An Adventure Serious Game for Teaching Effort Estimation in Software Engineering

Beatriz Marín, Matías Vera, Giovanni Giachetti
beatriz.marin@mail.udp.cl
matias.vera@mail.udp.cl
ggiachetti@inacap.cl
Agenda

- Introduction
- Related work
- Back to Penelope - Serious Game Design
- Evaluation of Back to Penelope
- Conclusions and future work
Agenda

• Introduction
• Related work
• Back to Penelope - Serious Game Design
• Evaluation of Back to Penelope
• Conclusions and future work
Introduction

Software development is not a rose road.
Introduction

• Estimation (Effortt / Cost) is one of the key factors involved in the failure of software development projects.
Introduction

• Proper planning is an important factor for the success of a software project.
Introduction

• Incorrect planning can be produced by:

  - Lack of expertise in the planning process
  - Unrealistic assumptions and expectations
  - Lack of a systematic measurement process
Introduction

• Effort estimation capability is one of the main aspects that must be properly learned by software engineers.

Comprehension of concepts

Ability to apply the concepts to practical problems
Introduction

• Traditional classes are effective to introduce measurement estimation concepts.

• However, they are not effective in motivating students or allowing them to put the knowledge learned into practice.
Introduction

• The use of games has been of help for teaching by offering to the students learning environments without risks.
Introduction

• By implementing serious games, it is possible to motivate and entertain students by modifying their behavior in a positive manner when coping with measurement estimation concepts.
Introduction

• Contribution: the design a serious game developed to teach effort estimation using the COSMIC Function Points measuring method applied to conceptual models.

http://backtopenelope.me
Agenda

• Introduction
• Related work
• Back to Penelope - Serious Game Design
• Evaluation of Back to Penelope
• Conclusions and future work
Related Work

There are several systematic reviews (SLRs) about serious games published.
Related Work

Systematic Mapping Review of Literature

What evidence about serious games in the field of teaching/learning time or effort estimation exists?
Related Work

1. The paper is written in English or Spanish.

2. The paper is about serious games oriented to effort or time estimation.

Inclusion

Exclusion

1. The paper is related to effort or time estimation for development of serious games.

2. The paper is related to effort or time estimation only, without a serious game.

3. The paper is related to serious game design or implementation only, without presenting an approach for learning estimation.

4. Grey literature

5. Papers duplicated
Related Work

- Results obtained from the execution of the search string.

<table>
<thead>
<tr>
<th>Library Name</th>
<th>Search Date</th>
<th>Search result</th>
<th>Candidate Studies</th>
<th>Selected Papers</th>
</tr>
</thead>
<tbody>
<tr>
<td>IEEEXplore</td>
<td>21-01-18</td>
<td>1152</td>
<td>5</td>
<td>2</td>
</tr>
<tr>
<td>ACM Digital Library</td>
<td>21-01-18</td>
<td>217</td>
<td>3</td>
<td>1</td>
</tr>
<tr>
<td>Springer Link</td>
<td>21-01-18</td>
<td>123</td>
<td>3</td>
<td>2</td>
</tr>
<tr>
<td>(Snowballing)</td>
<td>09-03-18</td>
<td>7</td>
<td>5</td>
<td>5</td>
</tr>
</tbody>
</table>

Total 10 papers
Related Work

Results

70%  30%  30%

- Project Management
- Effort Estimation

20% for students learning
## Related Work

<table>
<thead>
<tr>
<th>Paper Title</th>
<th>Game Name</th>
<th>Game Type</th>
<th>Learning Scope</th>
<th>Game Design</th>
<th>Val</th>
<th>EE</th>
</tr>
</thead>
<tbody>
<tr>
<td>Coverage of the ISO 21500 Standard in the Context of Software Project Management by a Simulation-Based Serious Game</td>
<td>ProDec</td>
<td>Simulation</td>
<td>Software Project Management</td>
<td>-</td>
<td>No</td>
<td>yes</td>
</tr>
<tr>
<td>Coverage of ISO/IEC 29110 Project Management Process of Basic Profile by a Serious Game</td>
<td>ProDec</td>
<td>Simulation</td>
<td>Software Project Management</td>
<td>-</td>
<td>No</td>
<td>yes</td>
</tr>
<tr>
<td>Integrating serious games as learning resources in a software project management course: the case of ProDec</td>
<td>ProDec</td>
<td>Simulation</td>
<td>Software Project Management</td>
<td>-</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>Simulation in software</td>
<td>SESAM</td>
<td>Simulation</td>
<td>Models</td>
<td>yes</td>
<td>yes</td>
<td></td>
</tr>
<tr>
<td>Challenges and issues in the development of a Software Engineering simulation game</td>
<td>SPLAL</td>
<td>Simulation, Role playing</td>
<td>Software Process Improvement</td>
<td>Models</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Engineering an Empathy for Software Engineering</td>
<td>SinjovaSP</td>
<td>Simulation, Role Playing</td>
<td>Software Project Management</td>
<td>Models</td>
<td>Yes</td>
<td>No</td>
</tr>
<tr>
<td>AMESE – A Media Education Initiative for Software Engineering Concepts, the Environment and Initial Experiences Model Driven Game Development: Experience and Model Enhancements in Software Project Management Education</td>
<td>AMESE</td>
<td>Simulation, Multiplayer, Competition</td>
<td>Software Project Management</td>
<td>Models</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>Management Education</td>
<td>The Incredible Manager</td>
<td>Simulation, Role Playing</td>
<td>Software Project Management</td>
<td>Models</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A Simulation-Based Game for Project Management Experiential Learning</td>
<td>The Incredible Manager</td>
<td>Simulation, Role Playing</td>
<td>Software Project Management</td>
<td>Models</td>
<td>No</td>
<td>No</td>
</tr>
<tr>
<td>A Game for Taking Requirements Engineering More Seriously</td>
<td>Quantum Game</td>
<td>Simulation</td>
<td>Requirement Engineering</td>
<td>Models</td>
<td>No</td>
<td>No</td>
</tr>
</tbody>
</table>

19
Related Work

- The other approaches do not consider effort estimation tasks, or indeed the effort is already predefined by the system without intervention of the player (student) in the estimation process.

ProDec
Albrecht function Point.
Students to estimate the effort of a set of pre-defined tasks.

The Incredible Manager
Effort estimation from expertise of developers.
We didn’t find approaches that present novel gaming scenarios or a story thread that differs from software engineering tasks, which could better motivate the use of the game as a complementary learning technique for measurement.
Agenda

• Introduction
• Related work
• Back to Penelope - Serious Game Design
• Evaluation of Back to Penelope
• Conclusions and future work
Design of Back To Penelope

• **Unity** game development engine, which uses C# as scripting language.

• It allows to develop games for **different platforms**, such as Windows, OSx, Linux, iOS, or Android operating systems.
Design of Back To Penelope

• Conceptual framework of the MDA (Mechanics, Dynamics and Aesthetics)
Game proposal
• *Back to Penelope* videogame helps in the learning process of effort *estimation* through the application of the COSMIC measurement method.

• In each of the *Back to Penelope* scenes, the player has challenges that correspond to tasks to be implemented starting from one or more *class diagrams*. 
Game Context

• In *Back to Penelope*, the player must take the role of *Ada*, a young girl astronaut on an exploration mission of a new solar system as part of the *Odyssey* project, whose mission is to find new planets.
Game Context

• Ada travels in a recognition spaceship that is designed to travel large distances among planets; however, it is not designed to land on or launch from a planet itself since it does not have enough power to break the eventual planet gravity.
Game Context

• Ada is orbiting the planet Omicron-IV, when her ship is trapped by the gravity causing Ada to force land.

• Then, she is trapped by the high gravity. This forces Ada to fix her ship in order to return to her mothership, which is named Penelope.

• To fix the ship, she must use the disposable Utilities Droids (dUD), which require the indication of the functional size of each task that needs to be accomplished.
BTP - Mechanics

• The game has two mechanics: to measure the COSMIC functional size of a system, and to correct a measurement performed.
BTP - Mechanics

• Each scene presents support systems that must be implemented for fixing the spaceship. These systems are represented by class models.

• The player must assign a dUD to each class.

• The player must estimate the corresponding size for the class to be implemented.
BTP Mechanichs

• The selected dUD will be in a working state. We convert the CFP to time considering the constant: 1 CFP corresponds to 3 seconds of implementation time for a dUD.

• The game provides a tutorial to learn how to perform an estimation by using COSMIC.
BTP - Dynamics

• Main menu / Scene selection
BTP - Dynamics

• Game play view and Class diagram
BTP - Aesthetics

• **Narrative** of the game. We create a fantasy story (the player is Ada) to motivate engineering students.

• A **time bar** for each scene.

• Different **difficulty levels** in the class diagram of each scene.

• **Feedback** that is given to the player when the implementation of a class has been under- or overestimated.
BTP - Aesthetics

Example difficulty levels
Demo BTP

Demo_BTP Scene 1

Demo_BTP Scene 2

Demo_BTP Scene 3

Demo_BTP Scene 4
Agenda

• Introduction
• Related work
• Back to Penelope - Serious Game Design
• Evaluation of Back to Penelope
• Conclusions and future work
BTP evaluation

• Exploratory empirical study: **usability** and **effectiveness**.

• Number of tries that are necessary by a player to perform a correct estimation.
BTP evaluation

- **UMUX questionnaire**

<table>
<thead>
<tr>
<th>Perceived Effectiveness</th>
<th>Does <em>Back to Penelope</em> allow you to learn how to estimate by using the COSMIC method?</th>
</tr>
</thead>
<tbody>
<tr>
<td>Perceived Satisfaction</td>
<td>Is playing <em>Back to Penelope</em> a frustrating experience?</td>
</tr>
<tr>
<td>General vision</td>
<td>Is <em>Back to Penelope</em> easy to use?</td>
</tr>
<tr>
<td>Perceived Efficiency</td>
<td>Do you spend too much time making corrections with <em>Back to Penelope</em>?</td>
</tr>
</tbody>
</table>
First BTP evaluation

• **10 students** graduate from the Engineering major of Information Technology and Telecommunications.

  – Brief explanation
  – Questionnaire
  – *Effectiveness* was not evaluated.
Results of first BTP evaluation

• 70% of the players is agreed or totally agreed with the fact that Back to Penelope allowed them to learn how to the estimate by using the COSMIC method.
Results of first BTP evaluation

- 90% of the players showed a tendency to not feel frustrated when using the game.

![Results from the first trial chart](chart.png)
Results of first BTP evaluation

- 80% of the players agreed or totally agreed that *Back to Penelope* was easy to use.
Results of first BTP evaluation

- 80% of the players disagreed they spent too much time making corrections with Back to Penelope.
Second BTP evaluation

• **30 students** that passed the Software Engineering course

  – Brief explanation
  – COSMIC
  – Questionnaire
Second BTP evaluation

• Only 27% of the players agreed to register the time that they spent on each scene, and we cannot use it in the analysis about playing time.
Efficiency evaluation

• Passing from one scene to another takes a few minutes for the player.

<table>
<thead>
<tr>
<th>Group</th>
<th>Scene 1</th>
<th>Scene 2</th>
<th>Scene 3</th>
<th>Scene 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>85.8</td>
<td>142.2</td>
<td>136.8</td>
<td>197.0</td>
</tr>
<tr>
<td>Group 2</td>
<td>98.2</td>
<td>179.1</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>92.0</td>
<td>160.7</td>
<td>136.8</td>
<td>197.0</td>
</tr>
</tbody>
</table>
Effectiveness evaluation

- Student estimations were higher than the real value, with an average of 9.5% over the real value.

<table>
<thead>
<tr>
<th>Group</th>
<th>Scene 1</th>
<th>Scene 2</th>
<th>Scene 3</th>
<th>Scene 4</th>
</tr>
</thead>
<tbody>
<tr>
<td>Group 1</td>
<td>39.0</td>
<td>92.0</td>
<td>94.0</td>
<td>120.0</td>
</tr>
<tr>
<td>Group 2</td>
<td>31.5</td>
<td>96.7</td>
<td></td>
<td></td>
</tr>
<tr>
<td>Average</td>
<td>35.3</td>
<td>94.3</td>
<td>94.0</td>
<td>120.0</td>
</tr>
<tr>
<td>Real Value</td>
<td>34.0</td>
<td>91.0</td>
<td>97.0</td>
<td>102.0</td>
</tr>
</tbody>
</table>

Students estimated the functional size of the class diagrams with adequate accuracy even though this is the first time that they used the COSMIC method.
Perceived Effectiveness

• 70% of the students answered that they use the maximum number of tries needed to perform a correct estimation.

10% of students perceived that they were ineffective.
Usability Evaluation

• Players agreed that Back To Penelope allows them to learn to estimate using COSMIC.
Agenda

• Introduction
• Related work
• Back to Penelope - Serious Game Design
• Evaluation of Back to Penelope
• Conclusions and future work
Conclusions

• **Effort estimation** is of paramount importance for planning the development of software projects.

• Measurement methods are needed to properly understand and plan SE projects.

• **Novel teaching techniques** are required, specially for SE.
Conclusions

• **BTP** was designed in order to provide a playful experience to learn COSMIC measurement method.

• **BTP** is available for download at
  • [http://backtopenelope.me](http://backtopenelope.me)
Conclusions

• An exploratory empirical study has been performed to verify the perception of students with respect of this new method of teaching/learning in Software Engineering.

• Results indicate that BTP provides benefits for learning measurement estimation with COSMIC.
Conclusions

• Limitations:
  – Lack of evidence of the Efficiency of BTP in the learning process.

Future work is referred to conduct experiments to evaluate the F-measure of BTP and to add more measurement methods to the game.
An Adventure Serious Game for Teaching Effort Estimation in Software Engineering

Beatriz Marín, Matías Vera, Giovanni Giachetti
beatriz.marin@mail.udp.cl
matias.vera@mail.udp.cl
ggiachetti@inacap.cl