Enhancing the CS1 Student Experience with Gamification

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IEEE ISEC 2015
STEM 101 Courses

• High attrition rates

Figure 2.
Percentage of 2003–04 beginning bachelor’s and associate’s degree students who left STEM and selected non-STEM fields after their entrance into these fields, by major field entered: 2003–2009

<table>
<thead>
<tr>
<th>Major Field</th>
<th>Left PSE without a degree or certificate</th>
<th>Switched to a different major field</th>
</tr>
</thead>
<tbody>
<tr>
<td>STEM, total</td>
<td>20</td>
<td>28</td>
</tr>
<tr>
<td>Mathematics</td>
<td>121</td>
<td>26</td>
</tr>
<tr>
<td>Physical sciences</td>
<td>18</td>
<td>28</td>
</tr>
<tr>
<td>Biological/life sciences</td>
<td>15</td>
<td>30</td>
</tr>
<tr>
<td>Engineering/technologies</td>
<td>20</td>
<td>21</td>
</tr>
<tr>
<td>Computer/information sciences</td>
<td>31</td>
<td>28</td>
</tr>
</tbody>
</table>

• Let’s try and fix this!

Student Experience

• Alternatives to lecture-based teaching
  – Flipped classrooms
  – Studio-based learning
  – Peer instruction
  – Think-pair-share programming
  – Gamification

• Focus on engagement and collaboration

"That was an awesome worksheet," said no student ever.

Gamification

• Learning game
  – “System that promotes learning while still engaging the students in a challenge governed by rules, feedback, and an objective outcome”

• Motivates students to participate and learn

CS1 Learning Game

• Programming-themed
  – Leader board
  – Problem Cards
  – Bonus Cards
    • Programmer mantras
      – “The code may not be pretty but it works”
    • Special abilities
      – “Recruit a larger task force” (get help from another team)

Promote Learning & Solve Problems

• Problem cards of varying difficulties
  – Quick
  – Standard
  – Challenging
  – Extremely difficult
• Rewards for correct solutions
• Feedback and encouragement for incorrect solutions
Interactive Game Play

- **Teamwork**
  - Groups of 2-3
  - Solve together
  - Share solution together
- **Until a correct solution is reached**
  - Randomly choose the next team
- **Play until a team reaches the top of the leaderboard**

Flowchart:

1. Starting team randomly selected.
2. Next team draws a problem card. Problem is displayed.
3. Timer resets and starts.
4. Submitted solution correct?
   - Yes: Team draws bonus cards. Determine next team randomly.
   - No: Explain the solution. Resolve any confusion.
5. Have all teams had the opportunity to submit a solution?
   - Yes: Explain the solution. Resolve any confusion.
   - No: No

Experiment (Playtest) Setup

• Midterm review session
  – Non-gamified individual and/or group work
  – 1 hour
  – 10 problems solved

• Final exam review session
  – Gamified group work
  – 2.5 hours
  – 31 problems solved
• 100% enjoyed the learning game
• 83.33% prefer gamified programming practice over traditional individual/group practice
What was your favorite aspect of the game?

– “The time rushing.”
– “Made us think quickly and not second guess ourselves.”
– “Working in groups trying to solve a problem.”
– “Competitive engagement and motivation.”
– “It was a fun way to review what I know.”
Limitations & Future Work

- Small sample size
  - FW: Investigate scalability
- Play-tested in a review session
  - FW: Adapt to lab exercises
- Focus on student enjoyment
  - FW: Quantifying student learning
- Tangible version
  - FW: Digital version?

https://explorable.com/images/generalization.jpg
Conclusion

• A gamified approach to programming practice
  – Engaged students
• High throughput of learning activities
• Perceived well by students
  – 100% enjoyed
  – 83.33% preferred
Thank you!

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Saturday, March 7, 2015
Friend Center at Princeton University
Creating a Culture of Achievement
Additional References

Student Interest in Gamification

- Small summer class (N=12)
- 75% consider themselves gamers
- 100% are interested in new lecture-based alternatives

Student responses to the following Likert questions:
Q1: As a student, I learn well from lecture-based teaching styles (e.g. slideshows).
Q2: As a student, I am interested in alternatives to lecture-based teaching styles.
Q3: I enjoy programming.
Q4: I enjoy problem solving.

*No responses were “Strongly disagree”*
# Game Requirements

<table>
<thead>
<tr>
<th>Physical</th>
<th>Time</th>
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</thead>
<tbody>
<tr>
<td>• 100 4”x6” cards</td>
<td>• Questions banks</td>
</tr>
<tr>
<td>• Notecards</td>
<td>• Solutions prepared (optional)</td>
</tr>
<tr>
<td>• Laptop/projector</td>
<td></td>
</tr>
<tr>
<td>• Whiteboards (optional)</td>
<td></td>
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</table>
## Student Hours Invested in Games

<table>
<thead>
<tr>
<th>Hours a week</th>
<th>Percentage of students</th>
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</thead>
<tbody>
<tr>
<td>Video, at least 1 hour</td>
<td>92.67%</td>
</tr>
<tr>
<td>Video, at least 4 hours</td>
<td>58.33%</td>
</tr>
<tr>
<td>Non-video, at least 1 hour</td>
<td>33.33%</td>
</tr>
<tr>
<td>Non-video, at least 4 hours</td>
<td>8.33%</td>
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