GAMIFICATION OF MOOCS
FOSTERING THE COMPUTER PROGRAMMING LEARNING

RICARDO QUEIRÓS

INDEX

- ME
- MOTIVATION
- THE BEGINNING - PETCHA
- MOOCS AND GAMIFICATION - ENKI
- THE FUTURE

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ME

RICARDO QUEIRÓS

- 42 years old
- Born in PORTO
- PhD in Computer Science (FCUP)
- Professor (ESMAD/P.PORTO)
- Researcher (CRACS/INESC-TEC)
- Web & Mobile Developer

ME

RICARDO QUEIRÓS

- Main activities/hobbies:
  - Teach computer programming
  - Do research at CRACS/INESC-TEC
    - E-Learning applications, standards and Interoperability
    - Computer Science Education
    - Programming Languages processing
    - XML processing and Architectural Integration
    - Mobile computing
  - Code (Java, C#, JavaScript, C, Sass,…)
  - Play soccer and running

- More about me: http://www.dcc.fc.up.pt/~rqueiros

ME

RICARDO QUEIRÓS

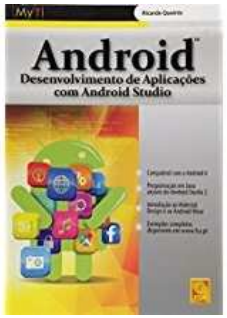
- Book writer

2008

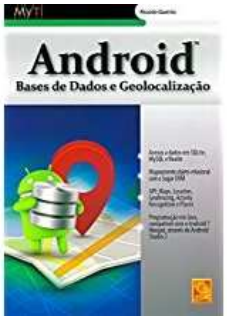
2013

2014

2015



2016

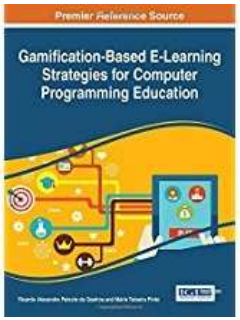


2016

2017

2012

2015



2016

ME

MY SCHOOL

- ESMAD (Media Arts and Design Superior School)
  - One of the schools of the POLYTECHNIC OF PORTO
  - In the middle of 2 cities: Vila do Conde & Póvoa de Varzim

P.PORTO

ESCOLA
SUPERIOR
DE MEDIA ARTES
E DESIGN

ME

MY SCHOOL

ME

MY SCHOOL

https://vimeo.com/212716938

ME

MY CITY

- PORTO
    - The second biggest city in Portugal
    - ESMAD is located 30km from Porto

ME

MY CITY

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GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Learning through practice is the best way
to learn and to engage novice students in complex domains

MOTIVATION

The importance of feedback

- For someone to acquire, improve or even maintain a complex skill it is necessary to **practice it**, on a regular basis, in order to keep it tuned
- The amount of practice required depends on the nature of the activity and on each individual
- How well an individual improves with practice is directly related with
  - its inherent capabilities
  - its previous know-how about the domain
  - the type of **feedback** that is available for improvement
- If feedback is either non-existent or inappropriate, then the practice tends to be ineffective or even detrimental to learning

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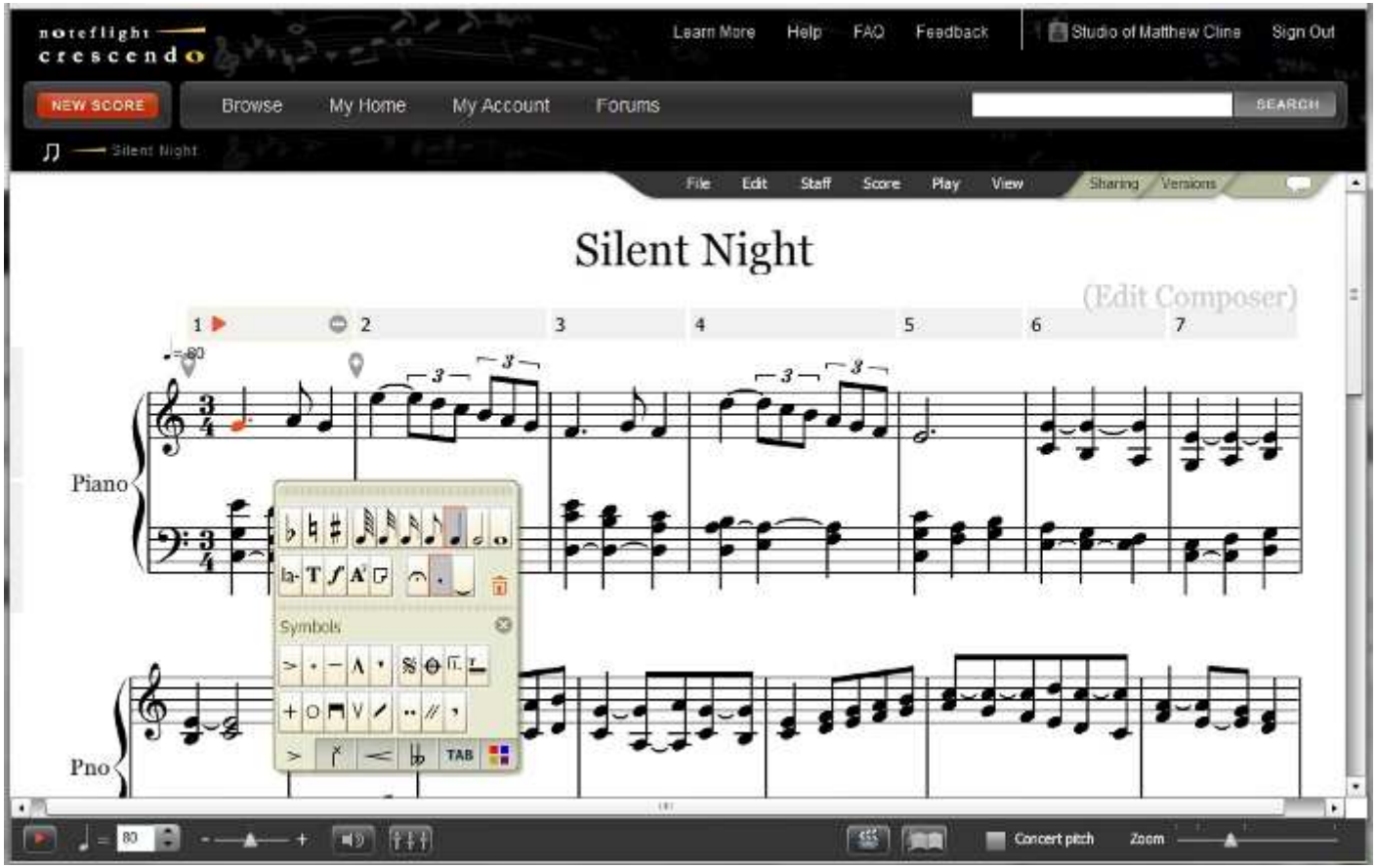
MOTIVATION



Noteflight application

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MOTIVATION

IBM Service Management Serious Game

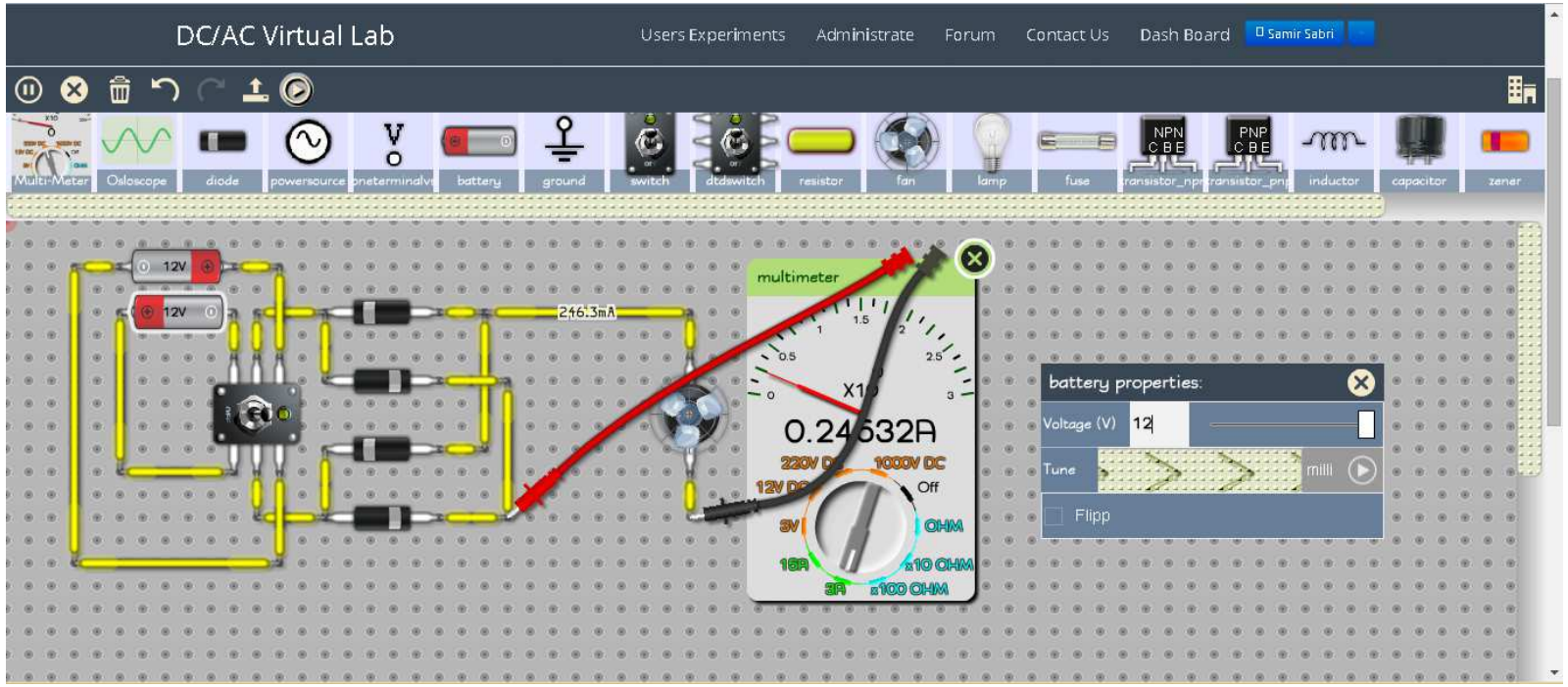
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Students treat a human patient simulator

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION



Elite Techno

MOTIVATION

What about computer programming?

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Computer programming

- Programming courses have **high failure** and **dropout rates**
  - teaching methods
  - subject complexity
  - student motivation

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Computer programming

- Programming courses have **high failure** and **dropout rates**
  - teaching methods
  - subject complexity
  - student motivation
- Teaching and learning is difficult
  - number of TAs insufficient
  - high number of students enrolled in courses
  - extensive course syllabus
  - weak availability of repositories of exercises
  - **manual assessment is time-consuming and error prone**

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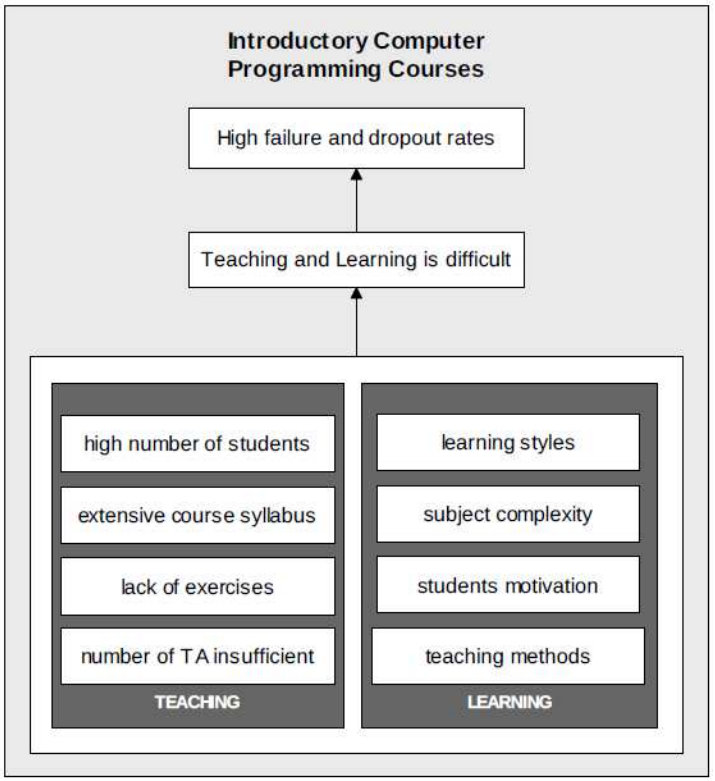

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Computer programming

- Several tools have been built
  - to assist teachers and students in introductory courses classified in three categories
    - integrated development interfaces
    - virtual learning environments
    - tools for submitting, rendering, managing, and testing exercises
  - but without any integration and interoperability concern!

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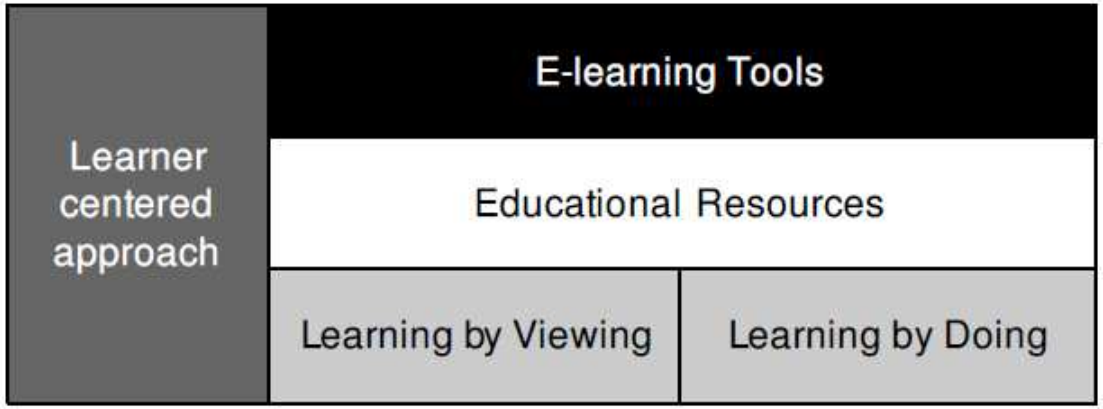
MOTIVATION

Approach

- Create a teaching-learning process based on
  - a learner centered approach
  - with a combination of paradigms: learning by viewing vs. by doing
  - where educational resources are always available and diversified
  - where e-learning tools are interoperable and ubiquitous



Sweller and Cooper (1985)

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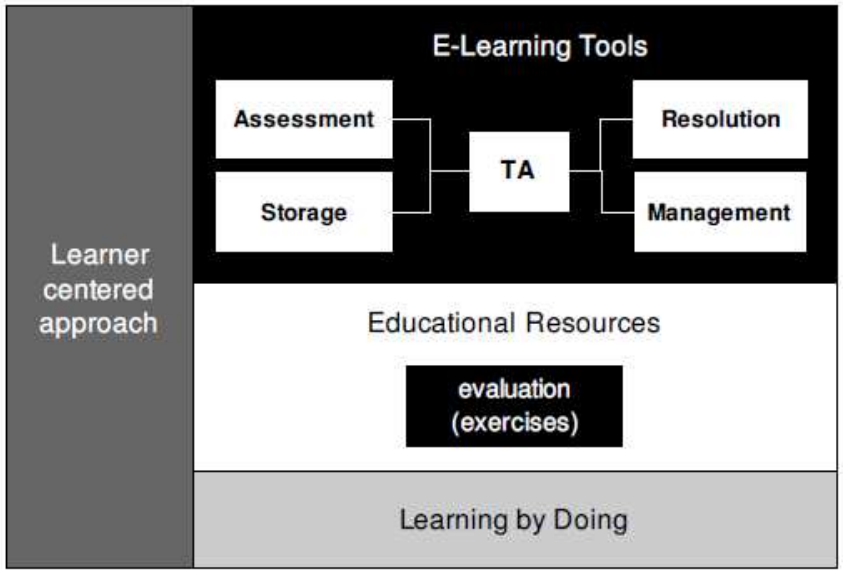
MOTIVATION

Approach

- Specialization of Ensemble framework for the Computer Programming domain
- Implementation of Sweller & Cooper paradigm in 2013



Ensemble instance (ESEIG, 2011/12)

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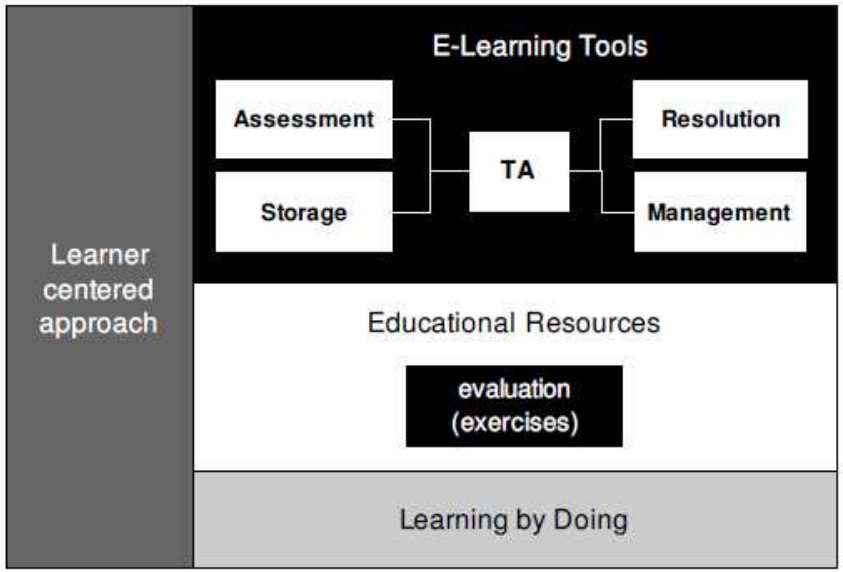
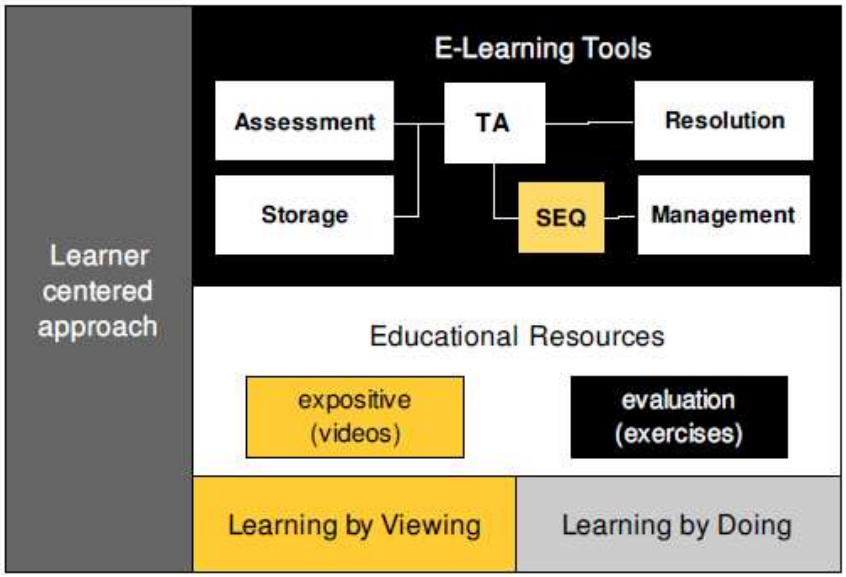


Ensemble instance (ESEIG, 2011/12)



Ensemble instance (ESEIG, 2013)

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOTIVATION

Computer programming

Approach

Create an automatic **Teaching Assistant** for programming exercises

- help teachers in exercise authoring
- help students in the exercise solving

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THE BEGINNING - PECTHA

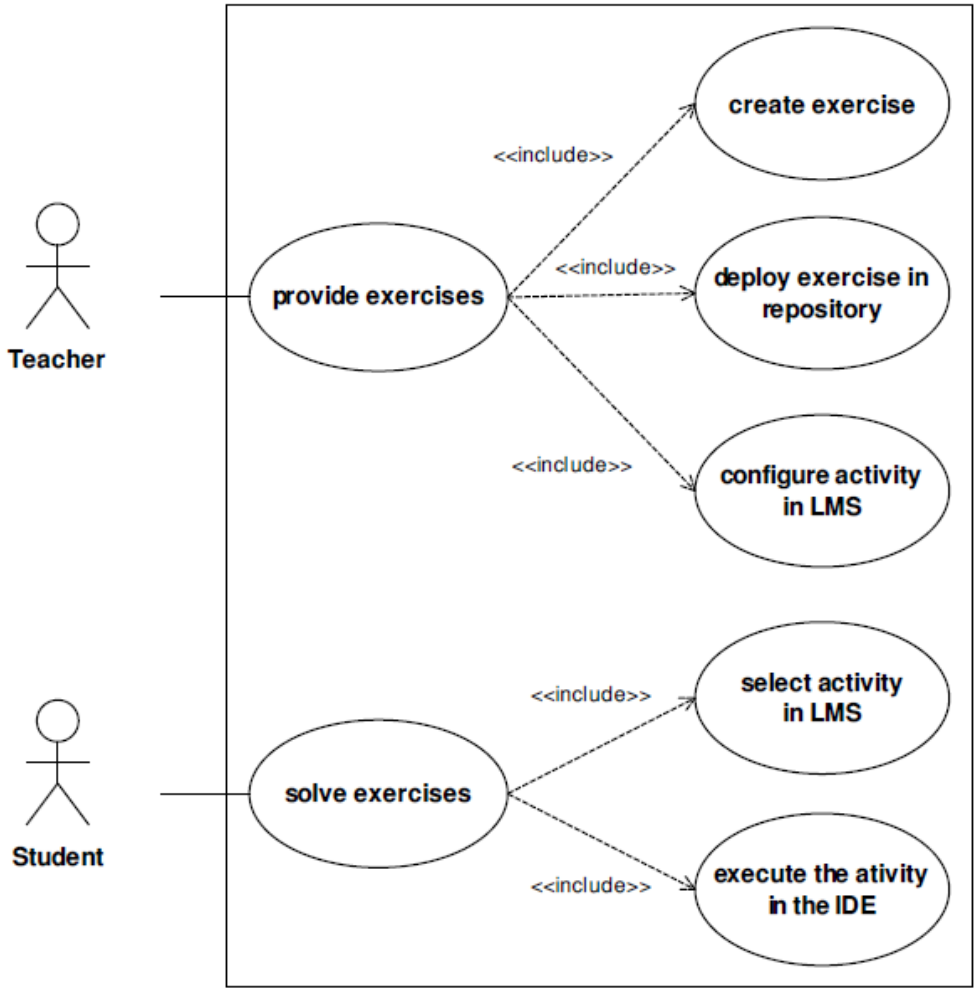
PETCHA (Programming Exercises TeaCHing Assistant)

- Created in the Faculty Sciences of Porto in 2012
- Teaching Assistant as a scaffolding tool with 2 facets:
  - bridge between the teacher and the students
    - it helps the teacher in exercise authoring
    - it helps the students in the exercise solving
  - pivot component on a network integrating other e-learning systems
    - **automatic evaluation** of programs and feedback generation
    - authoring and storing of programming exercises as learning objects
    - managing instruction and learning activities

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Use Cases

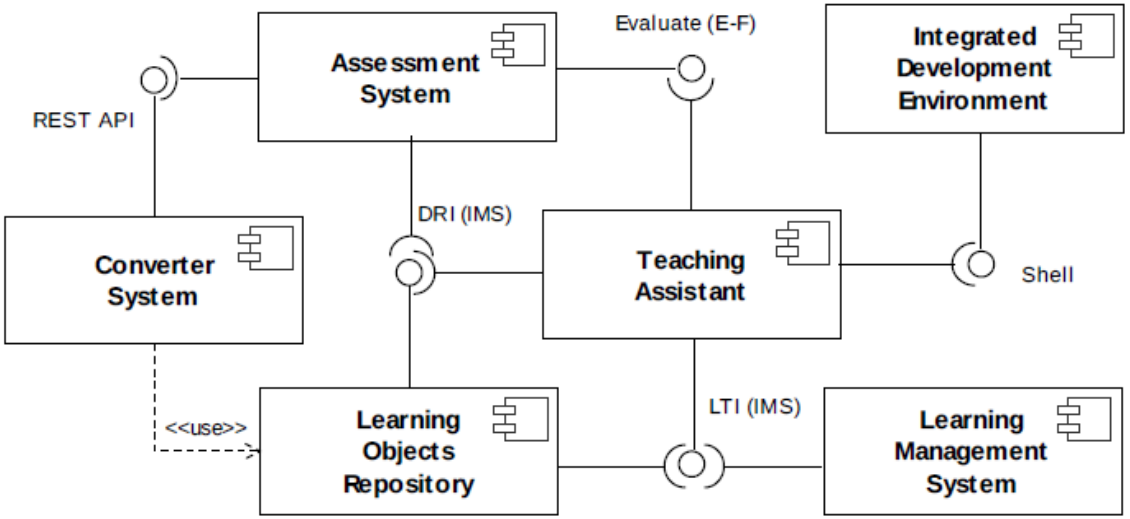


GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Architecture

- Architecture of the network coordinated by Petcha:
  - Learning Objects Repository - to store/retrieve exercises
  - Assessment System - to evaluate student exercises
  - Learning Management System - to present exercises to students
  - Integrated Development Environment - to code the exercises



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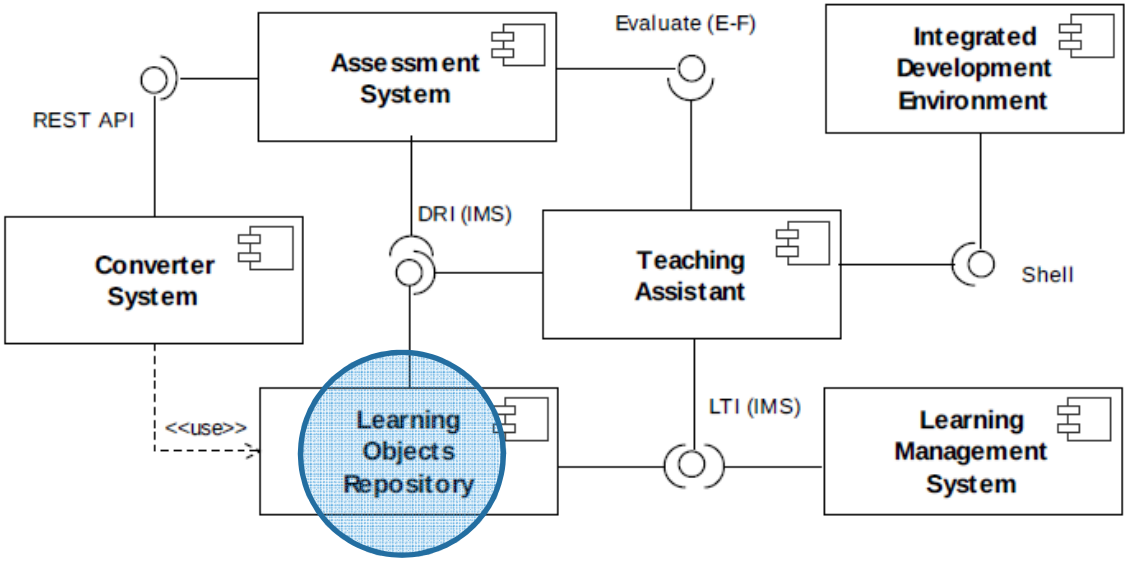
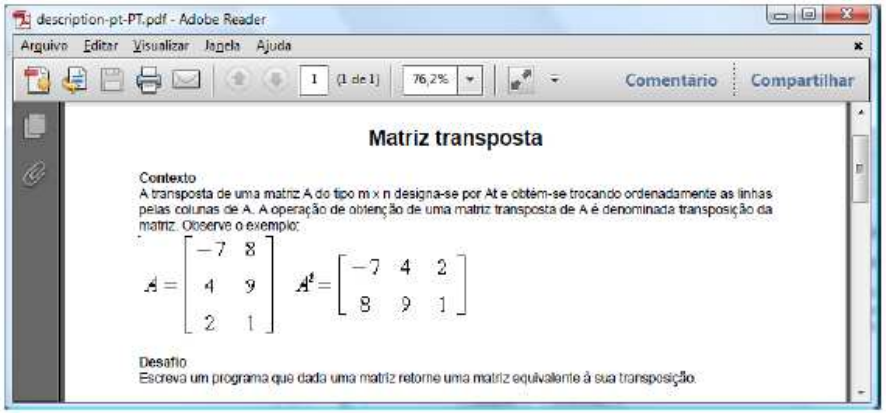


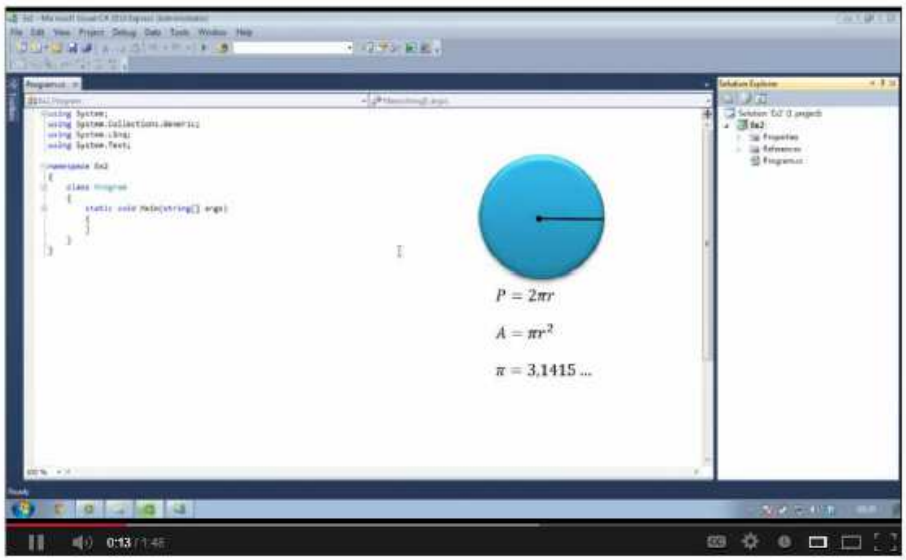
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Learning Objects Repository

- Educational resources
  - Evaluation (exercises, tests)
  - Expository (videos, PDF, HTML + images)





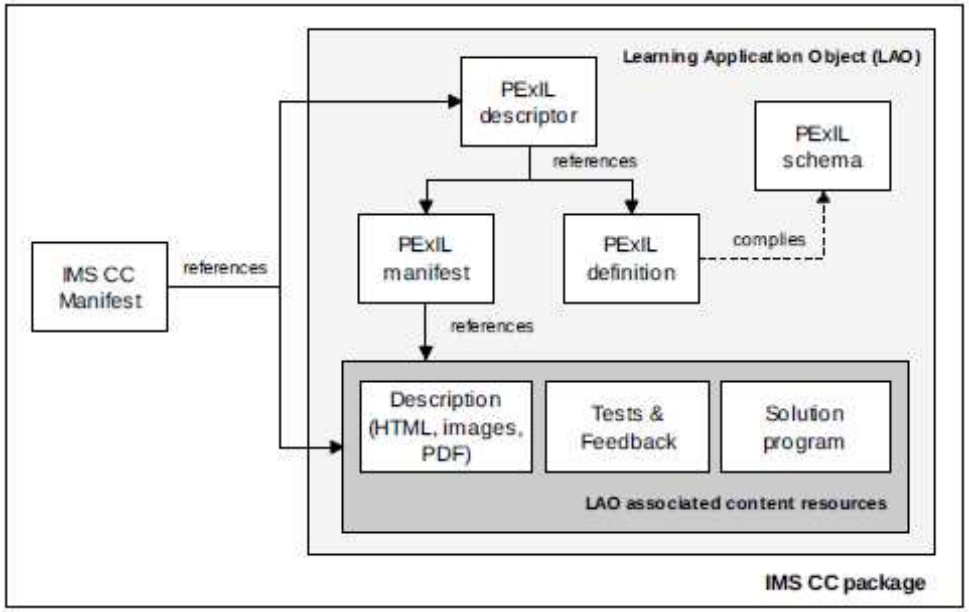
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Learning Objects Repository

- Educational resources
  - Evaluation (exercises, tests)
  - Expository (videos, PDF, HTML + images)

- Based on IMS CC standard
- Extended via LAO (PExIL)
- Created in Petcha (TA)
- Stored in repository

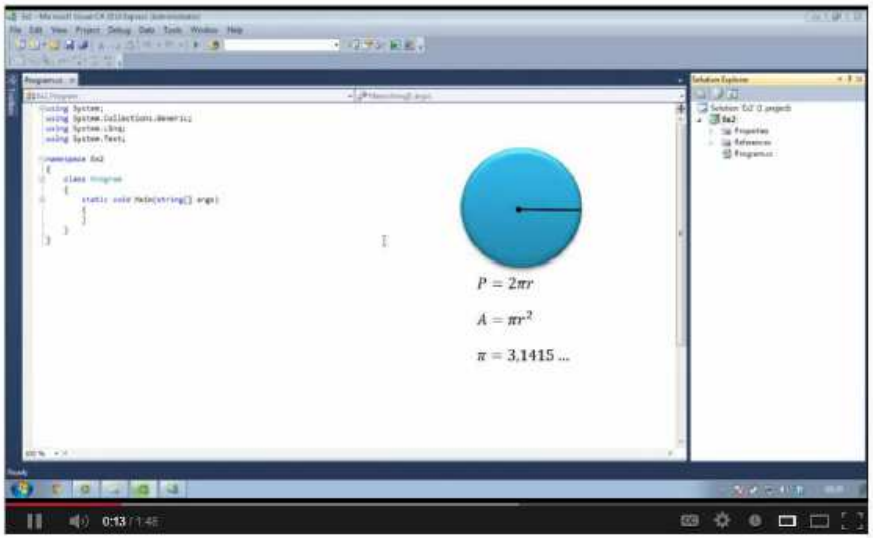


GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Learning Objects Repository

- Educational resources
  - Evaluation (exercises, tests)
  - Expository (videos, PDF, HTML + images)
- Essentially videos
- Created in Screen-o-matic
- Shared with YouTube
- Features
  - Cover all topics
  - Different difficulty levels
  - Short clips of video (< 5')
  - Complete (images, sound, subtitles, layers)



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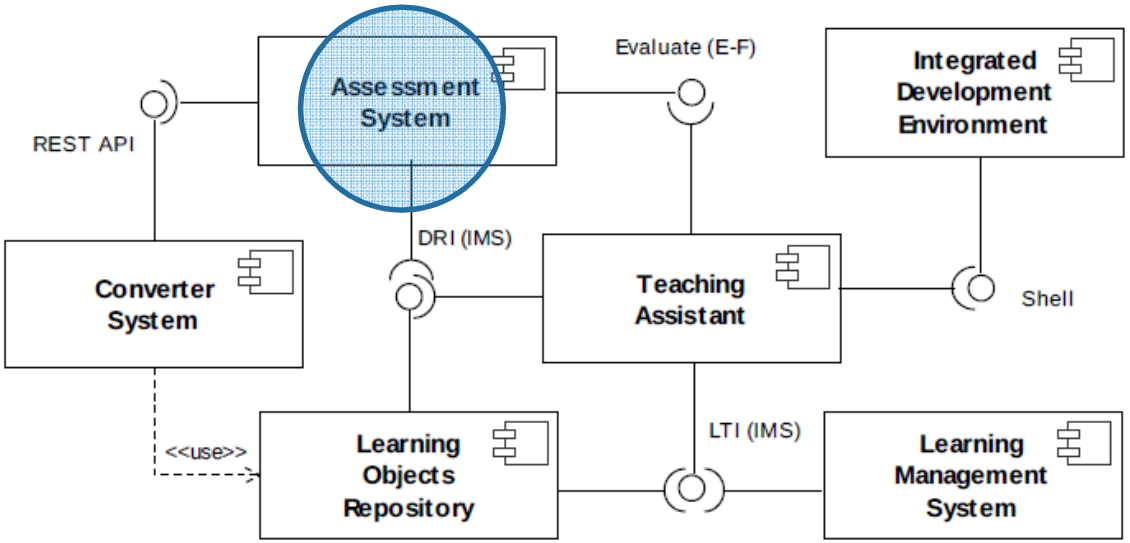

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Assessment Systems

- High number of assessment systems (e.g. Mooshak, Web-CAT, Verkkoke, DOMJudge, Boss)
- Main features:
  - multi-programming language support
  - evaluation type (static or dynamic)
  - feedback
  - interoperability
  - learning context
  - security
  - plagiarism

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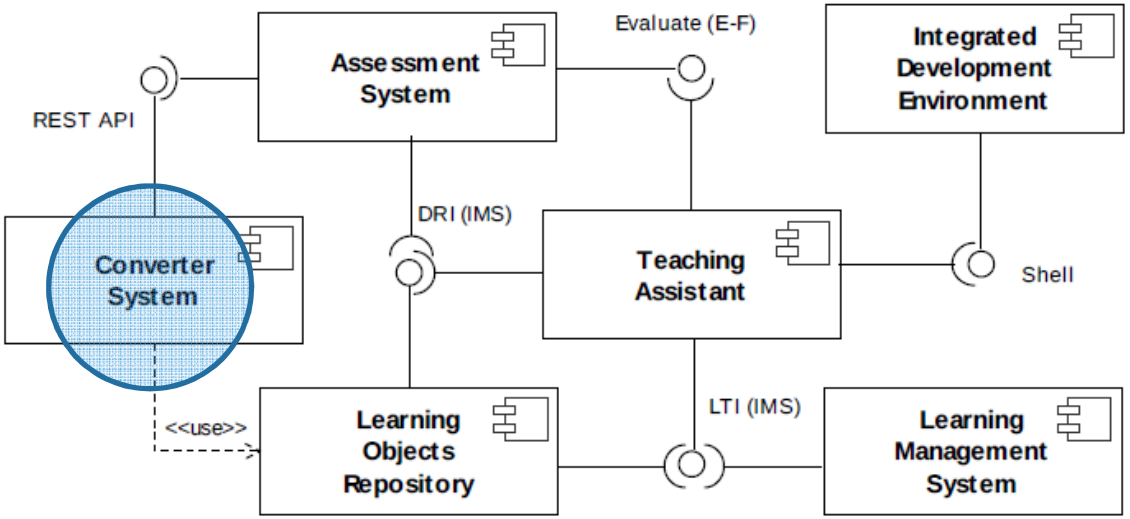


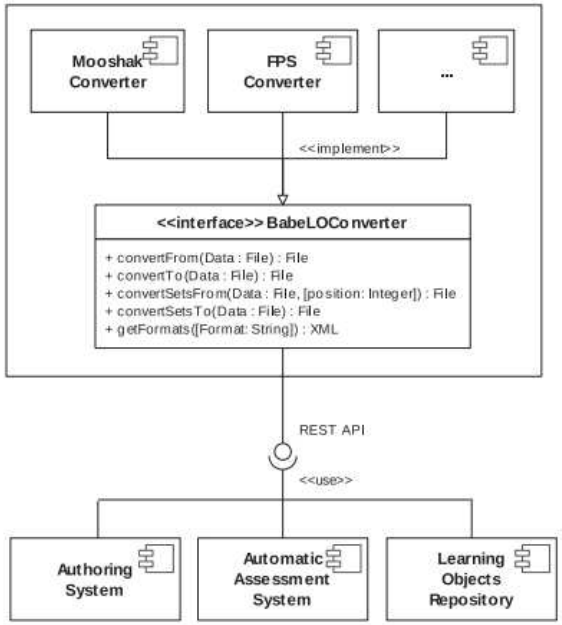
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Convert exercise formats

- Mostly of the programming exercises are
  - created manually or using ad hoc mechanisms
  - described with its own exercise format (e.g. FPS, Peach, CATS, MEF)
  - stored in proprietary systems (e.g. online judges)
  - used in programming contests

- Creation of BabeLO – a conversion WS



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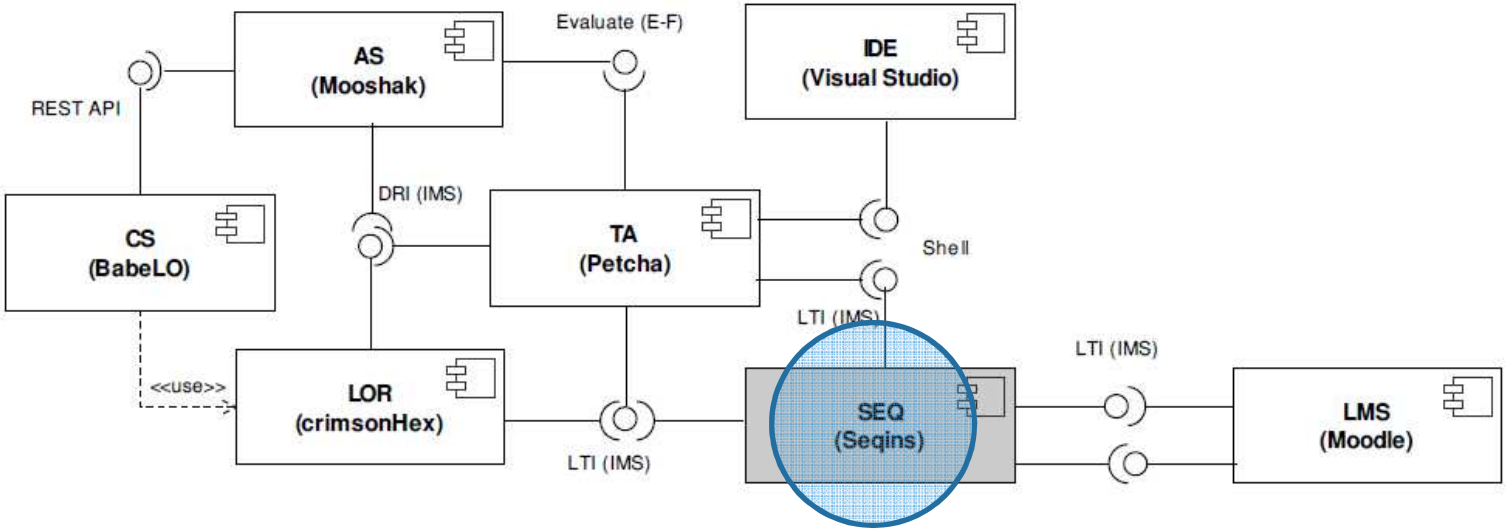
  - Sequencing Tool – to sequence the exercises to students



GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Sequencing tool

- Resources sequencing in learning environments
- Criticisms of the existing specifications (e.g. IMS “Simple” Sequencing)
  - Modularization - included in Learning Objects (IMS CP)
  - Scope - widen excessively the scope ("spray and pray")
  - Utility - more focused on quantity ("shovelware")
  - Complexity - diffIcult to implemente
- Creation of Seqins
  - Simple sequencing model
  - Weights associated with the evaluation resources of an unit
  - Sequential visualization and resolution within an unit
- Competitive facet
  - Success to a unit unlocks access to the next unit
  - "A la" computer games

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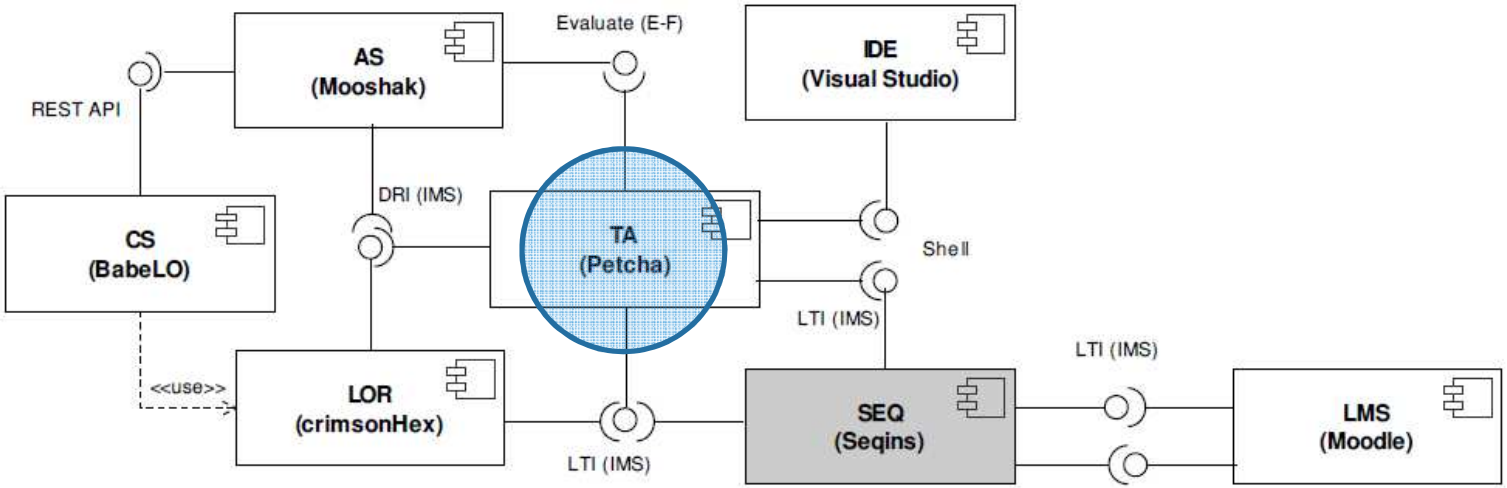


GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Teaching Assistant

- **Pivot component** of the services network
- A descentralized **orchestrator**
- Need to communicate with almost all the pieces of the puzzle
- Most importante: needs to communicate with the LMS!

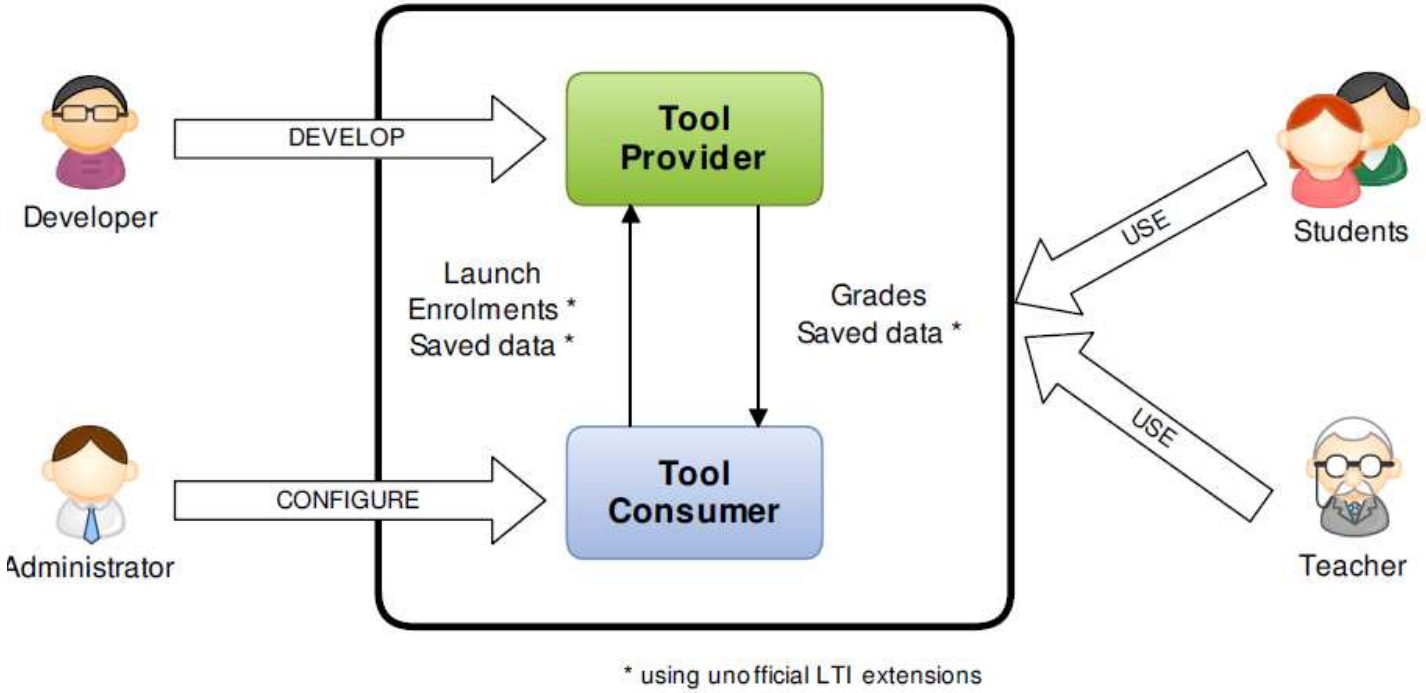
How we can integrate external applications in a LMS (e.g. Moodle) ?

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

Teaching Assistant

- Ad hoc solutions
- Proprietary plugins (Moodle Repository API)
- Focus on interoperability: IMS Learning Tools Interoperability



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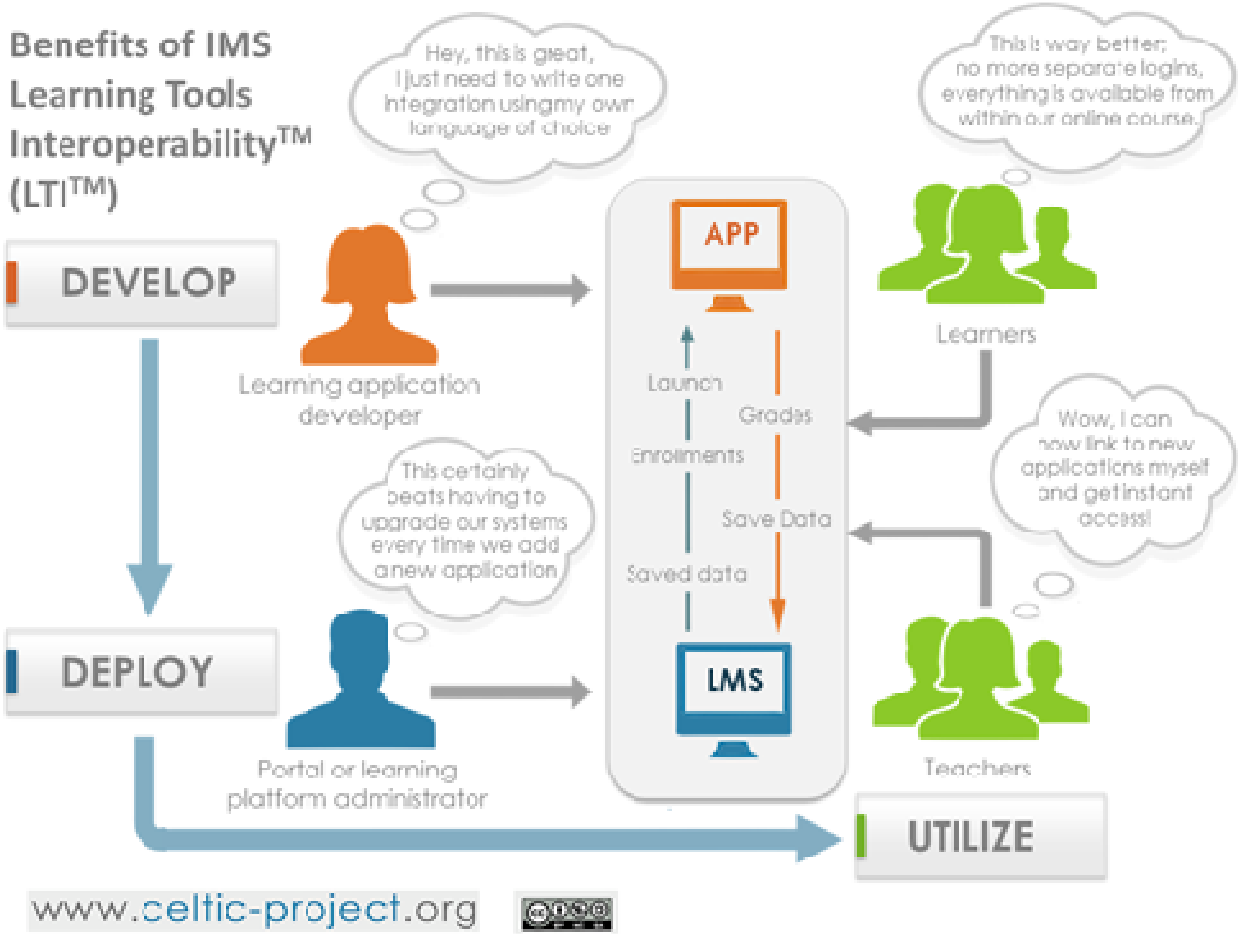
THE BEGINNING - PECTHA

Teaching Assistant

- IMS Learning Tools Interoperability



GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

GUI

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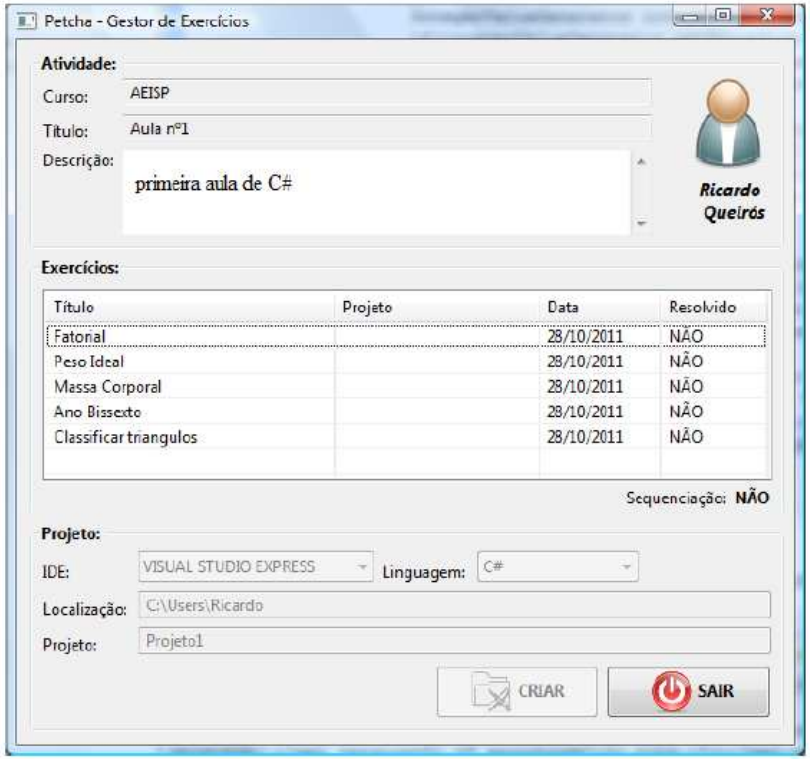
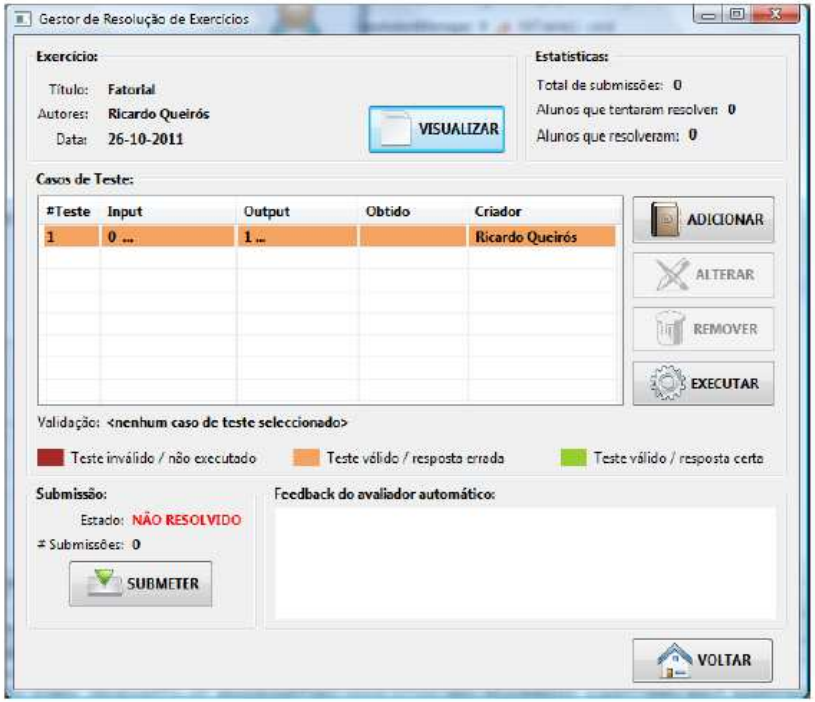
THE BEGINNING - PECTHA

GUI





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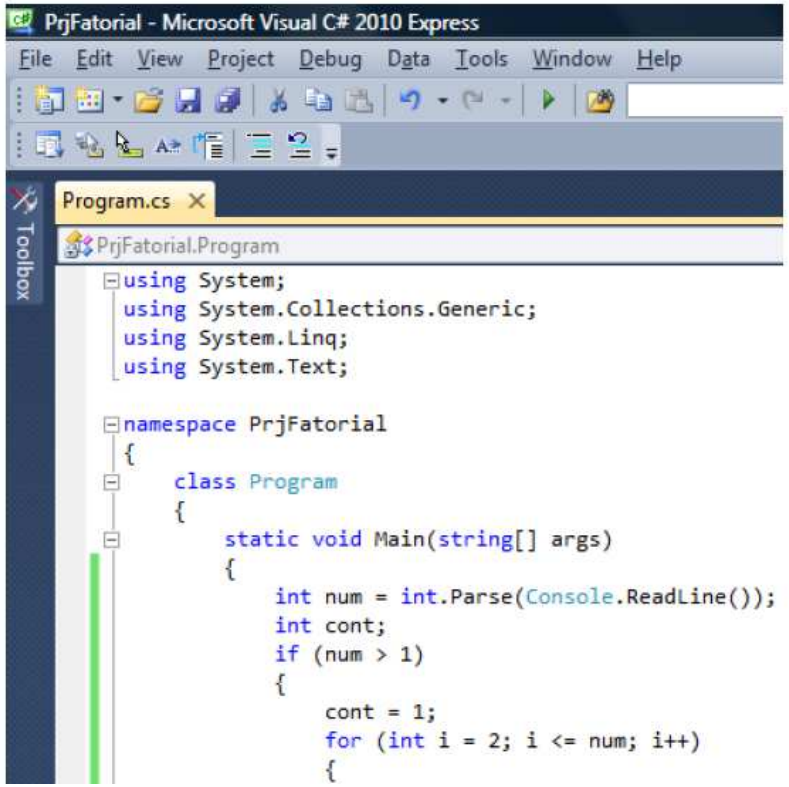

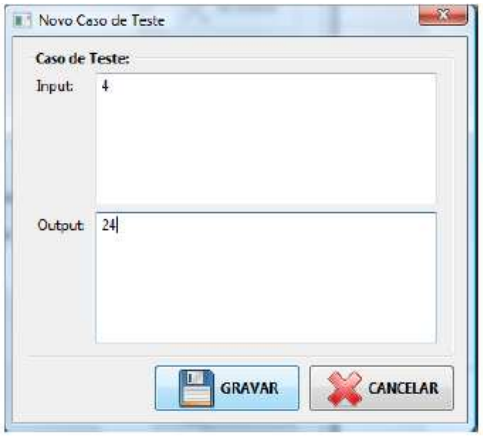

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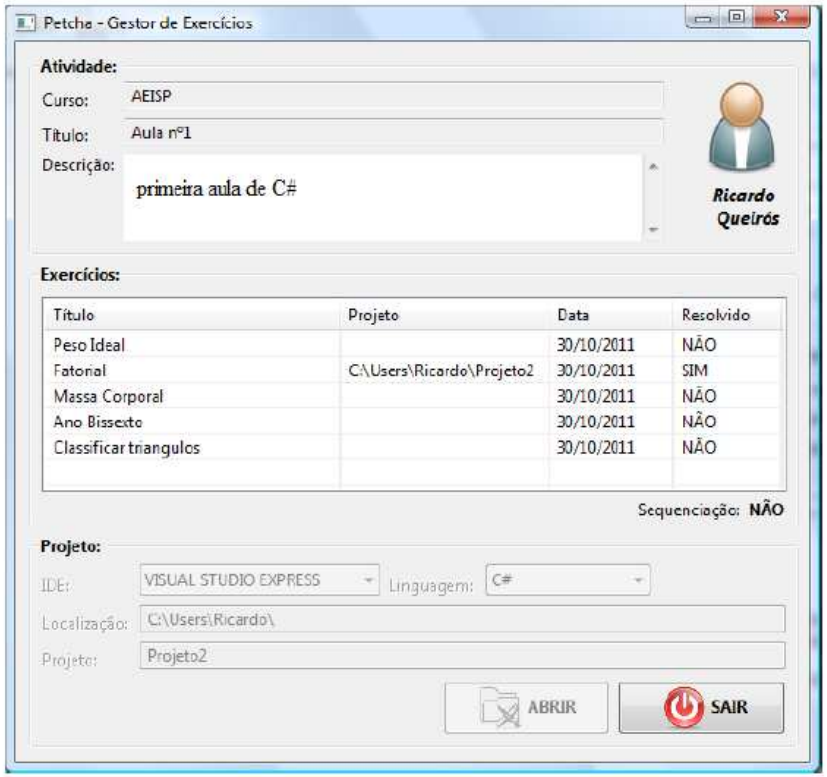

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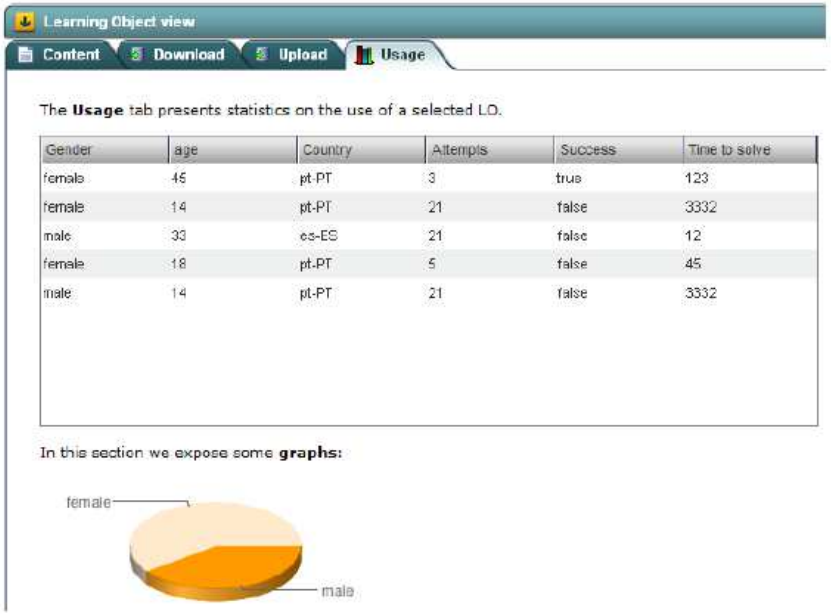

Gender	age	Country	Attempts	Success	Time to solve
female	45	pt-PT	3	true	123
female	14	pt-PT	21	false	3332
male	33	es-ES	21	false	12
female	18	pt-PT	5	false	45
male	14	pt-PT	21	false	3332

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

THE BEGINNING - PECTHA

EXPERIMENT

- Conducted at ESEIG - Polytechnic Institute of Porto

- First-year Mechanical Engineering students of the course Algorithms and Programming
- The course is divided in two classes (experimental and control)
- The experiment occurred in 6 lab sessions
- In each session students had 3 exercises to solve
- After each lab session both classes were surveyed

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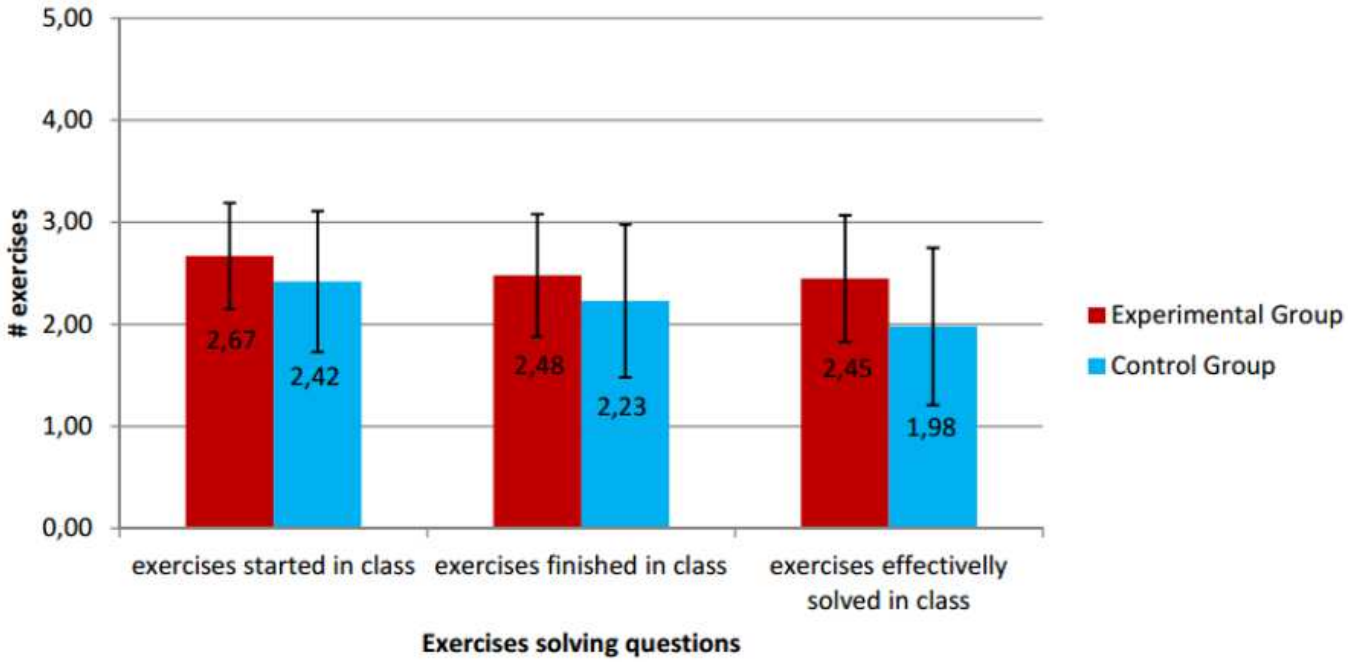
THE BEGINNING - PECTHA

EXPERIMENT



Question	Experimental			Control			T-Test	
	n	M	SD	n	M	SD	T	p
Exercises started	116	2.67	0.52	88	2.42	0.69	2.857	0.0048
Exercises completed	116	2.48	0.60	88	2.23	0.75	2.617	0.0097
Exercises solved	116	2.45	0.62	88	1.98	0.77	4.678	0.000006

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- MOTIVATION
- THE BEGINNING - PETCHA
- MOOCS AND GAMIFICATION - ENKI
- THE FUTURE

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION - ENKI

PETCHA PROBLEMS

- Poor feedback
- Updates
- Scalability/threading issues
- Low retention

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

PETCHA PROBLEMS

- Poor feedback
  - Solution: Implementation of code static analysis
- Updates
- Scalability/threading issues
- Low retention

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

PETCHA PROBLEMS

- Poor feedback
- Updates
  - Solution: transition to web-based (using Google Web Toolkit)
- Scalability/threading issues
- Low retention

GWT

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

PETCHA PROBLEMS

- Poor feedback
- Updates
- Scalability/threading issues
  - Solution: Mooshak update (v2)
  - Success with load and stress tests
- Low retention

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

PETCHA PROBLEMS

- Poor feedback
- Updates
- Scalability/threading issues
- Low retention
  - Solution: Gamification

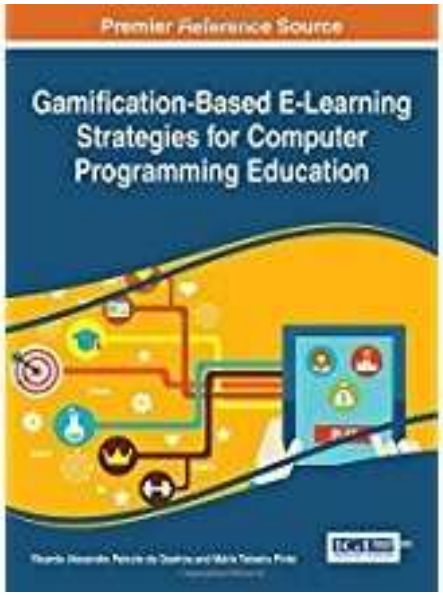
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

GAMIFICATION

How can I use gamification to motivate students to learn complex domains?

2015



2016

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification (Wikipedia definition)

- The use of game-design elements and game principles in non-game contexts
- Techniques intended to leverage people's natural desires for socializing, learning, mastery, competition, achievement and status
- Strategies
  1. Use rewards (points, achievement badges or levels) for players who accomplish desired tasks or competition to engage players, and making them visible to other players or providing leaderboards to encourage players to compete
  2. Make existing tasks feel more like games
     - meaningful choice
     - onboarding with a tutorial
     - increasing challenge
     - adding narrative

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

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Lets do it!

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

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MOOCS AND GAMIFICATION

Gamification

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

RETENTION

	Day 1	Day 2	Day 3	Day 4	Day 5	Day 6	Day 7
2/25/2015	65.0%						
2/24/2015	65.0%	55.0%					
2/23/2015	60.0%	55.0%	45.0%				
2/22/2015	60.0%	55.0%	45.0%	40.0%			
2/21/2015	50.0%	45.0%	40.0%	40.0%	35.0%		
2/20/2015	50.0%	40.0%	40.0%	40.0%	40.0%	30.0%	
2/19/2015	50.0%	40.0%	40.0%	40.0%	30.0%	30.0%	30.0%

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

- Games industry is growing exponentially in the worldwide economy
- Key factors: use of common game concepts such as leaderboards and achievements
- The massive use of this approach and the impressive growth of players led to the concept of **gamification as a service**
- **Game Backend as a Service (GBaaS)** appeared ...

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

	FEATURES	Google	Yahoo	GameUp	GSparks	PlayFab	Photon
SOCIAL	**Leaderboards**	YES	NO	YES	YES	YES	YES
	Achievements	YES	YES	YES	YES	NO	NO
	Multiplayer	YES	YES	NO	YES	YES	YES
	Save Data	YES	YES	YES	YES	YES	YES
	Quests	YES	NO	NO	YES	NO	YES
	Gifts	YES	YES	NO	YES	NO	YES
	Matchmaking	NO	NO	YES	NO	YES	YES

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

	FEATURES	Google	Yahoo	GameUp	GSparks	PlayFab	Photon
TECH	**Pricing**	Free	Free	Freemium	Freemium	Freemium	Freemium
	Auth	Google+	Yahoo Facebook	Facebook	Facebook Twitter	Facebook	Facebook
	Storage	-	BigDB	-	MongoDB	-	-
	Web Service	REST	-	REST	REST	-	REST
	Response format	JSON	-	JSON	JSON	-	JSON
	Platforms	Android iOS C++	ActionScript iOS Android C# Unity	Android iOS Unity	ActionScript C++ Cocos2D JavaScript Marmalade Unity	Android iOS Unity	Android .NET Unity

MOOCS AND GAMIFICATION

Gamification

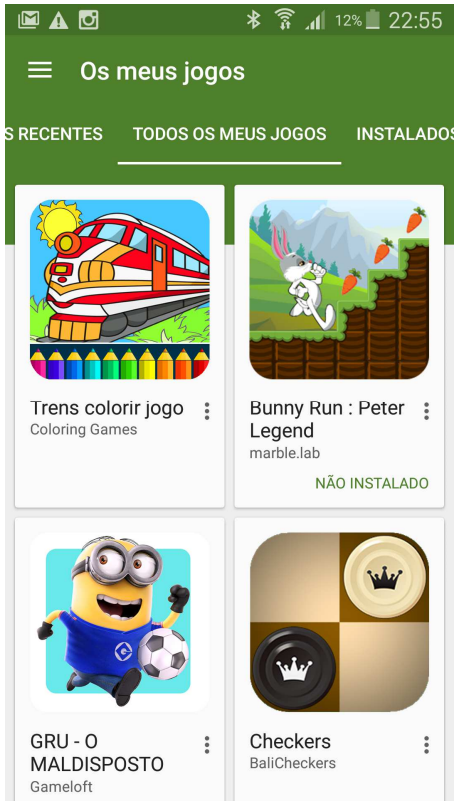
- **Google Play Games Services** is an online gaming service operated by Google;
- GPGS was introduced at the Google I/O 2013 Developer Conference;
- It features:
  - Real-time and Turn-based multiplayer gaming;
  - Cloud saves;
  - Social and public leaderboards;
  - Achievements;
  - Analytics;
  - Events and Quests;
- You can download client SDKs for Android, iOS and C++;
- Also a REST API for GPGS allows you to issue REST calls to set and retrieve game services data from your web game!

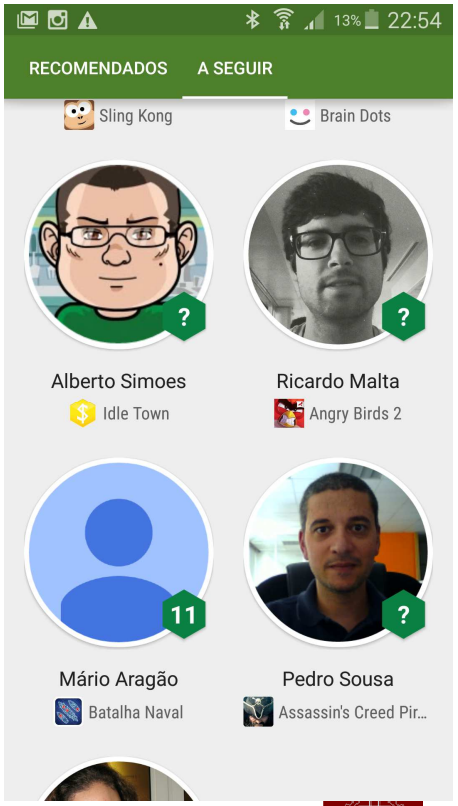
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

- **Google Play Games** app was launched on 2013
- Similar to Apple's Game Center, a social gaming network for iOS
- Play Games received over 100 million new users in the first semester of 2014, making it the fastest growing mobile gaming network of all time



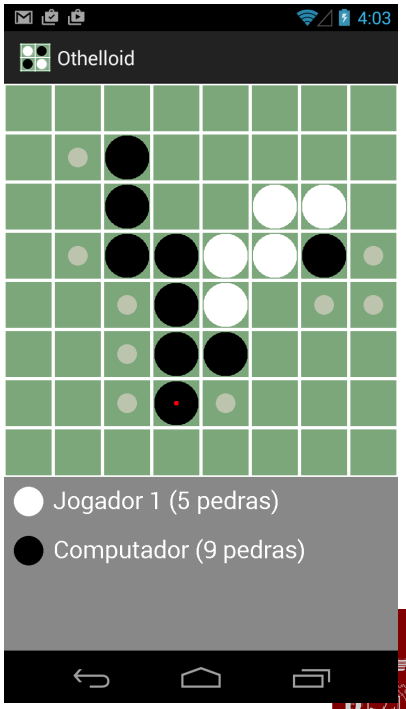


GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

- Reversi (Othello) is a strategy board game for two players, played on an 8×8 board
- Othello + Android = **Othelloid**



GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

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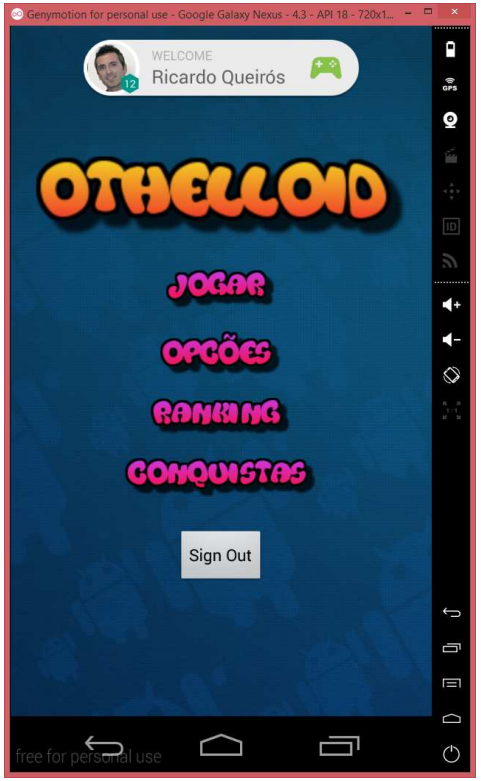
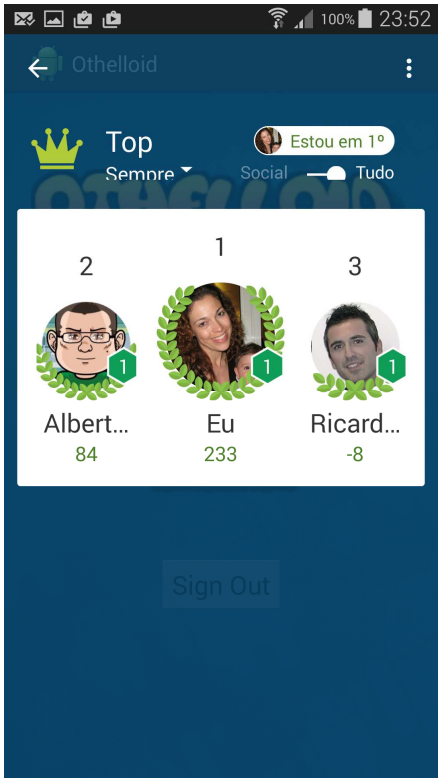
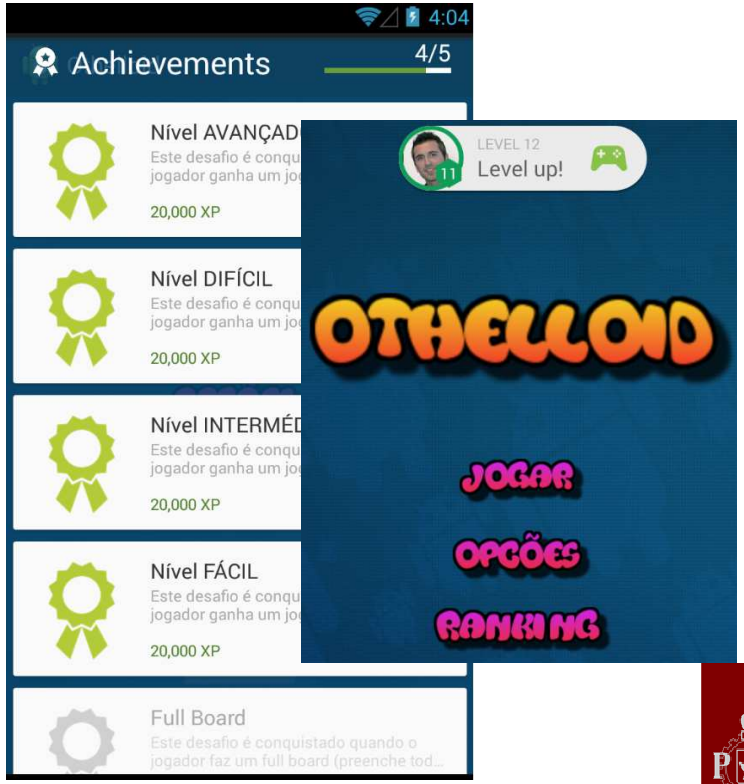






MOOCS AND GAMIFICATION

Gamification

So, I'm going to use Google Play Games Services?

MOOCS AND GAMIFICATION

Gamification

So, I'm going to use Google Play Games Services?

NO

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

Gamification

- Creation of Odin REST API (2016)
- A gamification service for learning activities
- You can use this API in any application requiring gamification features.
- With language bindings in Java

Odin

- Link: http://odin.dcc.fc.up.pt:8080/odin-web-api/

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

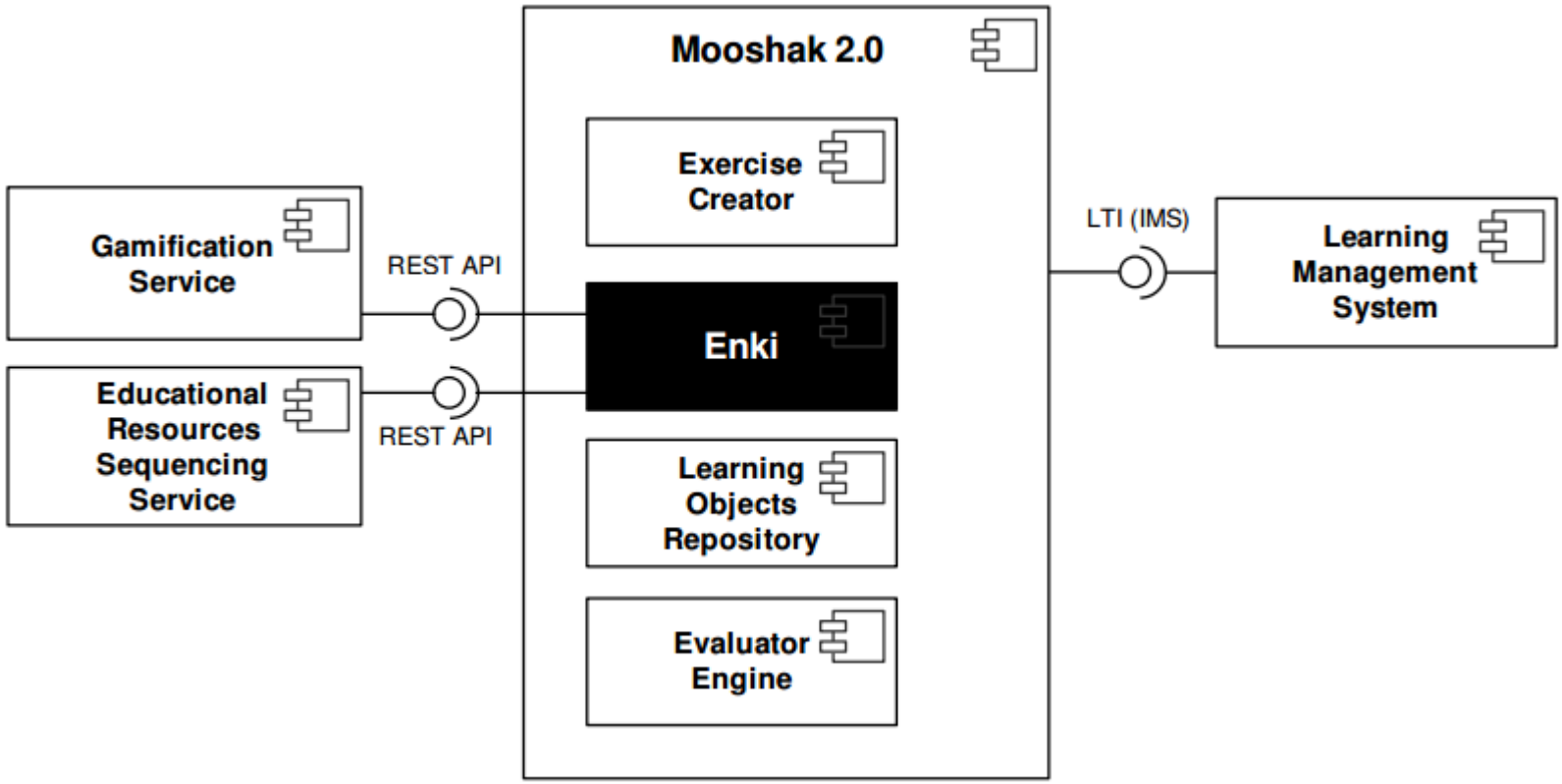
ENKI

- Creation of Enki (2016)
- A web-based IDE that integrates several pedagogical tools designed to engage students in learning programming languages
- Enki achieves this goal
  1. by sequencing educational resources, either expository or evaluative
  2. by using gamification services to entice students to solve activities
  3. by promoting social interaction
  4. by helping students with activities, providing feedback on submitted solutions
- Based on Mooshak 2.0
- Used in
  - Several universities
  - Several programming contests (IEEE, SWERC, TopAS, …)
- Link: http://mooshak2.dcc.fc.up.pt/mooshak/enki/overview-enki

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

ENKI



GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

ENKI

Enki

Tutorial | PT EN | Administrator Logout

Resources

Introduction to C# Programming

Data Types and Variables

Console Class

Data Types

Variables

Strings

Variable Life-Cycle

Area and Perimeter of Circumference

Area and Perimeter of Circumference using Variables

Hello World

Statement: Hello World | Editor | Ask a Question

Escolher ficheiro Nenhum ficheiro selecionado skeleton1

Program file name program.cs

```
3  using System.Linq;
4  using System.Text;
5  using System.Console;
6
7  namespace P01
8  {
9      class Program
10     {
11         static void Main(string[] args)
12         {
13             Co
14         }
15     }
16 }
```

Console local
Collections local
continue keyword
const keyword
ctor snippet
stackalloc keyword

Observations | Error

Tell others what you think ... why?

Submit

Statistics | Leaderboard | My Data

Player	Score
Alexandra Rodrigues	36.0
Joana Mendes	36.0
Luis Ferreirinha	36.0
César Menezes	34.0
Diogo Almeida	33.0
João Santos	22.0
Cláudia Damas	21.0

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Tests

Input	Output
	Hello World!

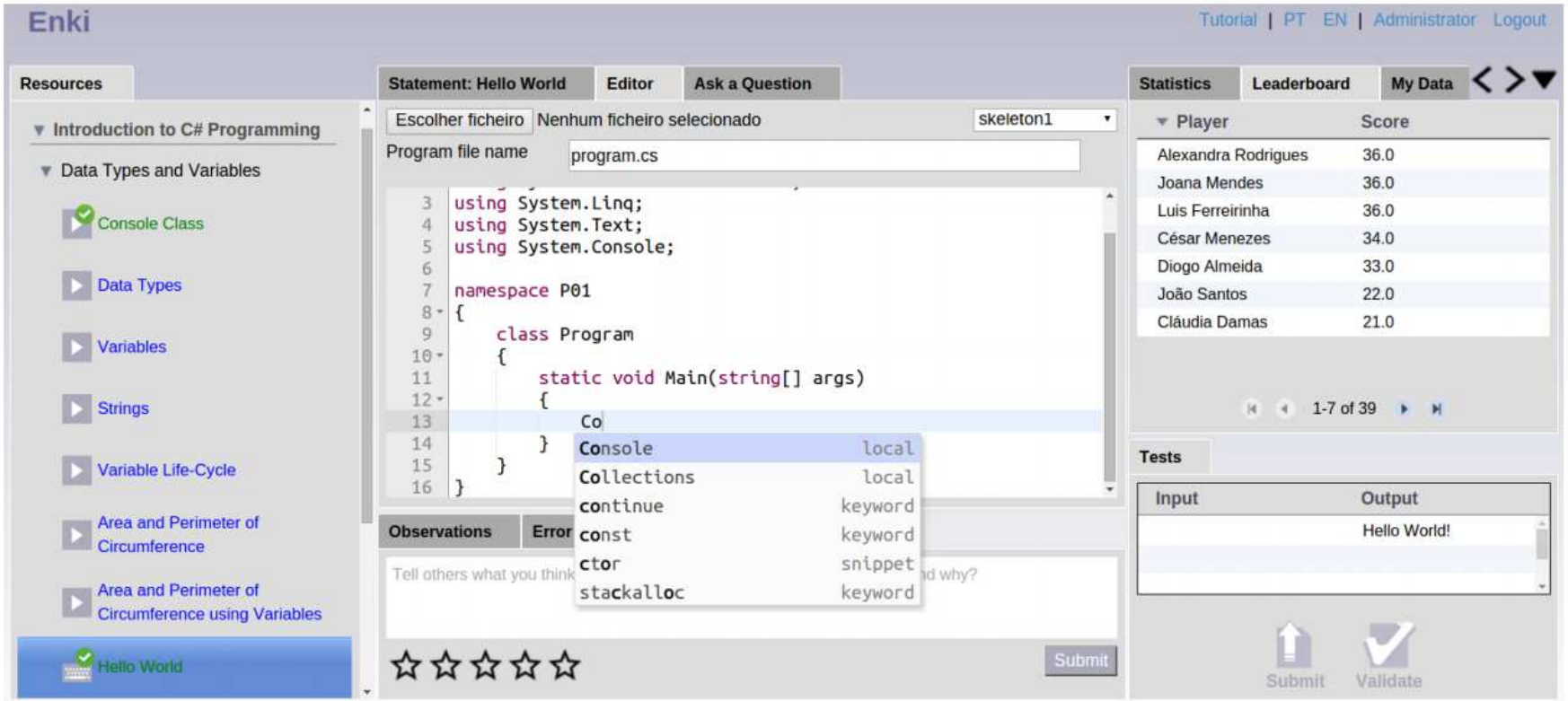
Submit Validate

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

ENKI

[VIDEO]

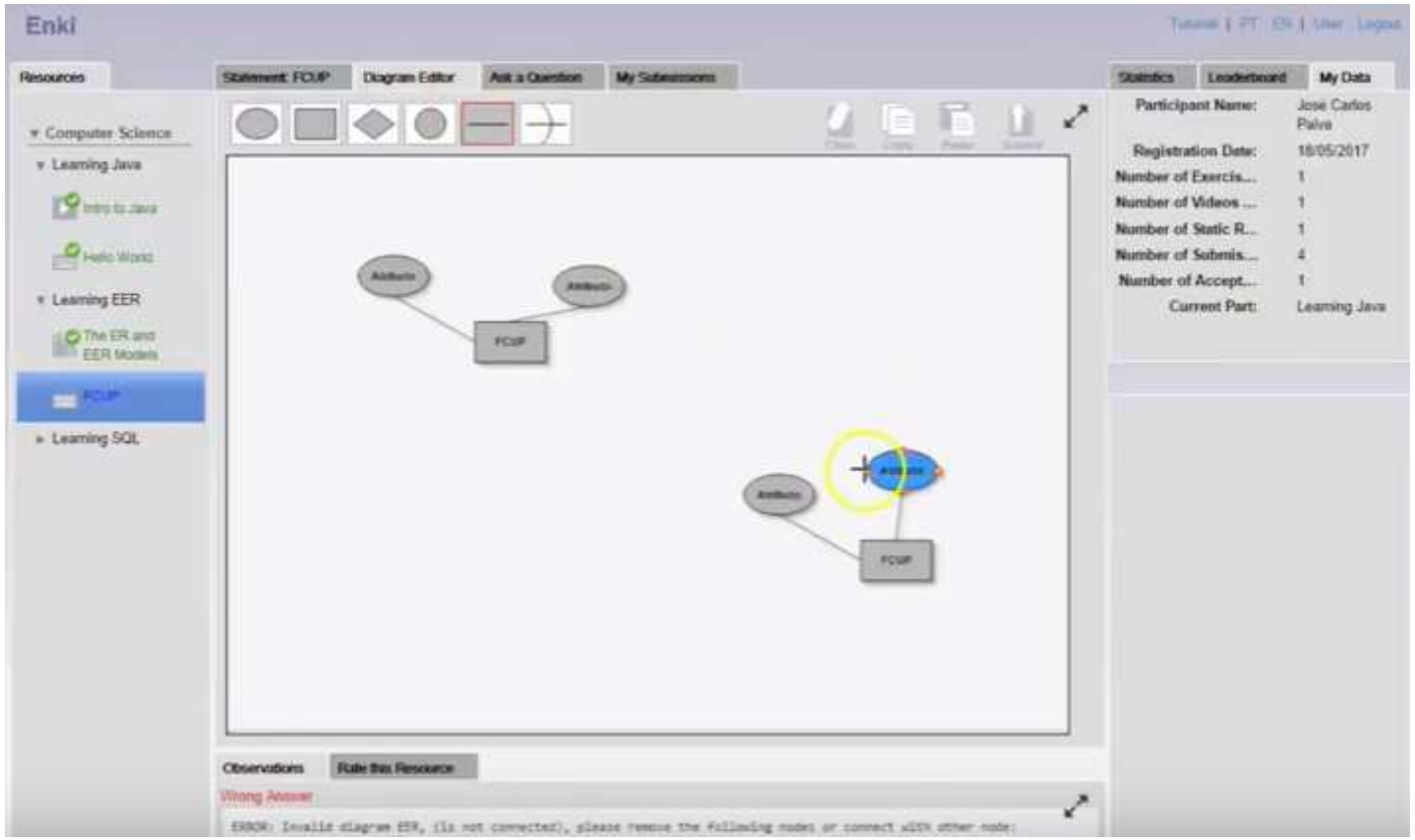


GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

ENKI

- Addition of other types of editors (ERD, SQL,…)



MOOCS AND GAMIFICATION

MOOC

And what about MOOCs?

MOOCS AND GAMIFICATION

MOOC

And what about MOOCs?

We just show a Computer Programming MOOC!

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

MOOC platforms

58M
Students

700+
Universities

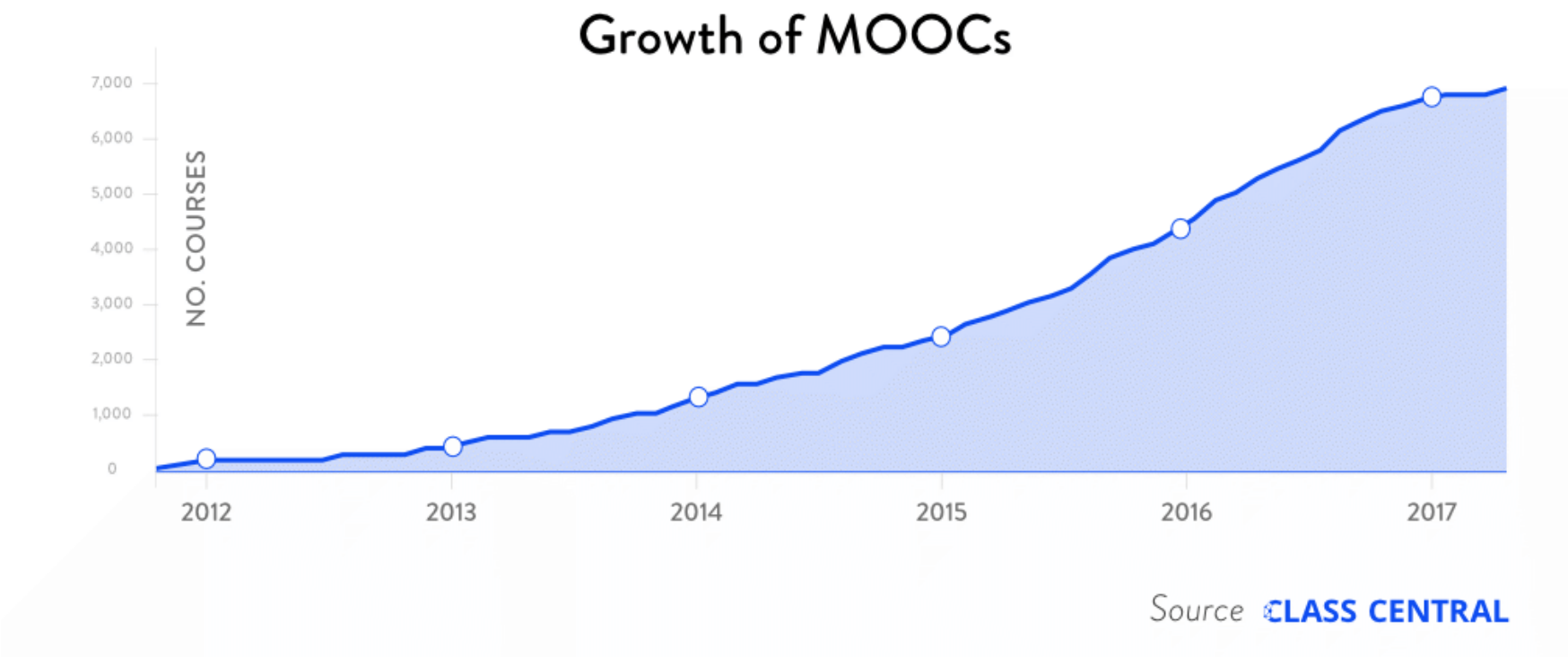
6850
Courses

MOOCs in 2016. Analysis by Class Central

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

MOOCS AND GAMIFICATION

MOOC platforms



MOOCS AND GAMIFICATION

MOOC platforms

- By registration count:
  1. Coursera – 23 million
  2. edX – 10 million
  3. XuetangX – 6 million
  4. FutureLearn – 5.3 million
  5. Udacity – 4 million

- Other players:
  - Moodle
  - CourseSites (BlackBoard)
  - Udemy
  - Versal

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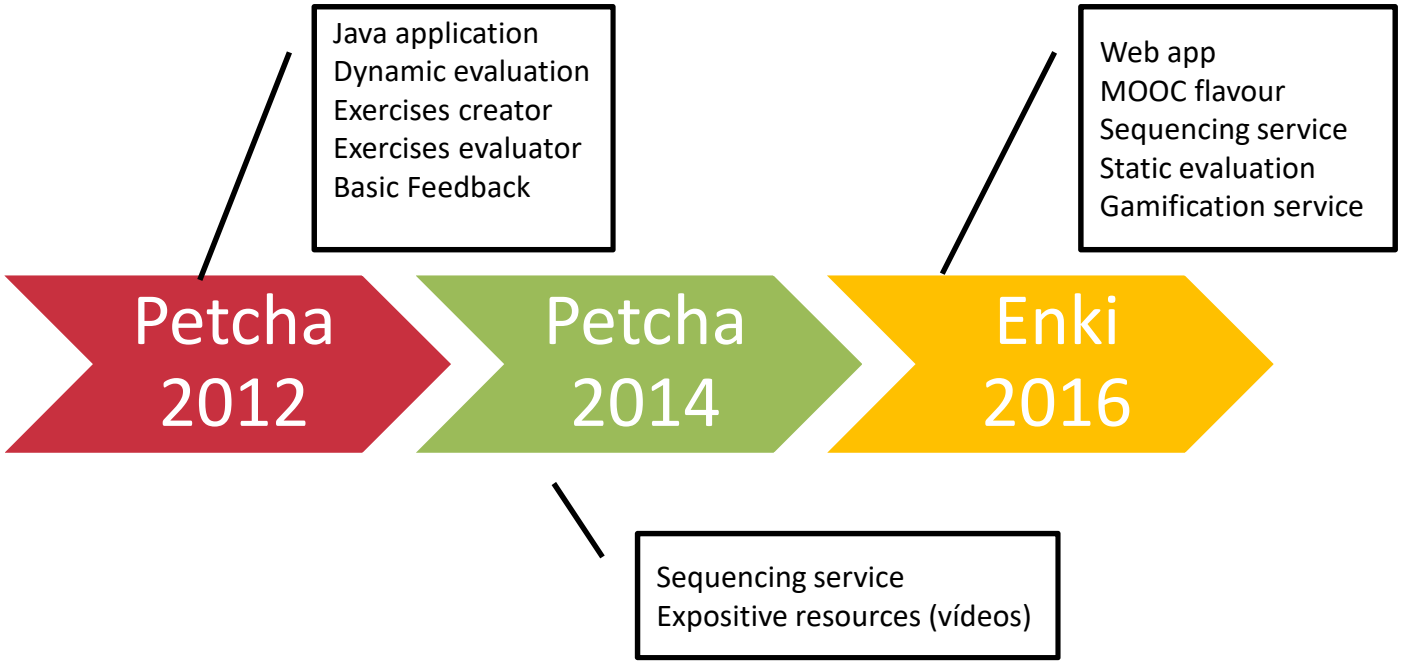
GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

FUTURE

Timeline



GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

FUTURE

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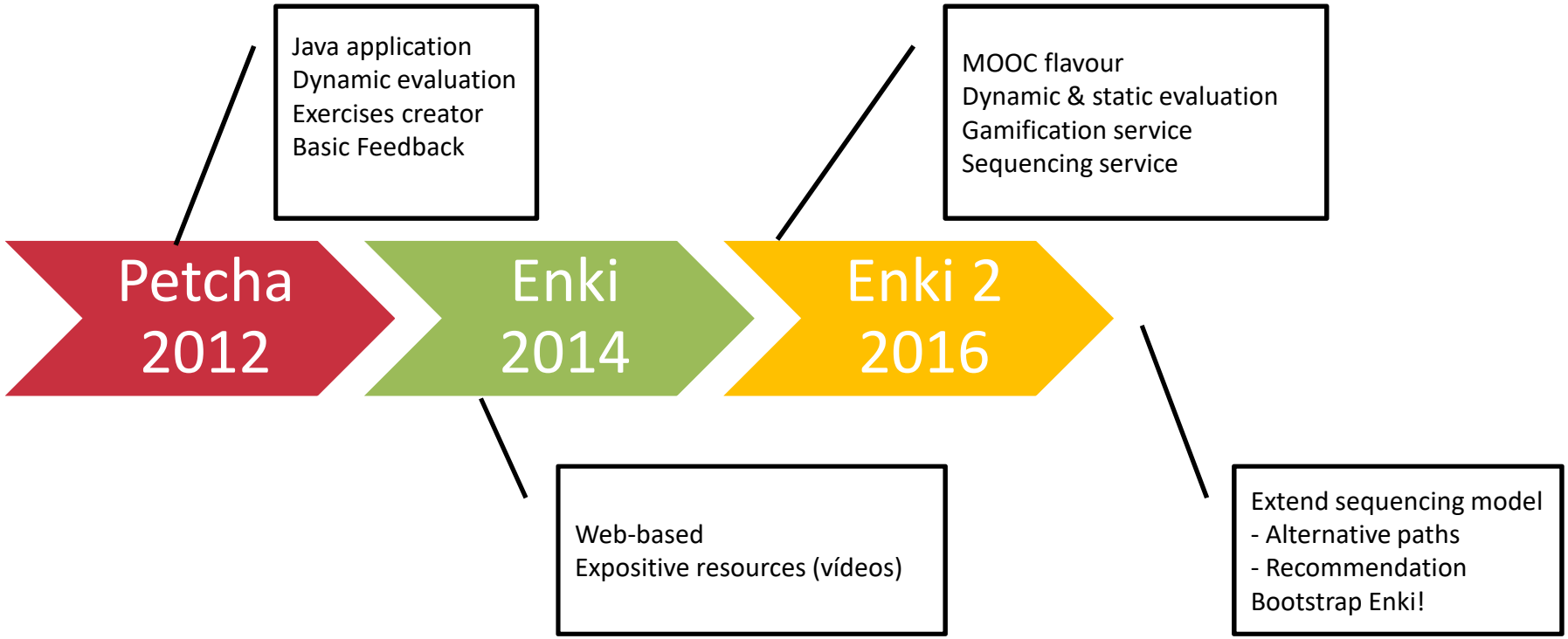

GAMIFICATION OF MOOCS: FOSTERING THE COMPUTER PROGRAMMING LEARNING

Q/A

Ricardo Queirós
ricardoqueiros@esmad.ipp.pt

"I practice until I have my life in my fingers"
Pianists' expression