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From Rationalism to Empiricism in Software Testing Education Through Gamification

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Importance of software testing

SCHARON HARDING, ARS TECHNICA

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A Leap Year Glitch Broke Self-Pay Gas Station Pumps Across New Zealand

It's like if the Y2K bug happened, but only for gas station pumps. And only in New Zealand.

Figure: Screenshot of an article titled "A Leap Year Glitch Broke Self-Pay Gas Station Pumps Across New Zealand" [1]

Software Testing in CS Education

- ▶ Integrating it into Computer Science curricula is challenging [2], [3].
- ▶ Often a **rational design paradigm** is used in CS programs.
- ▶ Little research on didactic approaches is available.

Consequences

The way we now teach software testing leads to:

- ▶ Students who use a ‘developer approach’ to testing [4].
- ▶ This approach lacks exploration and experimentation.

We need to shift the mental model of students away from this rational approach.

RATIONALISM - EMPIRICISM

RATIONALISM



EMPIRICISM



Abductive reasoning as the base for testing

Abductive reasoning is a form of logical inference that seeks the simplest and most likely conclusion from a set of observations [5].

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This fits very well with exploratory testing because:

What the behaviour of the system looks like is unknown, **how** the design process of tests should look like is unknown. The **desired situation** is unknown, and so is **the road towards it**.

Development of a game to teach software testing



Our goals for a serious game:

- ▶ Incorporating empirical methods and critical thinking.
- ▶ Supporting different educational contexts.
- ▶ Enabling abductive reasoning.

Gamification in CS

- ▶ Gamification is effective in CS education through: Real-world scenarios, competitive elements, immediate feedback, interactive activities, and collaboration [6].
- ▶ Gamification is applicable across various educational strategies and contexts [7]–[9].
- ▶ Applying gamification can lead to oversimplification and decreased intrinsic motivation [6].

CodeDefenders: game to learn mutation testing



The screenshot shows the CodeDefenders game interface. At the top, there's a navigation bar with links for 'Home', 'Multiplayer', and 'Puzzles'. Below that, the title 'Game #3666' is displayed, along with player roles: 'Meles' (Melee) and 'Observer'. A toolbar at the top right includes buttons for 'End Game', 'Rewards', 'Scoreboard', 'Timeline', 'Grade Report', 'Feedback', 'Editor Mode: default', and 'Chat'.

The main area is divided into two sections:

- Existing Mutants:** This section lists various mutants, each with a collapse/expand arrow. The mutants include:
 - All Mutants
 - Mutants outside methods
 - UFL(0x1,0x1)
 - getTopFloor()
 - getCurrentFloor()
 - getCapacity()
 - getNumFloors()
 - isFull()
 - addRiders(int)
 - goUp()
 - goDown()
 - calExit()
- Class Under Test:** This section displays the source code for the `Lift` class.

```
1 public class Lift {  
2     //  
3     private int topFloor;  
4     private int currentFloor = 0; // default  
5     private int capacity = 10; // default  
6     private int numRiders = 0; // default  
7     //  
8     public int highestFloor() {  
9         topFloor = highestFloor;  
10    }  
11    //  
12    public int highestFloor, int maxRiders) {  
13        this(highestFloor);  
14        capacity = maxRiders;  
15    }  
16    //  
17    public int getTopFloor() {  
18        return topFloor;  
19    }  
20    //  
21    public int getCurrentFloor() {  
22        return currentFloor;  
23    }  
24    //  
25    public int getCapacity() {  
26        return capacity;  
27    }  
28    //  
29    public int getNumRiders() {  
30        return numRiders;  
31    }  
32    //  
33    public boolean isFull() {  
34        return numRiders == capacity;  
35    }  
36}
```

At the bottom of the screen, there are buttons for 'Live', 'Killed', 'Claimed Equivalent', and 'Equivalent'. A note 'Mutant/Test restrictions: Moderate' is also present. The footer contains links for 'About CodeDefenders', 'Contact Us', 'Help', and 'Imprint and Privacy Policy'.

Figure: CodeDefenders, an online game to learn mutation testing

Testable: gamification of unit testing



Figure: Testable - gamified tool to improve unit testing teaching

Testing Maze: adventure into functional testing

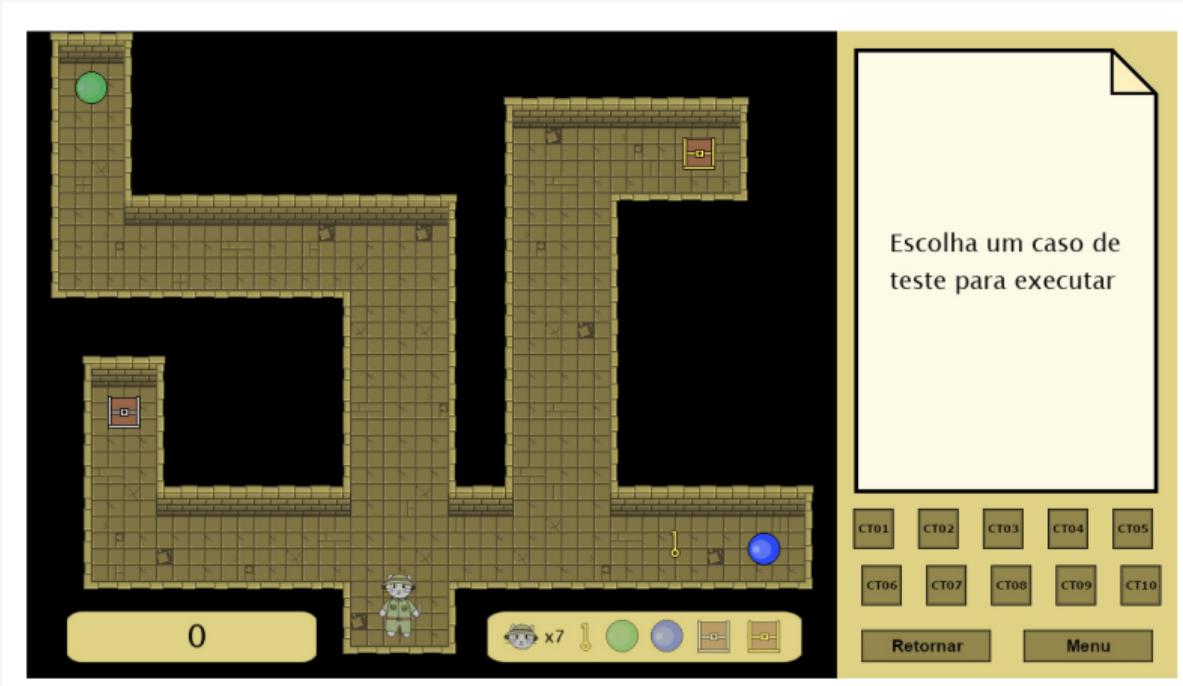


Figure: Testing Maze, an educational puzzle game for teaching functional testing concepts and test specifications containing a fantasy narrative

TestSphere: card deck to support interaction



Figure: TestSphere, a card deck to support testers thinking and talking about testing

Would Heu-risk it?: card deck to share experiences



Figure: 'Would Heu-risk it?' is centered around risk analysis, heuristics, patterns/anti-patterns of software testing

Gap in existing game and our goals

- ▶ Most games focus on techniques.
- ▶ No games on our goals.
- ▶ We need to develop a game ourselves.

Our game

Based on Risk Storming using TestSphere:

1. Starting with a System Under Test.
2. Identifying the most relevant quality aspects.
3. Identifying risks for these aspects, **supported by socrative questions**.
4. Mitigate these risks with techniques.
5. Form an initial testing plan.

Socrative Questioning

Socratic questions are a form of inquiry and discussion between individuals, based on asking and answering questions to stimulate critical thinking and to illuminate ideas.

Examples of Socrative Questions used in the game[®]

- ▶ How does the system verify and ensure that the data processed is current and accurate?
- ▶ In what ways does the system maintain the confidentiality and integrity of personal data?
- ▶ Are there any performance benchmarks or metrics that the system is expected to meet?
- ▶ What are the disaster recovery and business continuity plans for the system?

Wheel of socrative questions

Wheel of Socrative questions

This app is part of a serious game on software testing. For more information, visit the [GitHub repository](#).



"Spin" the Wheel

How would a substantial shift in the data patterns impact the strategic use of the system?

Pilot Study & Results

- ▶ We did a pilot study with four sessions with Bachelor and Master CS students of OU and NHL Stenden.
- ▶ Improvements observed in students' testing strategies.
- ▶ Students feel more secure about their tests.

Pilot Study & Results



Figure: Students playing the game

Future Work

- ▶ Further develop game mechanics.
- ▶ Validate and expand the socratic questions.
- ▶ Trials with students in different educational contexts.
- ▶ Publish the game (under CC license).

Thanks for your attention

- ▶ Software Testing is important.
- ▶ We need to shift to an approach based on empiricism.
- ▶ Gamification is an approach to support this in multiple educational contexts.
- ▶ We propose abductive reasoning as a basis for the didactic approach.
- ▶ We did a pilot to gain insights using socrative questioning.
- ▶ Game mechanics need to be further developed.



Figure: More information about my research on <https://research.nielsdoorn.nl>

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