An Interactive Introduction to Gamification in Technical Higher Education
Alexandru Iosup
A Testimonial

I want to thank you for showing that even though I’m not that good at written exams, I still can excel at other points in my study. I’d love to have a copy of my badge, as physical reminder of a course that made me eager to learn about things. Even when some of those things will never really have my interest. This course, and the way it was given, learned me a few things about what motivates me, and only for that reason it was totally worth getting up for every lecture.

Image source: http://www.bcsea.org/learn/educational-opportunities

**What Is This Talk About?**

Gamification* = Rich Challenge and Opportunity for Higher Education

Gaming is about a variety of worlds and of people

Gaming is challenge and reward, tension and catharsis

Game universes populated with all levels of skill

Game universes populated with all personalities

* Making courses similar to social game universes
Internal Information, Major Technical University in the NL (Top-20 in the World*)

- “P-in-een” of an important BSc track <40%
- Completion in time of the BSc (# years + 1) <35%

- Vs China, Romania, South Korea, etc.?
Exercise 1: The Blame Game – Who is responsible?

- Team work, first 5 minutes
  - Form team of 2-3 persons
  - Think about own experience
  - Convince your partner before proposing an answer

- Open discussion, next 5 minutes
  - Tell everyone the answer

Q: Who is responsible for the current outcome of higher education?

Voting on best answer
Why Fix It If It Ain’t Broken?

• Well, it’s broken bad (at least the grammar)

• New generation of students
  • Attention span
  • Is higher education needed?
  • A technical education?!

• New understanding of students
  • International means multi-cultural
  • Aware of individual personality and skill-level

• It’s not you, it’s me

• New ambition of GamificationU (Top-20 Eng/Tech*)
  • <35% finish 3-year B.Sc. Curriculum in 4 years ...
  • ... but cannot select students

What is This Talk Also About?
My Personal Curiosity*


* “A Magical New Adventure”
How to Think About This Talk?
This Talk is an Interactive Introduction

Q: What would you learn about the Van Gogh Museum from the poster?
What Is This Talk About?

1. Intro: Delft, we have a problem
2. What’s in a game?
3. Could gaming techniques work in education?
4. Our work on gamification
   1. How to gamify a course? (theory)
   2. Is gamification useful? (practice)
5. Conclusion
What’s in a name?

Over 250,000,000 active players

Social Gaming = (online) games for which social interaction improves or helps the gaming experience

1. **Mechanics**
   - Explore, do, learn, socialize, compete +

2. **Dynamics, incl. Rewards**
   - Player stats, badges, others +

3. **Game Content***
   - puzzles, challenges, extra-projects, culture

*Romeo and Juliet*  
*Art class pending.*
Why Gamification*?

* Making courses similar to social game universes

"Science and scholarship are much like games. [...] playing involves creating, testing and revising strategies as well as the skills necessary for progressing in the game." Mayra 2009

"51% US households own a console ... 58% Americans play ... 45% are women" ESA’14

## But…: (Meta-)Research on the Use of Game Elements in Education

### Meta-study of … studies

<table>
<thead>
<tr>
<th>Study</th>
<th>Meta-study of … studies</th>
<th>Findings</th>
</tr>
</thead>
<tbody>
<tr>
<td>Randel et al. (1992)</td>
<td>&gt;60</td>
<td>&gt;50% no difference if using games. &gt;30% significant improvement when using games.</td>
</tr>
<tr>
<td>Hays (2005)</td>
<td>&gt;100</td>
<td>Game <strong>design must match learning objectives.</strong></td>
</tr>
<tr>
<td>Vogel et al. (2006)</td>
<td>&gt;30</td>
<td>Games <strong>can help</strong> improve cognitive skills vs. traditional.</td>
</tr>
<tr>
<td>Sitzman (2011)</td>
<td>&gt;60</td>
<td>Playing <strong>improves confidence.</strong> Vs. traditional, better retention, declarative and procedural knowledge</td>
</tr>
</tbody>
</table>
What Is This Talk About?

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Our Work At GamificationU, >10+ Operational Years Since 2007

• B.Sc. Courses
  • (B) Computer Organization (4 years)  
    (previously, was rated consistently lower than others, considered tough and boring course, different type of learning—comp.systems)
  • Bachelorseminarium (5 years, evolving form, I stopped 2013)

• M.Sc. Courses
  • (M) Cloud Computing (3 year, pair teaching, new course)
  • Distributed Computing Systems (2 years, new course)
Into Our Approach to Gamification:
1 B.Sc. Course, 1 M.Sc. Course

<table>
<thead>
<tr>
<th>BSc-C0, 6EC (168h)</th>
<th>MSc-CC, 5EC (140h)</th>
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</thead>
<tbody>
<tr>
<td>Digital Logic and Data Representation</td>
<td>Overview of cloud computing</td>
</tr>
<tr>
<td>Computer Architecture and Organization</td>
<td>Scheduling and Resource Management</td>
</tr>
<tr>
<td>Interfacing and I/O Strategies</td>
<td>Data Centers and Energy Efficiency</td>
</tr>
<tr>
<td>Memory Architecture</td>
<td>Multi-tenancy concepts, incl. virtualization</td>
</tr>
<tr>
<td>Functional Organization</td>
<td>Cloud programming models</td>
</tr>
<tr>
<td>Multiprocessing</td>
<td>Case studies</td>
</tr>
<tr>
<td>Performance Enhancements</td>
<td>Guest lecturer</td>
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<tr>
<td>Directions in Computing</td>
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</tbody>
</table>

- Education in systems, especially parallel and distributed computing
- Technically deep, conceptually at least broad
- Scalability and elasticity are long-lasting research topics
- Emerging comp.sci. topics, such as GPUs and cloud computing
Start With the Perfect Student

- Explain students what is expected to learn and do
- Explain how to get a 10, not how to get a 6
- Coarse and detailed explanation of expectations
- Coarse and detailed time allocation

Q: What is the problem with this student?
Innovation [1/3]:
Address Different Students

- Richard Bartle’s “Players who suit MUDs”

  - **Achievers**
    - Solve the challenge

  - **Explorers**
    - See what’s there

  - **Socializers**
    - There for others

  - **Killers / Winners**
    - Win against others

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Innovation [2/3]: through Diverse Gamification Elements

- Too many to list here
  - Scoring system is but one element
  - Badges? Only for B.Sc., some “random” Manga cum laude

- Onboarding (dynamics)
  - Entry quiz
  - Story every lecture

- Social Learning (dynamics)
  - In-class teams
  - Self-study as team effort
  - Involve Winners and Achievers in class
  - Involve Winners and Explorers in self-study

- Different player types
  - Ladders, ranking, end-lecture quiz: mostly for Winners
  - Content unlocking (dynamics): Explorers and Achievers

## Innovation [3/3]: ... and a Diverse Scoring System

<table>
<thead>
<tr>
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</thead>
<tbody>
<tr>
<td>10,000 for straight 10</td>
<td>Start with 1</td>
<td>I will bake brownies for you! (but not force you to eat them)</td>
</tr>
<tr>
<td>+1,000 for straight 10</td>
<td>1. Gamification = more tracks of advancement (Lab, Lectures, Tutorial, Self-Study) + keeps top students involved in the classroom</td>
<td></td>
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<tr>
<td>+1,000</td>
<td>2. Decoupling grading schemes = responding to diploma hunters (“cultuur van zesjes”)</td>
<td></td>
</tr>
<tr>
<td>+500 for straight 10</td>
<td>3. Access to unlocked content = content, both graded and not, offered as reward for achieving/excelling at course milestones</td>
<td></td>
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<tr>
<td>+300 for straight 10</td>
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<tr>
<td>+500 for straight 10</td>
<td></td>
<td></td>
</tr>
<tr>
<td>+25 correct end-lecture quiz</td>
<td></td>
<td></td>
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<tr>
<td>+500 entry quiz</td>
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**Gamification**

- More tracks of advancement (Lab, Lectures, Tutorial, Self-Study) + keeps top students involved in the classroom

**Decoupling grading schemes**

- Responding to diploma hunters (“cultuur van zesjes”)

**Access to unlocked content**

- Content, both graded and not, offered as reward for achieving/excelling at course milestones

**References**

Exercise 2
(5 minutes work + 5 minutes talk)

- Groups of 3-4
- Convince your team before writing down an answer
- Discussion (talk) at end

Q: What game elements would you use in your own course?
“I would use ... because ...”

Voting on best answer

1. **Mechanics**
   Explore, do, learn, socialize, compete
   +

2. **Dynamics**
   Onboarding, player stats, unlocked content, social engagement, others
   +

3. **Game Content**
   puzzles, challenges, extra-projects, culture
What Is This Talk About?

1. Intro: Atlanta, we have a problem
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The TU Delft Gamification Movie

• Best Lecturer of the TU Delft, 2013—2014
  http://goo.gl/NtORVi
Is This Playful (or) Education?

Q: Is gamification useful for educators?

Two thirds of our students pass after their first try.

Exam in 2012 more difficult than exam in 2011. etc.
Self-study work in 2012 more extensive than in 2011. etc.
We keep top students in the classroom.
We get requests for Honors Track/Challent.
etc.
Gamification, the Numbers: Overall Participation and Success

- Increasing number of students, B.Sc. (M.Sc. designed for ~15)
- Exam results: Gamification delivers at least as traditional approach
- Scalability limit with gamification? Future work.
Gamification, the Numbers: Successful Via Alternative Paths

Successful = bonus-worthy

- A significant fraction of students take alternative paths of advancement
- Increasingly more students benefit from each alternative (warning: natural limit at 100%)
- At least one successful alternative? 45%

Q: Is it good for so many students to receive bonuses? (Hint: In-class bonus=0.5%/item)
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What’s Next to Study in Gamification?

- Macro
  - Does gamification lead to sustained improvement at TUD?
  - Which gamification element is responsible for the largest improvement at TUD?
  - Which type of learning goal gains most from gamification, at TUD?
  - Which type of student gains most from gamification?
  - Which level of student gains most from gamification?
  - How to measure? Long-term studies, etc.

- Micro
  - Tuning point flows
  - Tuning gamification elements
  - Measure reaction of students
Gamification* in Higher Education = Rich Opportunity

* Making courses similar to social game universes

Gamification = mechanics, dynamics, content (art)

10+ operational years of experience at GamificationU

Gamified courses can deliver results at least as good as traditional approaches, but can engage students more

There’s no free lunch!

Tip: Ask me about the costs.

TODO: which mechanisms? Longitudinal studies. Etc.

Tip: Ask me, at the end, about the future work.
Gamification* in Higher Education = Rich Opportunity

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Gamified courses can deliver results at least as good as traditional approaches, but can engage students more

Tip: Ask other findings?

There’s no free lunch!

Tip: Ask me about the costs.

TODO: which mechanisms? Longitudinal studies. Etc.

Tip: Ask me, at the end, about the future work.
In-Class Questions
(Summary of Two Sessions)

1. Why did you not design this as a gamified experience?
   I did design it as a gamified experience, but also to show that you do not need to change your entire course to use gamification. Here, elements of narrative, interactivity, verbal reward for good questions and answers (“Good question!”), work in pairs and teams. Plus... was it fun for you?

2. What is specifically game-related in technique X or element of gamification Y that you have shown?
   Ludologists would perhaps solve this more elegantly, but let me state again: gaming and other performing arts are intertwined. The challenges, the puzzles, the goal-setting and achieving introduced in this workshop are the specifically game-related elements.
In-Class Questions
(Summary of Two Sessions)

3. I think there are other issues with higher education, such as funding. How does gamification solve these? (Can gamification solve all my problems?)
Gamification can only solve a part of the problems, among which many of the problems identified in the agenda point 2. It cannot replace bad teaching skills, funding, etc.

4. I don’t think (computer) games are as wide-spread as you claim. Or that they can help with education.
First, you are fighting a growing body of evidence with personal opinions. Games are spread well enough that our students know them well. This lecture has very little to do with computer games or any specific type of game, but it does mention core rules (mechanics) that appear in many games.
In-Class Questions (Summary of Two Sessions)

5. Is gamification only about rewards? Aren’t rewards extrinsic motivation and inherently bad?
   As show in this workshop, gamification includes many different elements, one of which is the reward structure. Rewards can often be thought as both extrinsic and intrinsic (a final grade is an extrinsic goal—to finish—but also an intrinsic goal—to evaluate and later improve.) Designing rewards is an art.

6. I would have liked to get a checklist on how to gamify a course. Unfortunately, this is like asking for a checklist in a course on novel writing; I could explain the process, but the details would still solicit the student’s skills (knowledge, design, and art). In other words, there is no detailed list, only general guidelines and some detailed examples.
A Brief History of Computer Games

1970s: The Device
- Pong

1980s: The Hero Era
- 1981: Handheld Crash
- 1983: Videogame Crash
- Space Invaders
- Pac-Man

1990s: The Tech & Genre Era
- Doom
- Elite

2000s: The Social Gaming Era
- Mario
- Animal Crossing
Intuition: Games Cater for Different Player Levels

- **RuneScape**: 135M+ open accounts (world record)
- **Dataset**: 3M players (largest measurement, to date)
  - 1.2M players under level 100
  - Max skill 2,280
- **Number of players at each level** (low, mid, high) is significant, anytime

### Detailed Time Allocation

<table>
<thead>
<tr>
<th>Course</th>
<th>Lecture</th>
<th>Tutorial</th>
<th>Lab</th>
<th>Self-Study</th>
</tr>
</thead>
<tbody>
<tr>
<td>1. Digital Logic</td>
<td>4h</td>
<td>1/2h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>2. Data Repr./Processing</td>
<td>4h</td>
<td>1/2h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>3. ISAs/Assembler</td>
<td>6h</td>
<td>2h</td>
<td>16+8h</td>
<td>20h</td>
</tr>
<tr>
<td>4. Basic Processing Unit</td>
<td>4h</td>
<td>2h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>5. I/O + OS Principles</td>
<td>2h</td>
<td>1h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>6. Memory + Performance</td>
<td>2h</td>
<td>1h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>7. Pipelining + Perf.</td>
<td>2h</td>
<td>2h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td>8. Programming Principles</td>
<td>2h</td>
<td>-</td>
<td>-</td>
<td>5h</td>
</tr>
<tr>
<td>9. Parallelism/Distribution</td>
<td>2h</td>
<td>1h</td>
<td>-</td>
<td>10h</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>28h</td>
<td>14h</td>
<td>16+8h</td>
<td><strong>95h</strong></td>
</tr>
</tbody>
</table>
There’s No Free Lunch in Comp.Sci. (My Personal XP)

- Gamification takes time and energy
  - One week to consider gamification elements +
  - One day per lecture for adaptation +
  - Continuous adaptation +
  - End-lecture quiz +
  - Explaining a new system to students +
  - The nitty-gritty details

- Gamification takes moral strength (did I say that?!)
  - A new system has to conquer inertia
  - An untested new system has to conquer doubt
  - Support from TUD at most limited
  - On the positive side, I really enjoyed the open and inquisitive attitude of the Dutch student
We Also Found That…

- Top students like to learn for the sake of learning (based on participation in un-marked extra-lectures).

- Mid-term performance characterizes well the top performers. This allows for an early identification of Winners and Achievers.

- Only about 10-15% of the students fit, in our experience, the profile of Winners (~5%) or Achievers. This is much less than expected (25%).

- For the gamification-based courses, a high fraction of students who have failed the first time return to take the re-examination exam. This contrasts starkly with non-gamified courses.

http://pbskids.org/itsmylife/blog/2010/03/miyazaki-mania.html
Exit Quiz (started Q3 2012—2013)

- (Yes-No-Don’t care questions) (>90% 75-90% 50-75%)

- I understand how this course was gamified

- Gamification made me more motivated

- Gamification made me think more carefully about what I like to do (where I can get bonus points)

- I enjoyed the interactive part of the lectures

- I enjoyed the exercises at the end of the lectures
Testimonials

Did you learn enough from this project?
Yes: Not only did I learn a lot about workload modeling, I also really improved speaking English. I have learned what a real “research” project looks like. I have learned that I need to be more clear in expressing myself, as subtleties tend to get lost in translation.

Were all your expectations in terms of supervision met?
Yes, the huge amounts of red ink were really helpful for me to be able to finish the project. The informal and pleasant meetings really helped to keep me motivated. I would have liked a more planned approach, but I blame this at the rush-start we had in an attempt to make the August 2011 deadline. I would really have liked more freedom in the project.

Would you recommend doing a thesis with your direct supervisor to your friends?
Certainly: I like the informality and openness of our meetings. I like the optimistic approach to the supervision. I like that there are always suggestions to enhance some.

Would you recommend doing a thesis in this group to your friends?
Certainly: There are nice things going on in the group and there are lots of nice research opportunities, for example on a elastic MapReduce system and on the adaption of Skymark for other types of workloads. The Grids ‘n Cloud meetings help to keep in touch with the other group members and really

Conclusion
Was the thesis project worth it?
Yes, for me personally it is a huge benefit to have completed a research project.
Thanks from the PDS Group at TU Delft. Questions? I have one…

Q: May I help you gamify your course?

Alexandru Iosup
Grids/Clouds
P2P systems
Big Data
Online gaming

Dick Epema
Grids/Clouds
P2P systems
Video-on-demand
e-Science

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HPC systems
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