Serious Games in Computer Science Education – Playing Games in a Data Structures and Algorithms course

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Introduction

• Serious games
  – Also other objectives than entertainment
  – Include all aspects of education: teaching, training, informing

• Why?
  – Games can be very motivating
  – Students already learn a lot by playing games
  – Games and puzzles can improve problem solving skills

• Why not?
  – Not suitable for everyone
  – 2 typical problems:
    • Fail to integrate educational aim to the game (just add game elements in an educational tool)
    • Game can be played without understanding the learning objectives
Serious Games in CS Education

• Games can be used in various ways:
  – Implementing a game as a programming assignment
  – Implementing a critical aspect of a game
  – Writing a program that acts as a player
  – Playing a game

• There are a lot of game-like elements in computer science
  – Data structures, algorithms, error detection...

• Example: Computer Science Unplugged
  – Created by Tim Bell, Ian H. Witten and Mike Fellows
  – A collection of learning activities (off-line games, puzzles, cards...)
  – Especially for young students
Data Structures and Algorithms course

• Programming courses: CS1 (Java), CS2 (Java)
• Data Structures and Algorithms course
  – 100 CS major students
  – 300 other students
• Course consists of:
  – Lectures
  – Automated algorithm simulation exercises (TRAKLA2)
  – PeerWise (multiple-choice questions)
  – Lab-sessions (only CS major students)
    • Programming and analytical exercises
  – Project work (not CS major students)
Advanced programming students (pilot)

• 20 1\textsuperscript{st} year students
• Programming + Data Structures and Algorithms courses
• Programming competitions theme:
  – Weekly lab sessions
  – Old programming competition exercises
    • ACM ICPC (International Collegiate Programming Contest)
    • Project Euler
  – Practicing competition
    • In groups of 1-3 students
    • Substitutes course exam
Games at the Data Structures and Algorithms course

• Games were used for the first time this year
  - CS major + Advanced programming students
• 1 exercise session (total of 36 students, 3*2h)
• Groups of 3-5 students
• 4 games:
  - SortingGame
  - SortingCasino
  - Secret rule
  - Draw and guess
• Feedback
SortingGame

• Cardgame for 2-6 players
• Game about sorting algorithms and related concepts
• 2 decks: algorithms and special
• Special card round
  – Place down a special card ("stable", "in-place", "O(N log N)", ...)
• Algorithm round
  – Play one algorithm that satisfies all the criteria on the table
  – The algorithm with the best worst case complexity wins the round
  – You can try to slip in an incorrect card → others have to notice
  – Robbery cards
SortingCasino

- Same card decks with SortingGame
- Place 6 cards on the table
- 4 hand cards for each player
- Take all matching cards from the table with 1 hand card
- … or place one card on the table
- Clear the table and get bonus points
Secret Rule

• Cards including course topics + algorithm cards
• One player makes up a secret rule
  - ”Linear data structure”
  - ”Is related to graph traversal”
  - ”In-place sorting algorithm”
• Others try to guess the rule by playing cards on the table
• Dealer acts as a judge for played cards
• The winner is the player who gets rid of all hand cards or guesses the secret rule
Draw and Guess

• A deck of cards with data structures and algorithm concepts
• 2 teams
• A player draws the concept on the board
• Own team has 30s time to guess
• +30s time for all teams to guess
Overall results

A) Games don't seem to be a sensible teaching method even if they are developed further (3%)

B) Games didn't work well now, but in principle they seem like a sensible teaching method, if they are developed further in a right direction (3%)

C) Games are already a sensible teaching method in the course, but some of their features should be improved notably (56%)

D) Games are already a sensible teaching method in the course and they don't need any drastic changes, at most some small refinements (35%)

E) Something else (3%)
Lessons learned

• Overall ratings (from 1 to 5):
  – SortingGame: 3,5
  – SortingCasino: 3,5
  – Secret rule: 3,5 (only 4 students played this game)
  – Draw and guess: 3,4

• Rules need refining (and maybe simplification)
• Secret rule is too intimidating and hard
• Draw and guess needs more content (e.g. definitions)
Future

• Promising experience
• Integrated more to teaching
• More games
• Different gaming possibilities
  – Exercise sessions
  – Game room
  – Online games
• Research setting for evaluating the results of playing the games
Thank you!