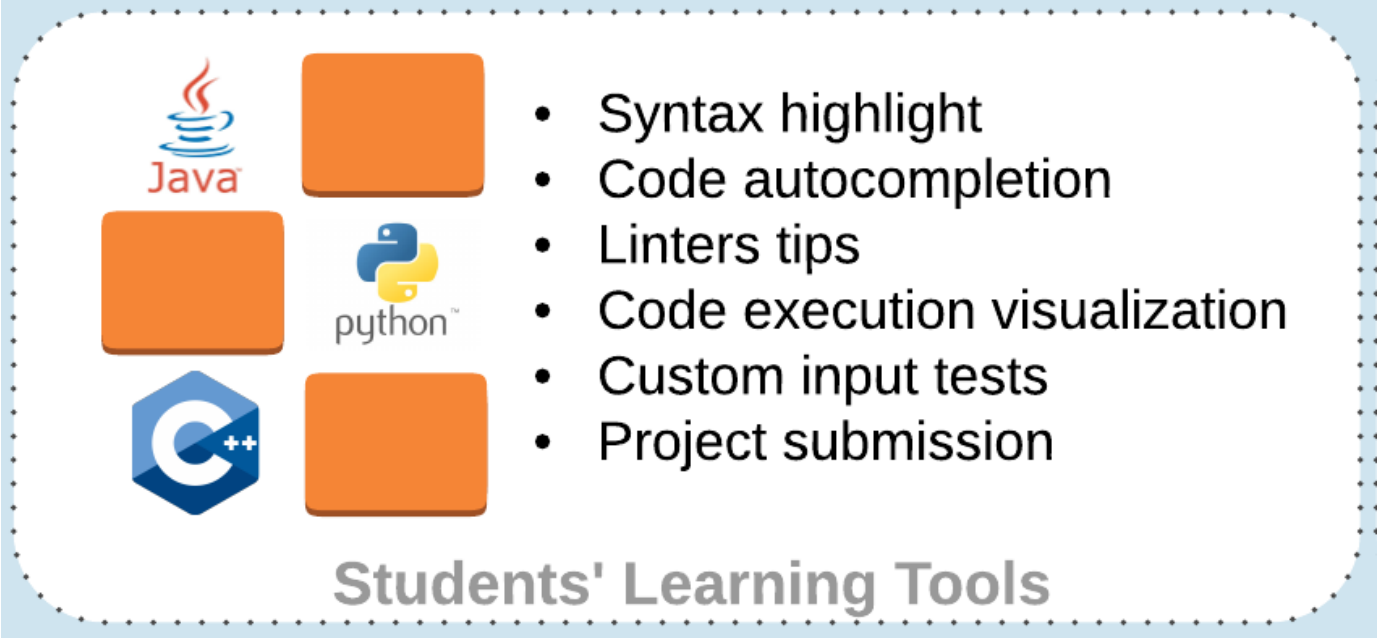
**Monitoring tools**

# UNCode

## UNCode Architecture: UNCode Plug-ins

### Students' learning tools

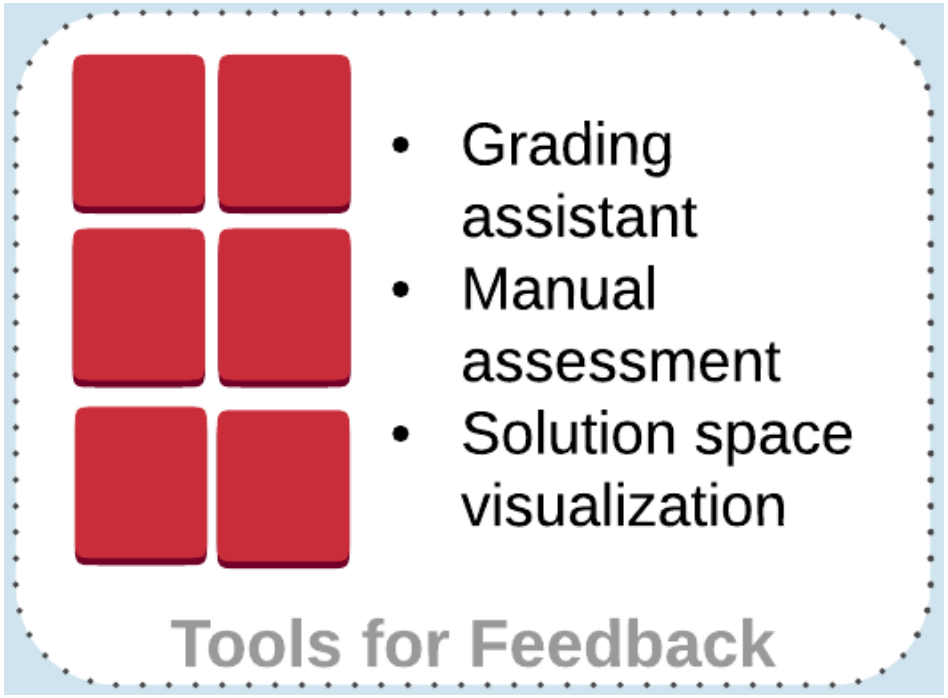
- Students do not have to wait until they make a submission to obtain feedback
- They get formative feedback along the process in several ways:
  - ✓ Syntax
  - ✓ Semantics
  - ✓ Code maintainability
  - ✓ Tests
  - ✓ ...



# UNCode

## UNCode Architecture: UNCode Plug-ins

### Tools for feedback




**Grading assistant:** to interactively generate the grader for the exercises. Supports:

- partial grading
- selection of test cases to be shown to the students
- time and memory limitations, ...

**Manual assessment:** teaching assistants can provide extra feedback to the students by manually assessing a submission

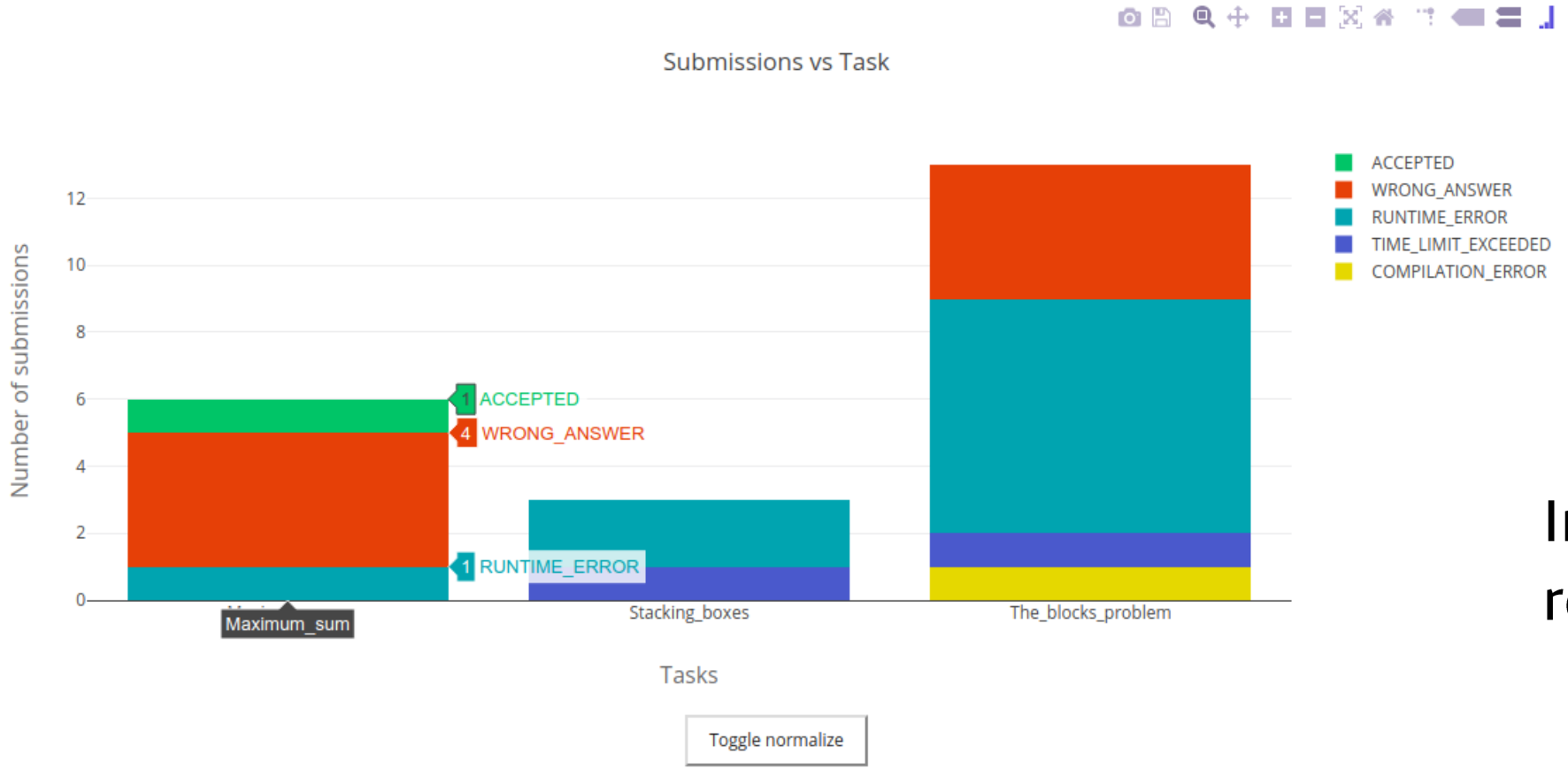
**Solution space visualization:** refers to an interactive tool for the visual analysis of the submissions of all students, identifying groups of similar solutions and visualizing their relationships in a graph (Rosales-Castro et al., 2016)

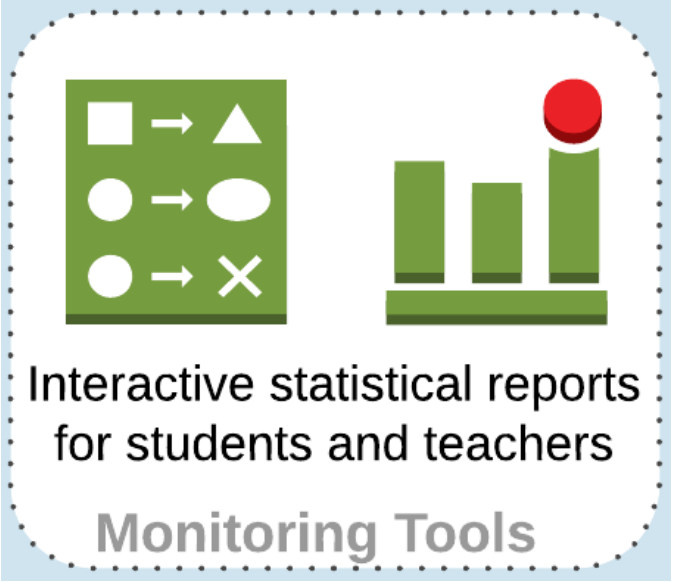
# UNCode

## UNCode Architecture: UNCode Plug-ins

### Monitoring tools

Bar Submissions Per Tasks



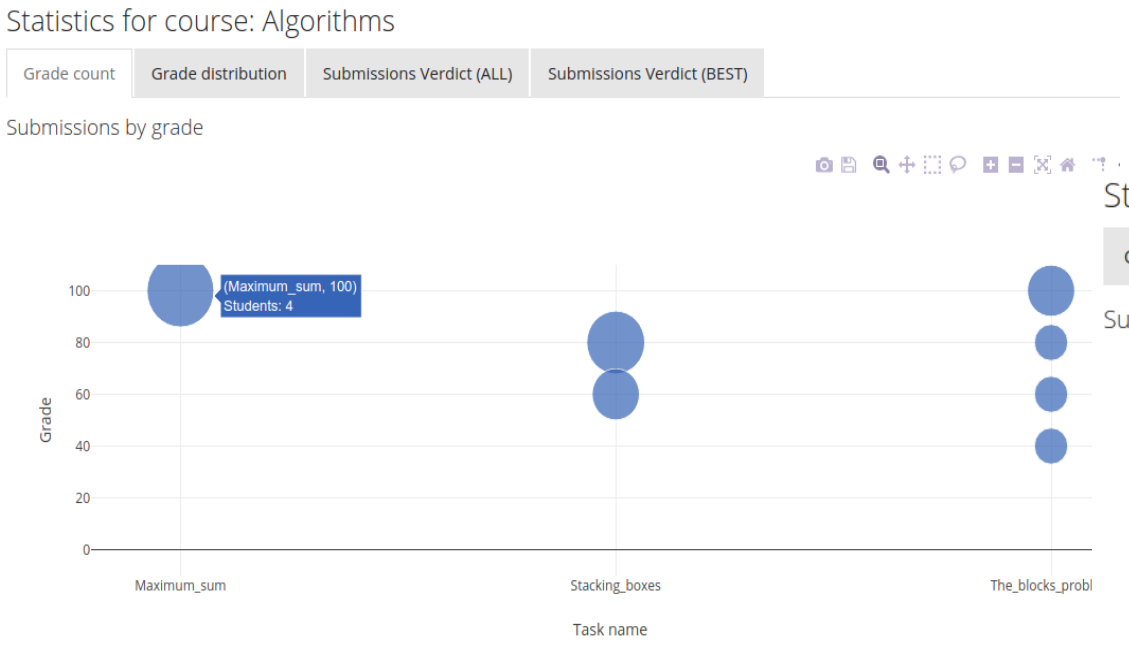



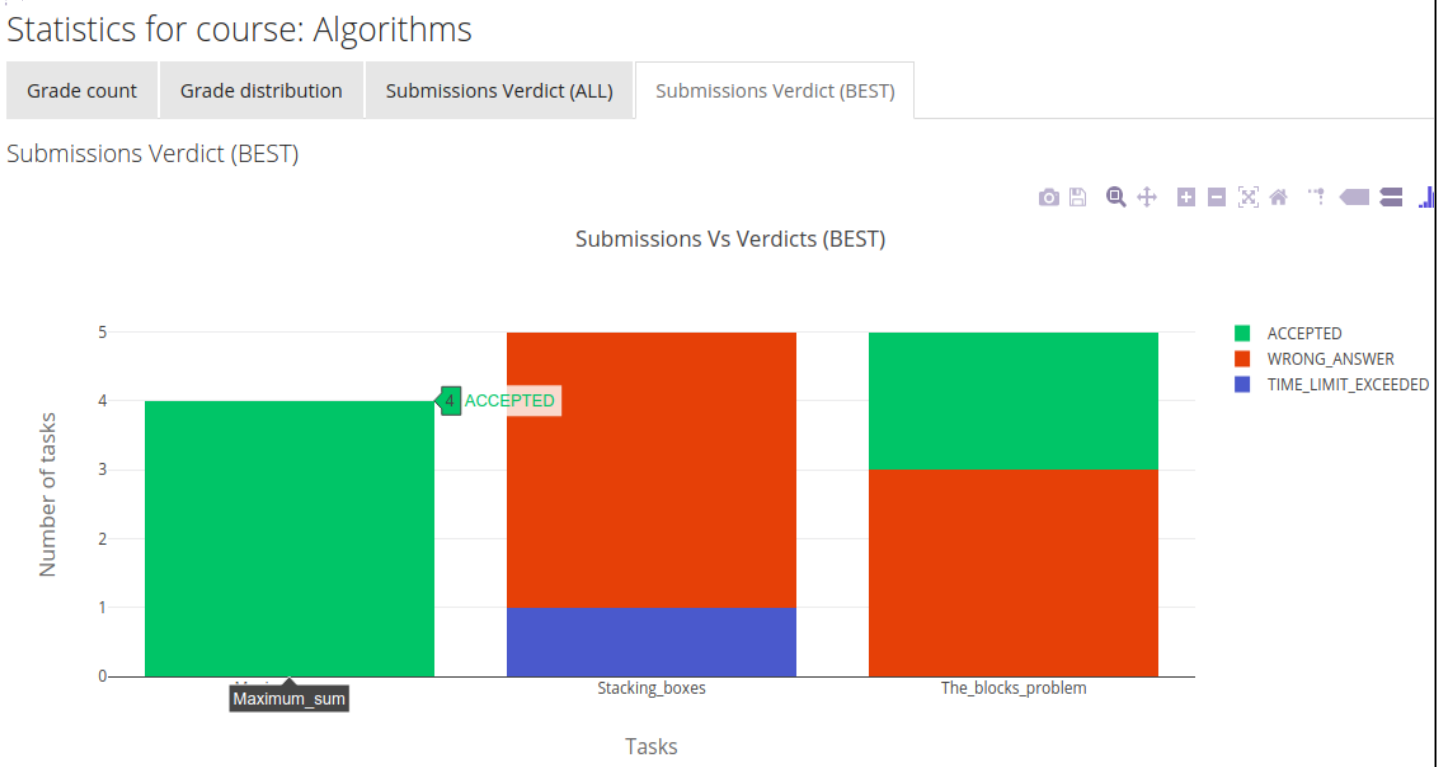

Interactive statistical reports for **students**

# UNCode

## UNCode Architecture: UNCode Plug-ins

### Monitoring tools




Interactive statistical reports for **teachers**

# Results

## Comparative between DomJudge, INGInious, and UNCode

- Work in progress
- Needs validation in a programming course

| | Feature | DomJudge | INGInious | UNCode |
|---|---|---|---|---|
| Summative feedback | Syntax | ✓ | ✓ | ✓ |
| | Semantics (functionality) | ✓ | ✓ | ✓ |
| | Efficiency | ✓ | ✓ | ✓ |
| | Resubmissions | ✓ | ✓ | ✓ |
| | Partial grading | | * | ✓ |
| | Automatic grading (numerical) | ✓ | ✓ | ✓ |
| | Manual grading | | | ✓ |
| Formative feedback | Syntax highlight | | * | ✓ |
| | Code autocompletion | | * | ✓ |
| | Code maintainability (linters) | | | ✓ |
| | Code execution visualization | | | ✓ |
| | Custom input tests | | | ✓ |
| | Project submissions | | | ✓ |
| | Customizable grading assistant | | | ✓ |
| | Solution space visualization | | | ✓ |
| | Basic statistical reports | | ✓ | ✓ |
| | Interactive statistical reports | | | ✓ |
| Technical features | Programming languages | Many | Many | Java, Python, C/C++ |
| | Web-based | ✓ | ✓ | ✓ |
| | Courses and assignments | | ✓ | ✓ |
| | Distribution and Availability | ✓ | ✓ | ✓ |

* Configurable

# Conclusions

- We have presented UNCode: a free, open-source, web-based educational environment for learning programming skills and for the automatic assessment of assignments
- It leverages the best of automatic assessment tools and integrates features from learning environments
- It provides summative and formative feedback to the students

## Future work

- We will validate the impact of each one of the proposed modules in an academic environment, using UNCode as a support system in several programming courses

# Thank you for your attention!

# Questions?

**UNCode: Interactive System For Learning and Automatic Evaluation of Computer Programming Skills**

- Deployed at https://www.ingenieria.bogota.unal.edu.co/uncode
- Source code available at https://github.com/JuezUN (AGPL 3.0 license)

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