WASHINGTON STATE UNIVERSITY

Enhancing the CS1 Student Experience with Gamification

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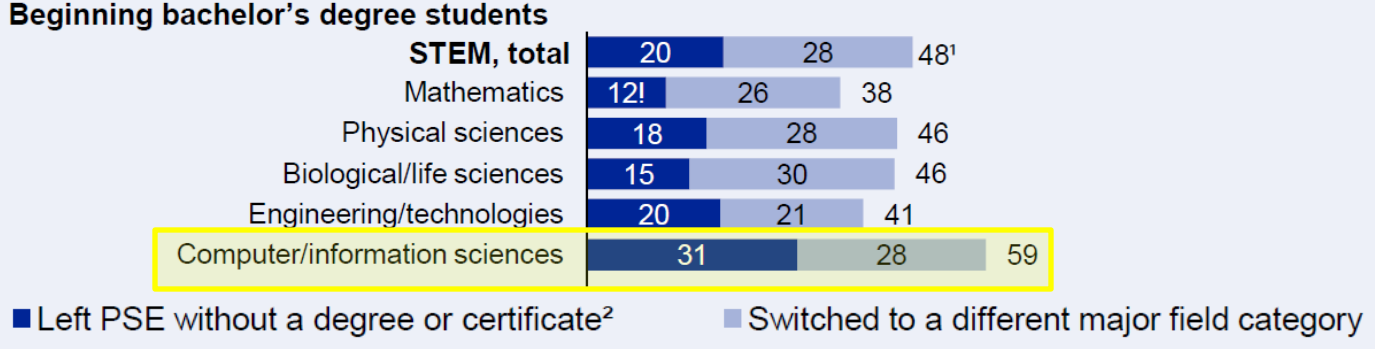
IEEE ISEC 2015

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



- Let's try and fix this!

X. Chen, "STEM Attrition: College Students' Paths into and out of STEM Fields. Statistical Analysis Report. NCES 2014-001.," *Natl. Cent. Educ. Stat.*, 2013.

Student Experience

- Alternatives to lecture-based teaching
  - Flipped classrooms
  - Studio-based learning
  - Peer instruction
  - Think-pair-share programming
  - Gamification
- Focus on *engagement* and *collaboration*

D. Horton, M. Craig, J. Campbell, P. Gries, and D. Zingaro, "Comparing outcomes in inverted and traditional CS1," 2014, pp. 261–266., A. S. Carter and C. D. Hundhausen, "A review of studio-based learning in computer science," *J. Comput. Sci. Coll.*, vol. 27, no. 1, pp. 105–111, 2011., J. G. Politz, D. Patterson, S. Krishnamurthi, and K. Fisler, "CaptainTeach: multi-stage, in-flow peer review for programming assignments," 2014, pp. 267–272., D. Zingaro, "Peer instruction contributes to self-efficacy in CS1," 2014, pp. 373–378., A. Kothiyal, S. Murthy, and S. Iyer, "Think-pair-share in a large CS1 class: does learning really happen?" 2014, pp. 51–56.

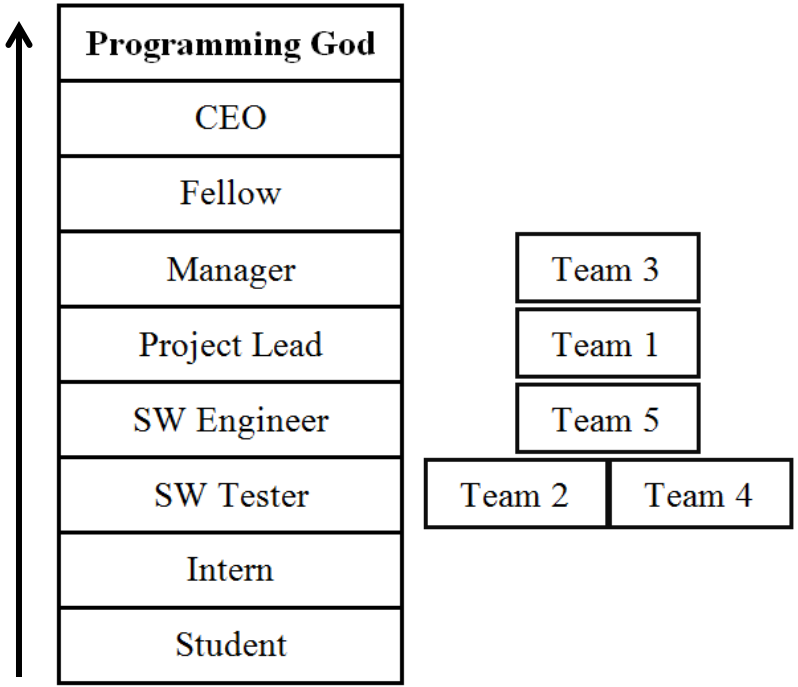
Gamification

- 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

K. M. Kapp, *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*, 1 edition. San Francisco, CA: Pfeiffer, 2012., A. Iosup and D. Epema, “An experience report on using gamification in technical higher education,” 2014, pp. 27–32., B. B. Morrison and B. DiSalvo, “Khan academy gamifies computer science,” 2014, pp. 39–44., ninjamarketing.it

CS1 Learning Game

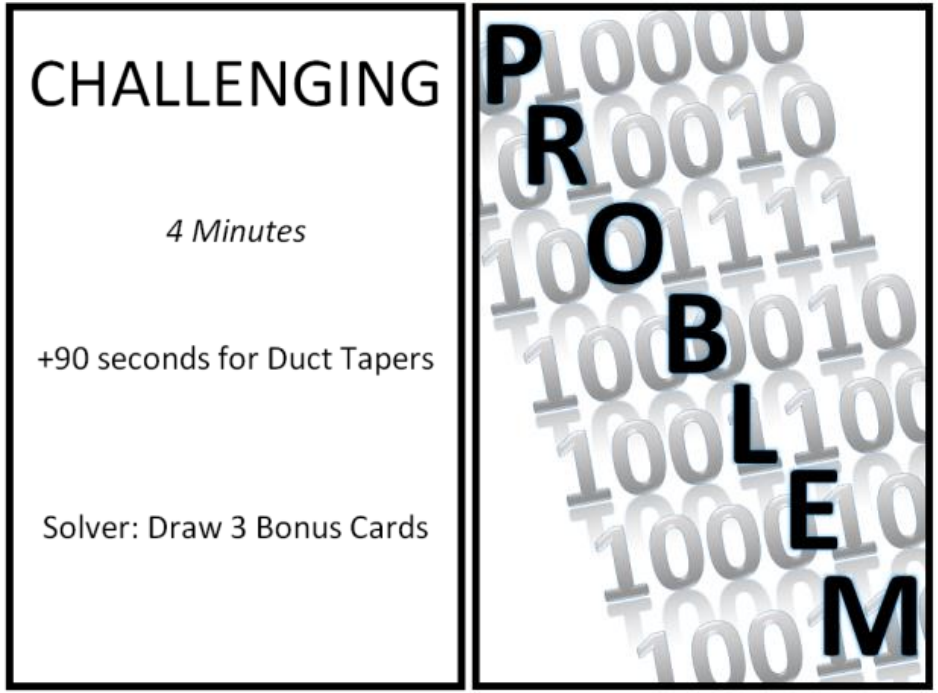
- Programming-themed
  - Leader board
  - Problem Cards
  - Bonus Cards
    - Programmer mantras
      - "The code may not be pretty but it works"
    - Special abilities
      - "Recruit a larger task force" (get help from another team)



S. Benner, "The 5 types of programmers," *Steven Benner's Blog*.

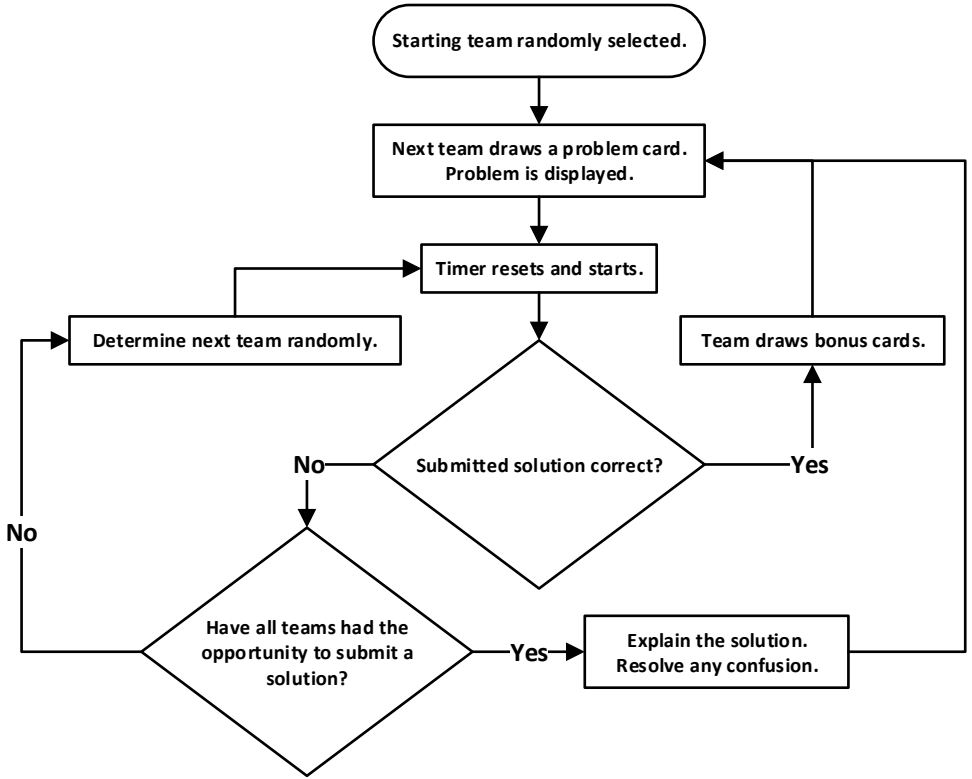
Promote Learning & Solve Problems

- 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

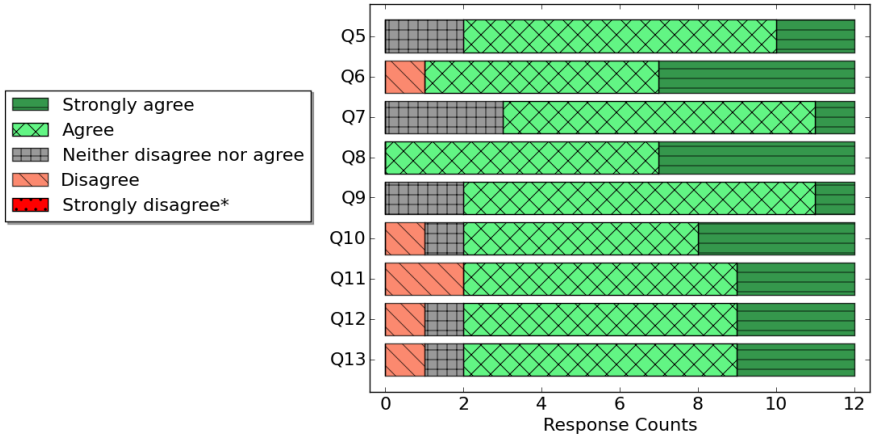


Experiment (Playtest) Setup

- 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

Game Evaluation

- 100% enjoyed the learning game
- 83.33% prefer gamified programming practice over traditional individual/group practice



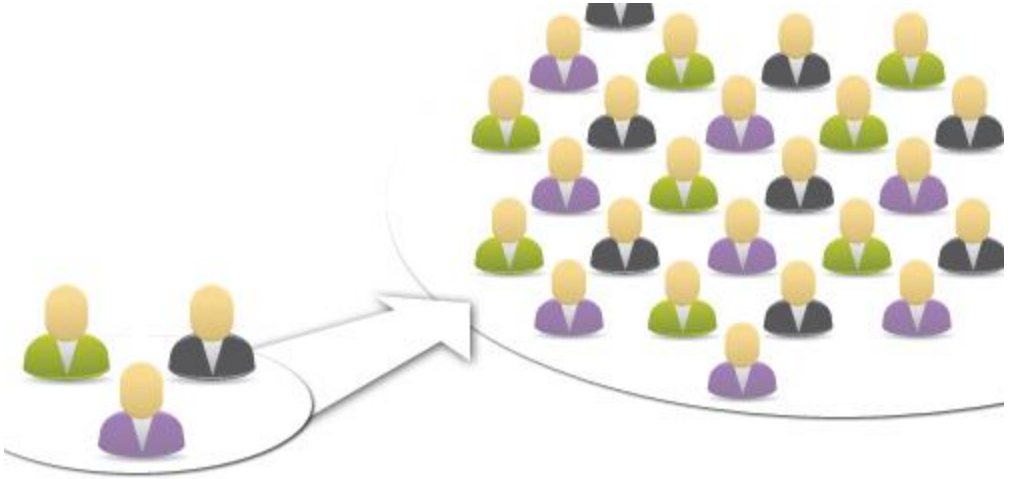
Student responses to the following Likert questions:
Q5: The midterm review session was beneficial.
Q6: The gamified review session was beneficial.
Q7: The midterm review session was enjoyable.
Q8: The gamified review session was enjoyable.
Q9: The midterm review session motivated me to study for the midterm.
Q10: The gamified review session motivated me to study for the final.
Q11: I prefer the gamified review approach over the approach used for the midterm review.
Q12: I would like to see gamified programming used again in my future.
Q13: As a student, I learned well from the gamified review session.

Student Testimonials

- 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!

IEEE Integrated STEM Education Conference

Saturday, March 7, 2015

Friend Center at Princeton University

Creating a Culture of Achievement

Additional References

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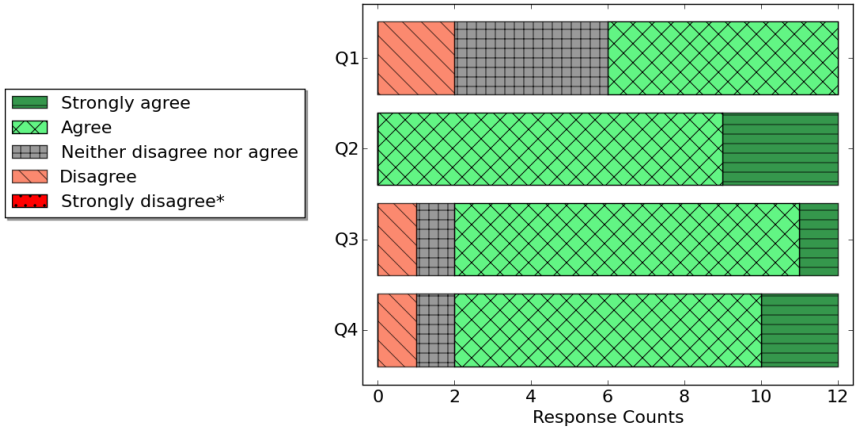
BACKUP

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

Physical	Time
• 100 4”x6” cards • Notecards • Laptop/projector • Whiteboards (optional)	• Questions banks • Solutions prepared (optional)

Student Hours Invested in Games

Hours a week	Percentage of students
Video, at least 1 hour	92.67%
Video, at least 4 hours	58.33%
Non-video, at least 1 hour	33.33%
Non-video, at least 4 hours	8.33%