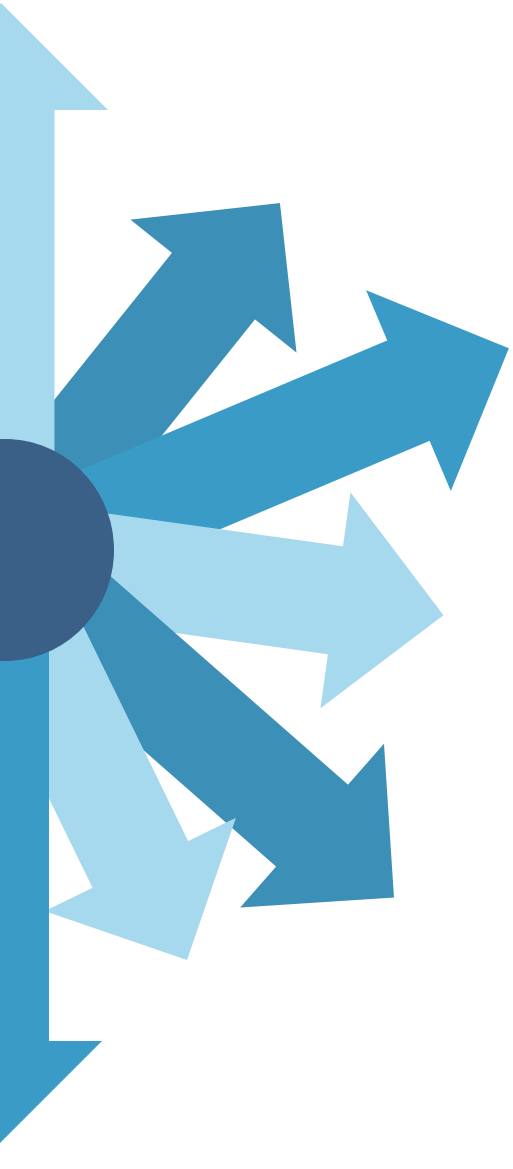


Personalizing Software Engineering Serious Games with AI

FaSE4Games 2025 Keynote

Jeremy S. Bradbury

Software Engineering & Education Research Lab
Ontario Tech University, Oshawa, Canada

http://www.seerlab.ca

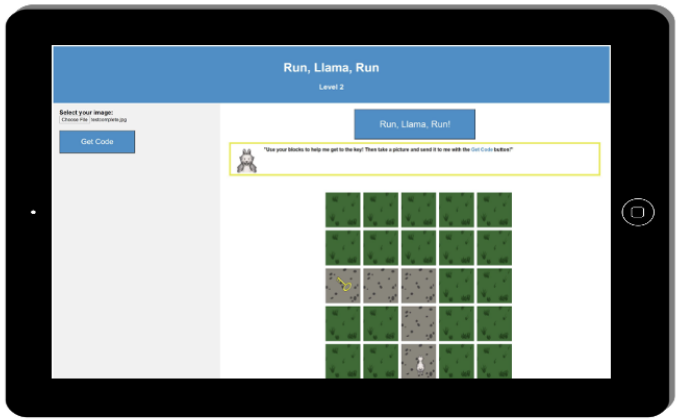
SEER LAB | OntarioTech UNIVERSITY

FaSE4Games'2025
Co-located with FSE'25

What is a Serious Game?

- A game that is not purely for entertainment
- Has a serious purpose – usually **learning**
- **Can still be fun!**
- Serious game ≠ gamification

Serious Games in the SEER Lab



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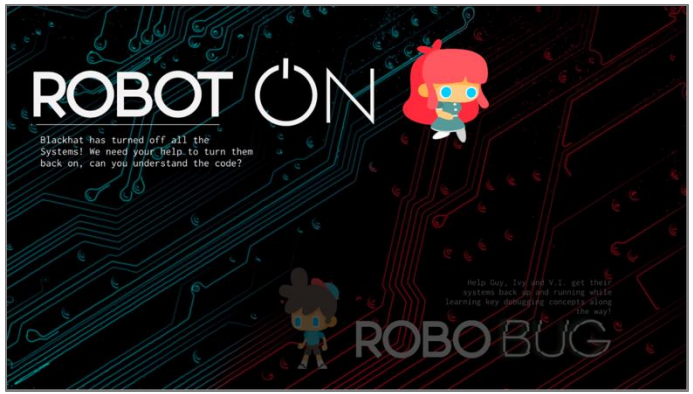

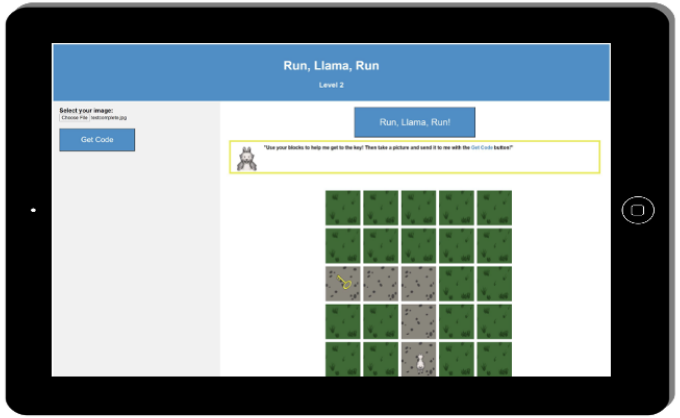

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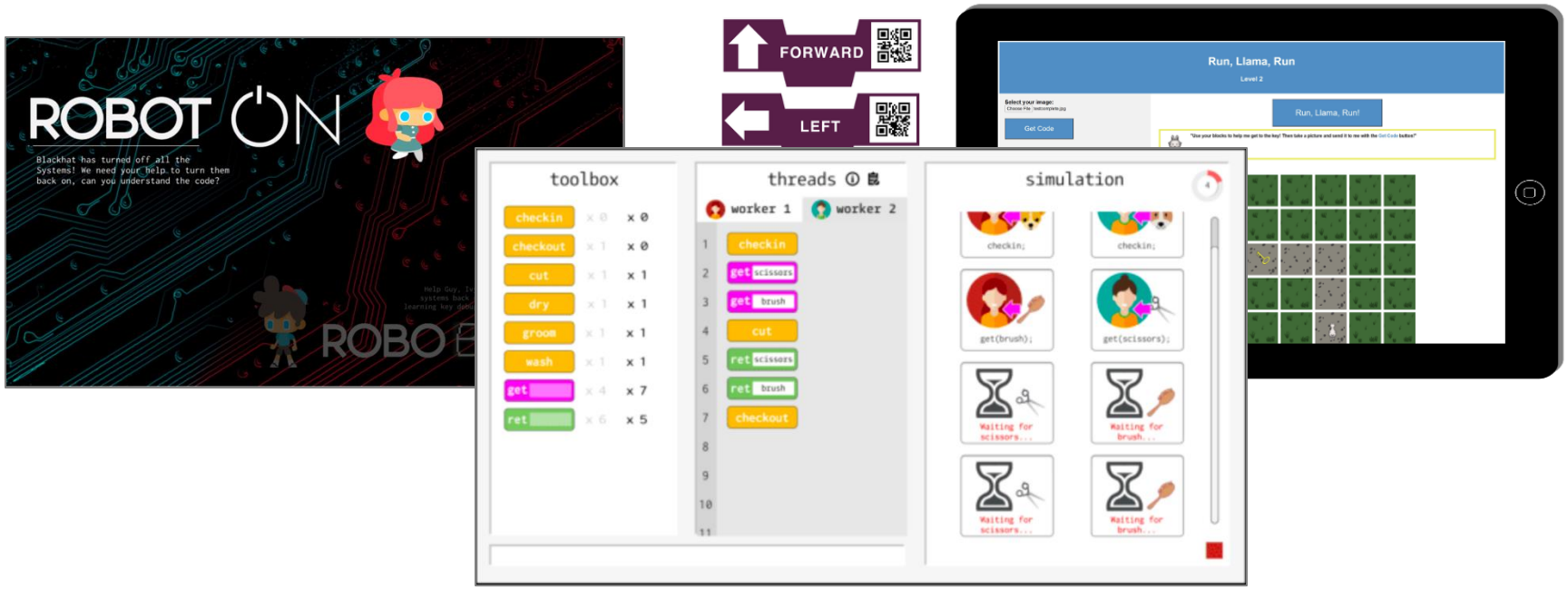

Serious Games in the SEER Lab

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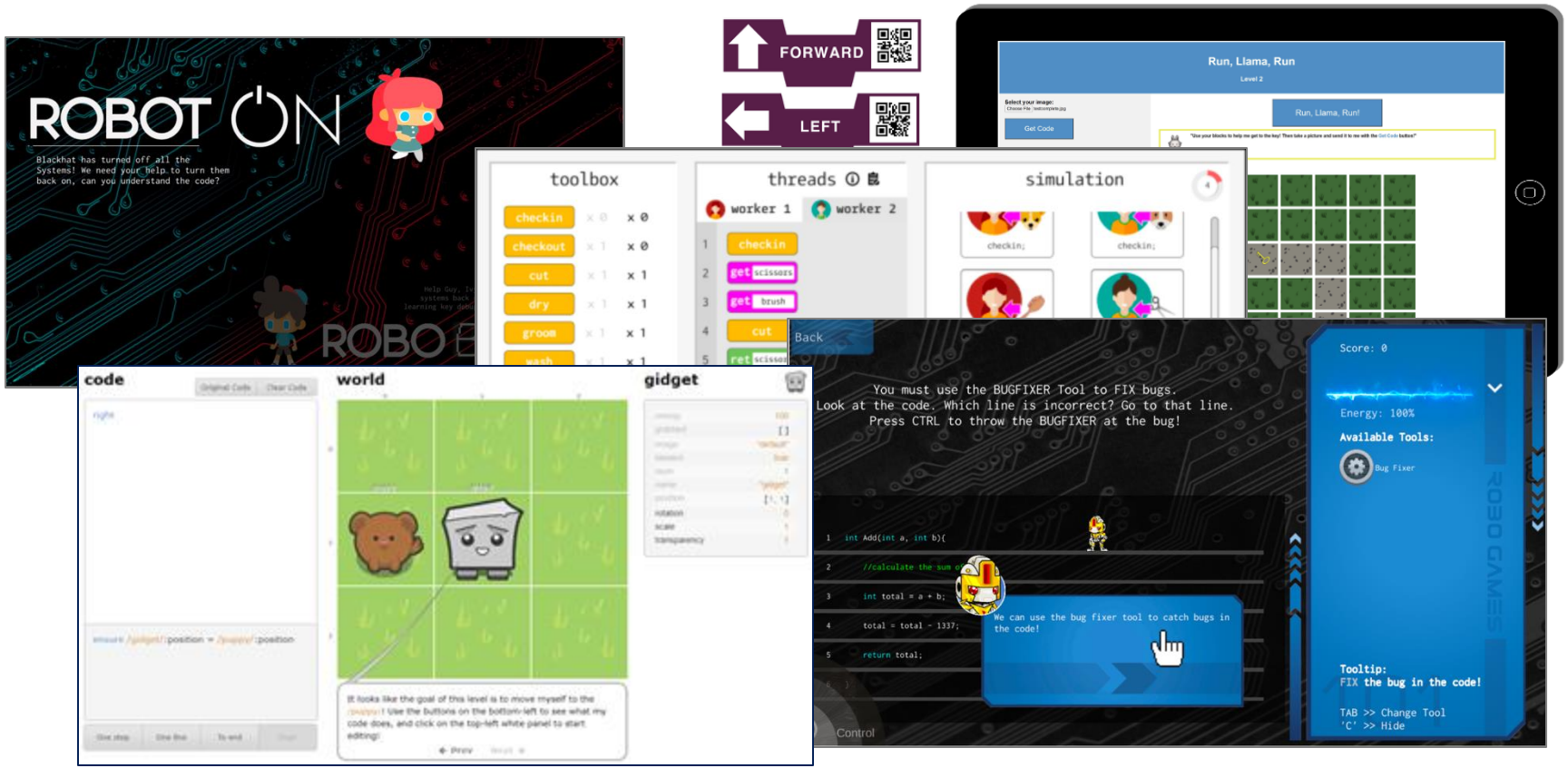

Collaborators

Michael Miljanovic, Stacey Koornneef, Riddhi More, Niranjan Girhe, Luisa Rojas Garcia, Mario Velazquez, Ibrahim Mushtaq, Kashif Hussain, Jana Kanagalingam, Scott McLean, Alexander Baxter, Sylvain Rocchia, Rosie Khurmi, Daniel Hinbest

Software Engineering + Games + AI

- Using AI to enhance or automate Software Engineering activities in game development (AI4SE)
- Using Software Engineering to improve the development of AI-enhanced games (SE4AI)
- Using AI to enhance learning of Software Engineering using games (AI4CSEd)

Software Engineering + Games + AI

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What are the benefits of using AI to personalize serious games?

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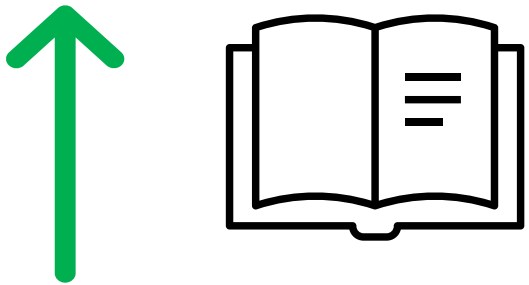
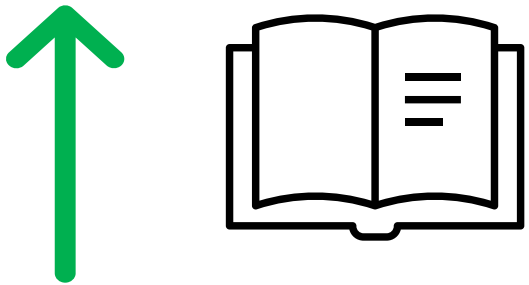
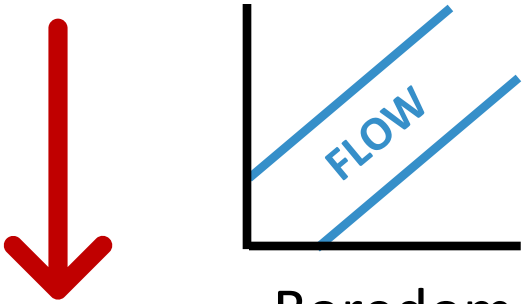


Learning

What are the benefits of using AI to personalize serious games?



Learning



Boredom
Frustration

Open Research Questions

1. What are effective **adaptive/personalization** approaches to use with serious software engineering games?

2. Do personalized software engineering games provide a significant **benefit** for learners over non-personalized games?

3. Can adaptive programming games find a balance between **engaging** game play and ability to achieve the **learning outcomes** of the software engineering curriculum?

Engineering personalized serious games is **NOT** easy! There are numerous challenges…

Michael A. Miljanovic, Jeremy S. Bradbury. **"Engineering Adaptive Serious Games Using Machine Learning."** in Software Engineering for Games in Serious Contexts – Theories, Methods, Tools, and Experiences, 2023, 17 pages.

Challenge #1: Selecting Data

- *How do you decide what serious game data to select for use in an ML model?*

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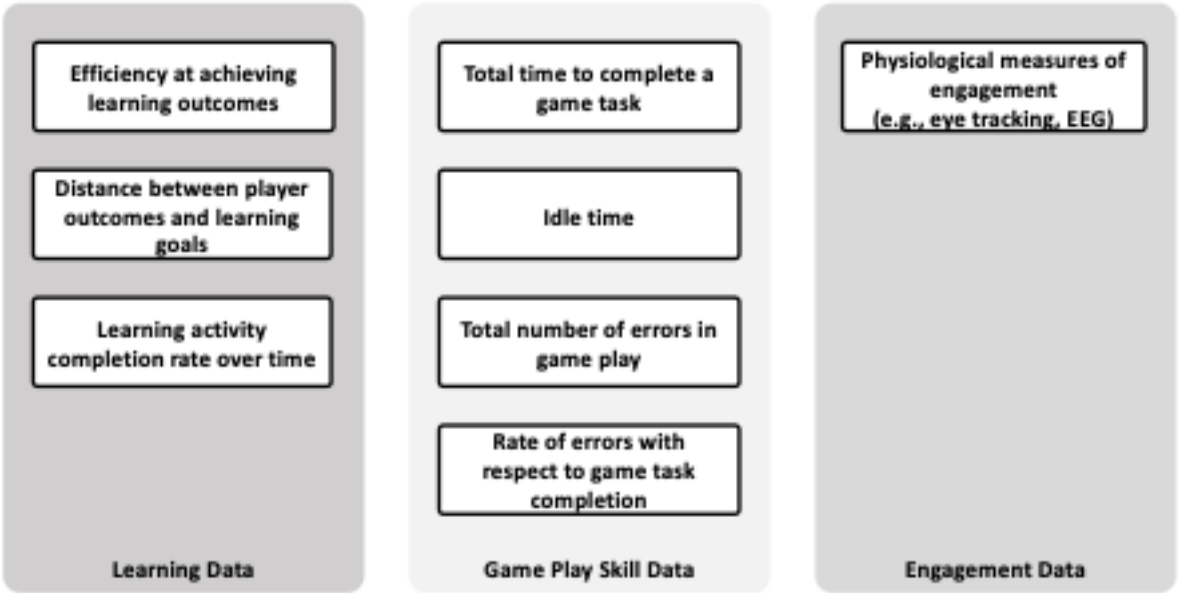

Challenge #2: Game Elements

- *How do you select what game elements to adapt?*

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- Feedback and hints
- Game play obstacles
- Game play content
- Limits on in-game tasks
- …

Challenge #3: Cold Start

- *How do you solve the cold start problem in adaptive serious games?*

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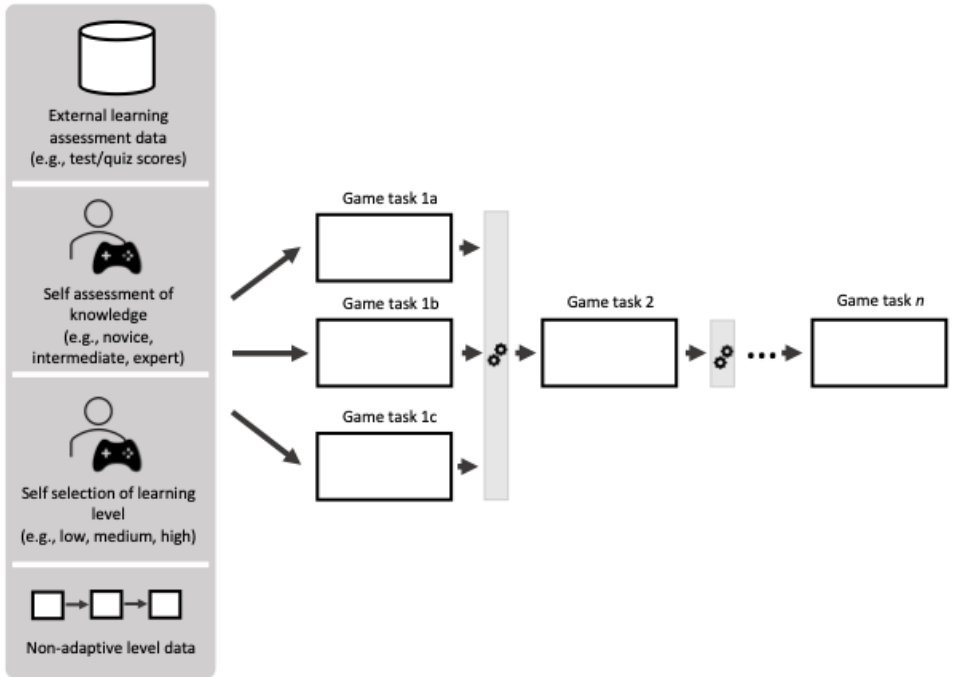

Challenge #4: Adaptation Frequency

- *How frequently should you adapt in a serious game?*

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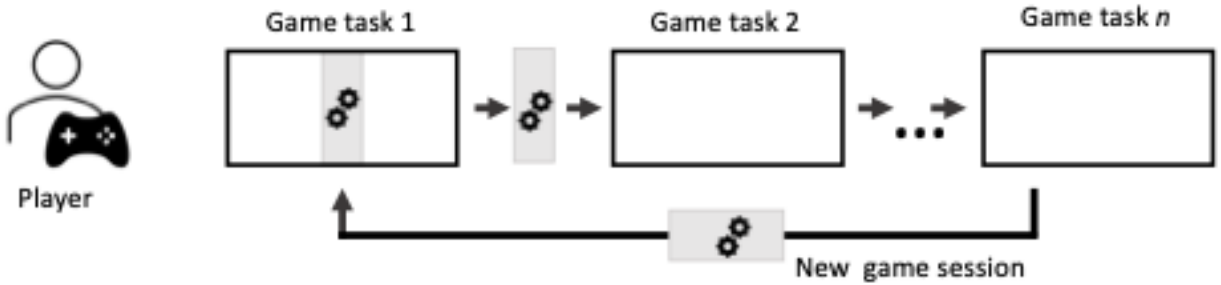
- Within game tasks? Between game tasks? Between game sessions?



Challenge #4: Adaptation Frequency

- *How frequently should you adapt in an SG?*

	Computational cost of adaptation	Time to adaption	Quantity of game data available
Within tasks	•••	•	•
Between tasks	••	••	••
Between sessions	•	•••	•••

Challenge #5: Evaluating Learning

- *How do you evaluate that an adaptive serious game benefits learning?*

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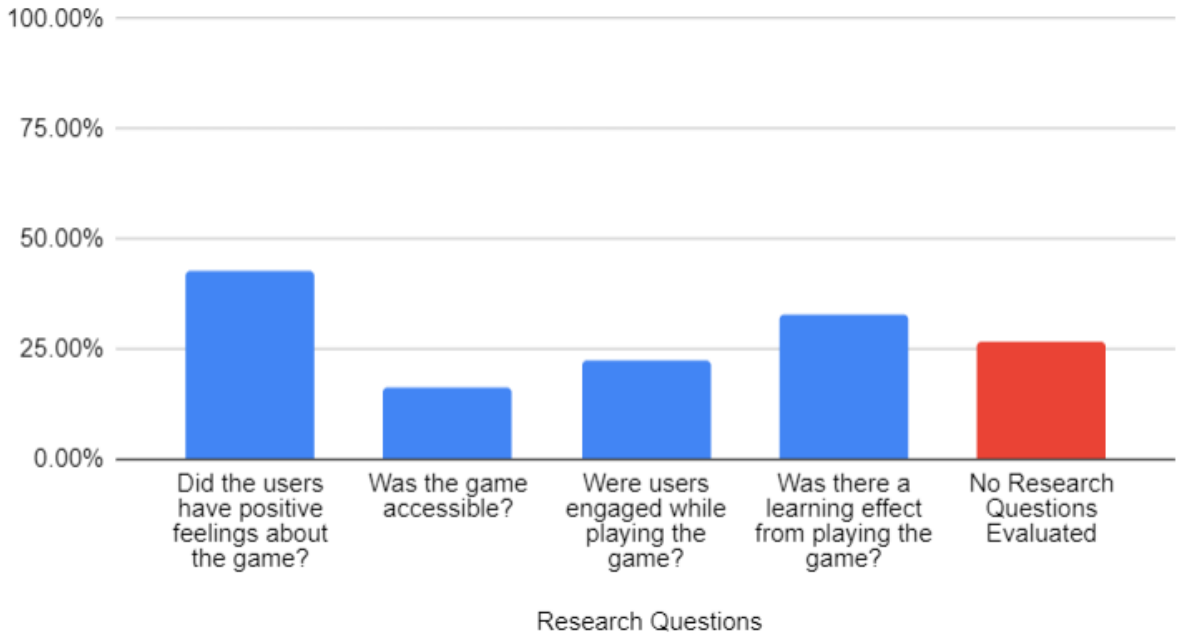

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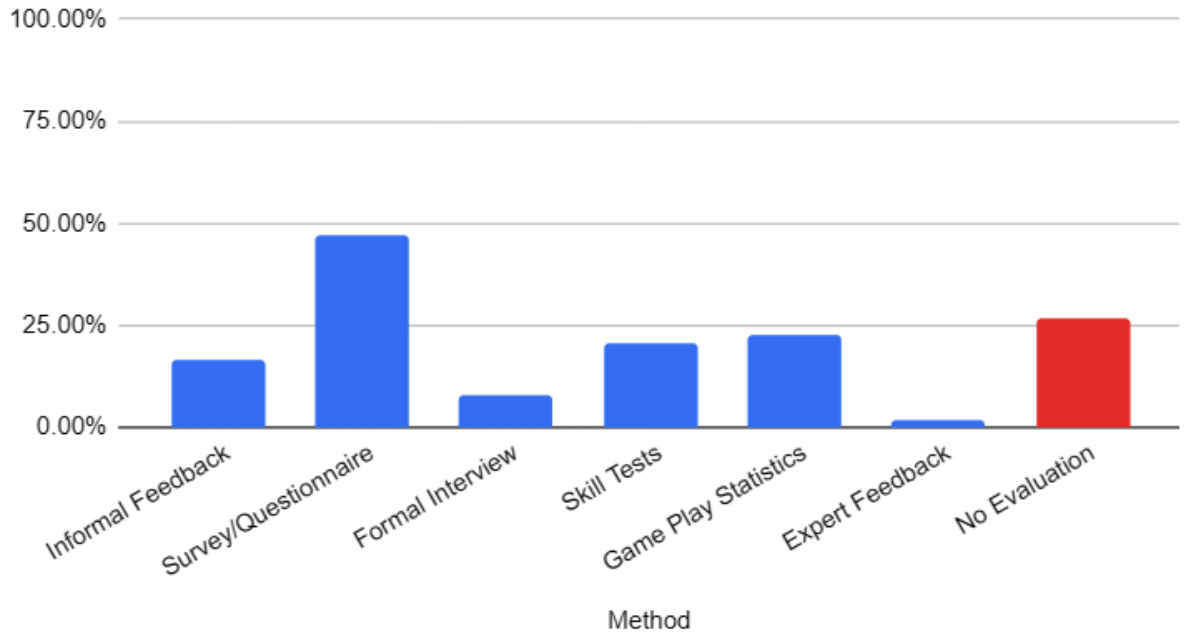
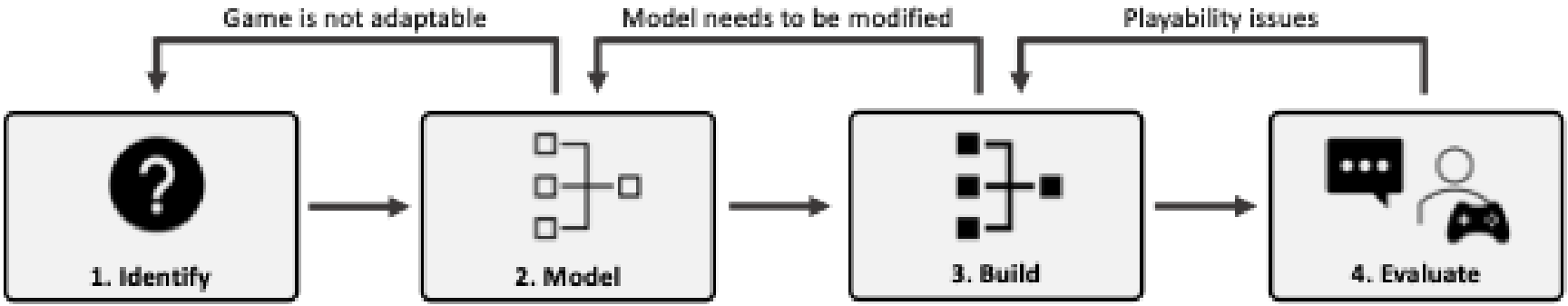


Our Solution

- Automatically adapt game play **tasks** based on non-invasive player **assessments**
- Use **Competence-based Knowledge Space Theory (CbKST)** to aid in selecting tasks that improve learner competences

Christina M Steiner, Alexander Nussbaumer, and Dietrich Albert. ***Supporting self-regulated personalised learning through competence-based knowledge space theory.*** *Policy Futures in Education, 7(6):645{661, 2009.*

Adapting Games to Leverage AI



Michael A. Miljanovic, Jeremy S. Bradbury. **"Making Serious Programming Games Adaptive,"** Proc. of the 4th Joint Conference on Serious Games (JCSG 2018), pages 253-259, Darmstadt, Germany, Nov. 7-8, 2018.

CASE STUDY: GidgetML

Michael A. Miljanovic, Jeremy S. Bradbury. **"GidgetML: An Adaptive Serious Game for Enhancing First Year Programming Labs,"** Proc. of the 42nd International Conference on Software Engineering (ICSE 2020), The Software Engineering Education and Training (SEET) track, Seoul, South Korea, Oct. 2020.

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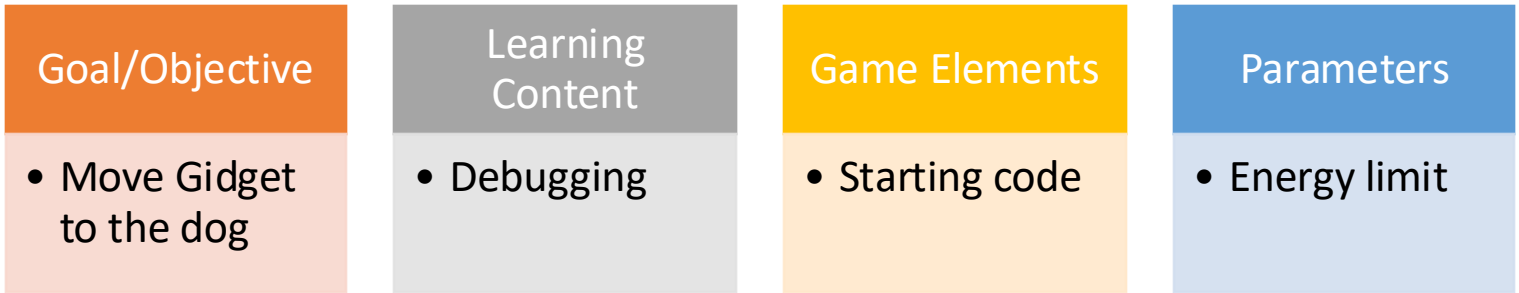
Gidget

Michael J. Lee and Amy J. Ko. 2011**. Personifying programming tool feedback improves novice programmers' learning.** In Proceedings of the seventh international workshop on Computing education research (ICER '11).

1. Identify

- **Technical Factors**
  - Prefer open-source ✓
  - High quality and robust code ✓
  - Games with a playability study ✓
- **Learning Factors**
  - Determine topics and learning outcomes ✓
  - Prefer games with a diverse audience ✓
  - Games with existing evaluations ✓✓✓

2. Model



Task Model

2. Model

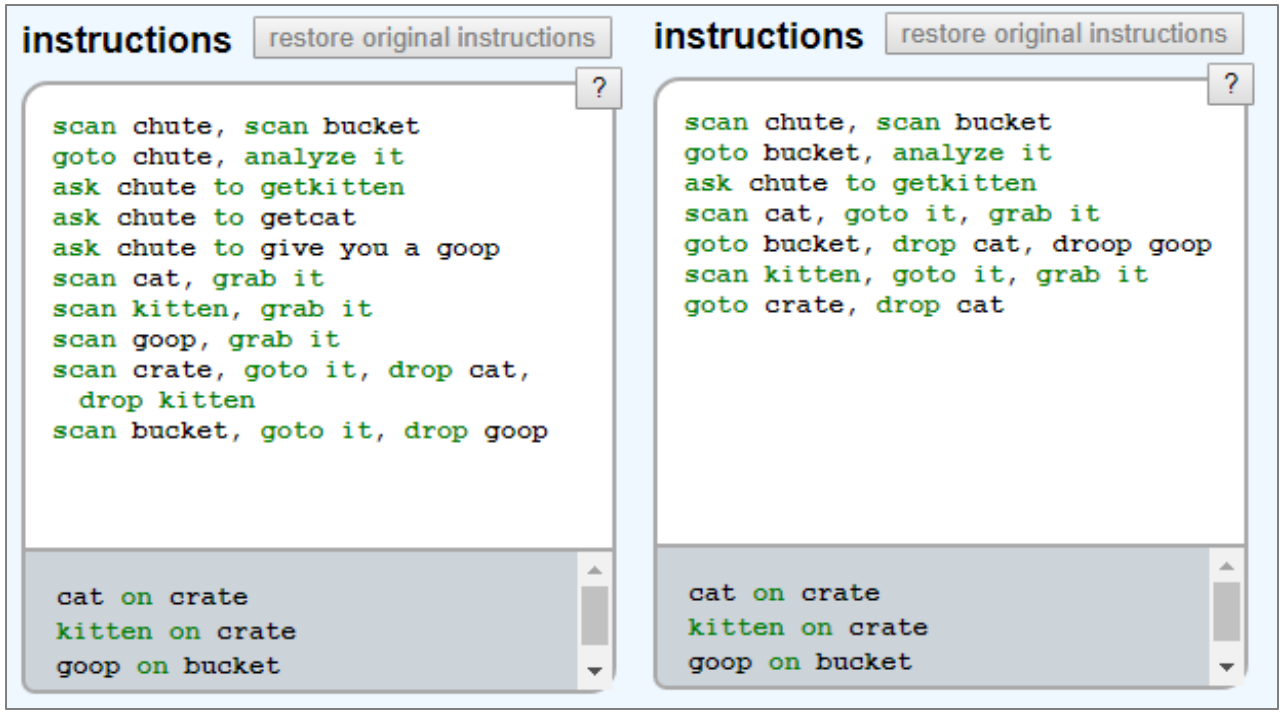
Goal/Objective	Learning Content	Game Elements	Parameters
• Move Gidget to the dog	• Debugging	• Starting code	• Energy limit

Task Model

Success Rate	Comprehension	Engagement	Play Skill
• Number of failed submissions	• Errors in levels with conditionals	• Completed 10/15 levels before quitting	• Completed previous level in 3 minutes

Assessment Model

3. Build – GidgetML Adaptations



Low Competence Game Data **High Competence Game Data**

3. Build – ML Approach

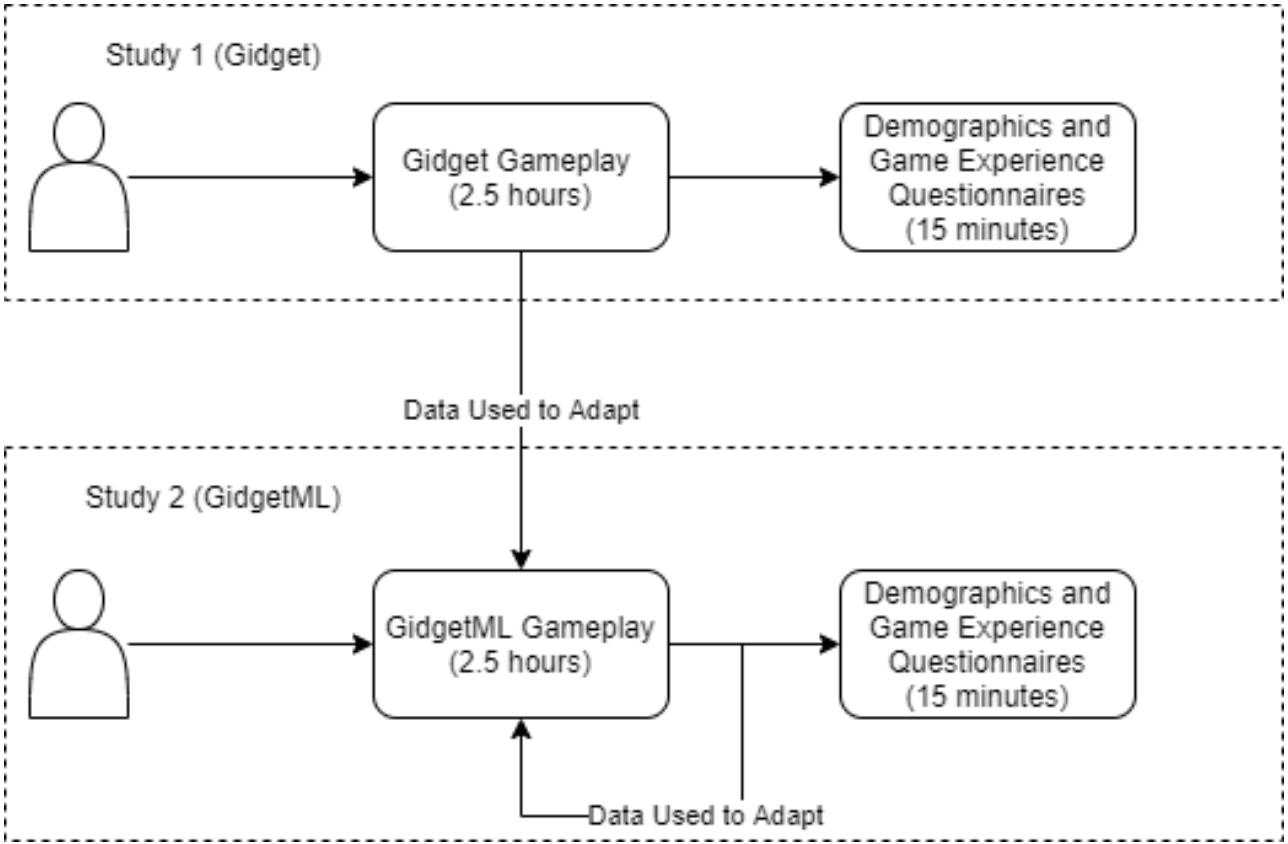
- Manually develop low, medium and high competency game data for each level of Gidget
- Use failure and solution efficiency log data to train K-means clustering algorithm.
- Use an individual learner's data from one level to predict competency for next level

4. Evaluation

Does Gidget benefit from AI personalization?

Is a personalized version of Gidget effective at adapting to a learner's level of competency?

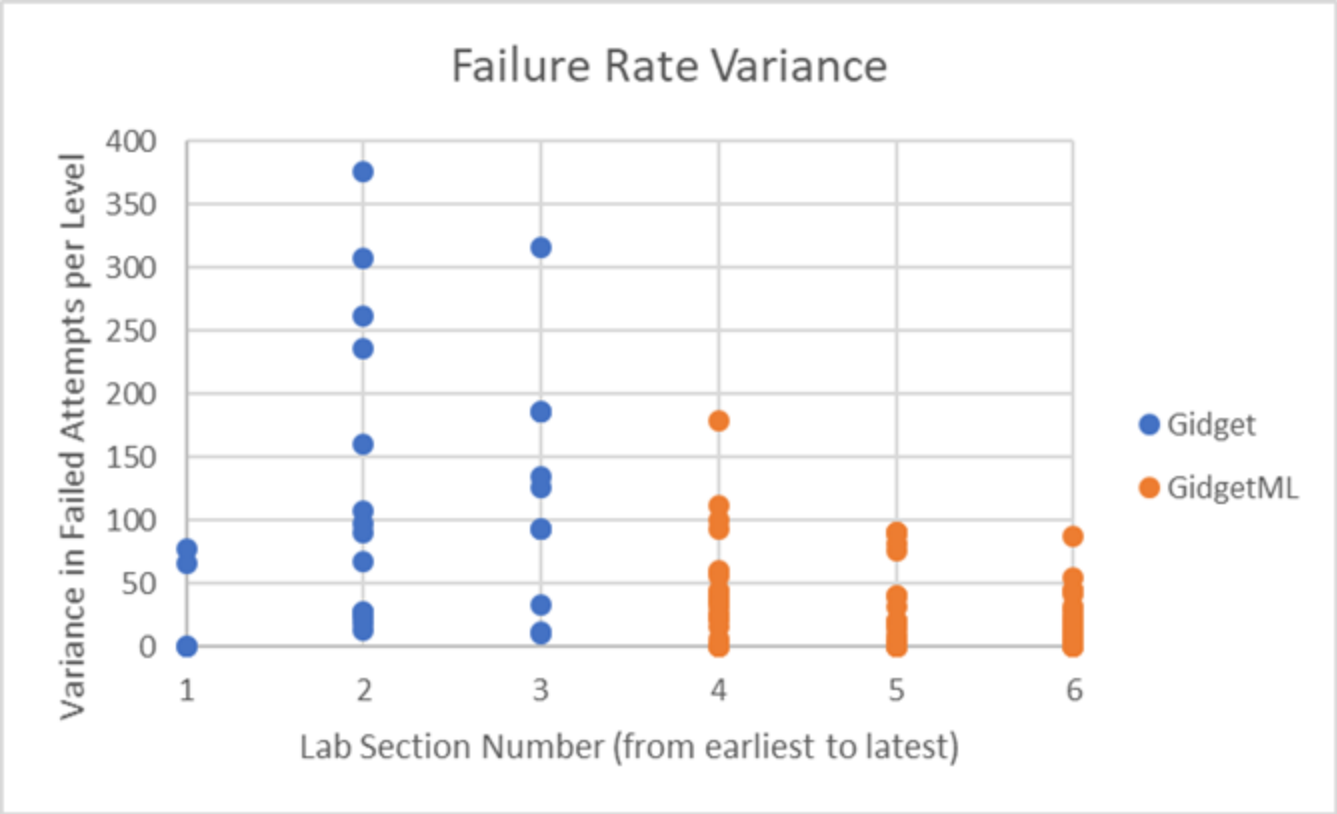
Experimental Design



4. Evaluation

- **100** undergraduate students enrolled in a first-year programming course at Ontario Tech University
  - **32** participants played Gidget, **68** played GidgetML
  - Age:
    - **18.5** years (average)
  - Gender:
    - **81** men, **12** women, **7** either transgendered or no gender specified (grouped to maintain anonymity)
  - Programming experience:
    - **23%** had never taken a previous programming course
    - **30%** had never written a program before
- The study was run in **week one** of the course laboratories, across 6 distinct sections

Variance of Failure Rate



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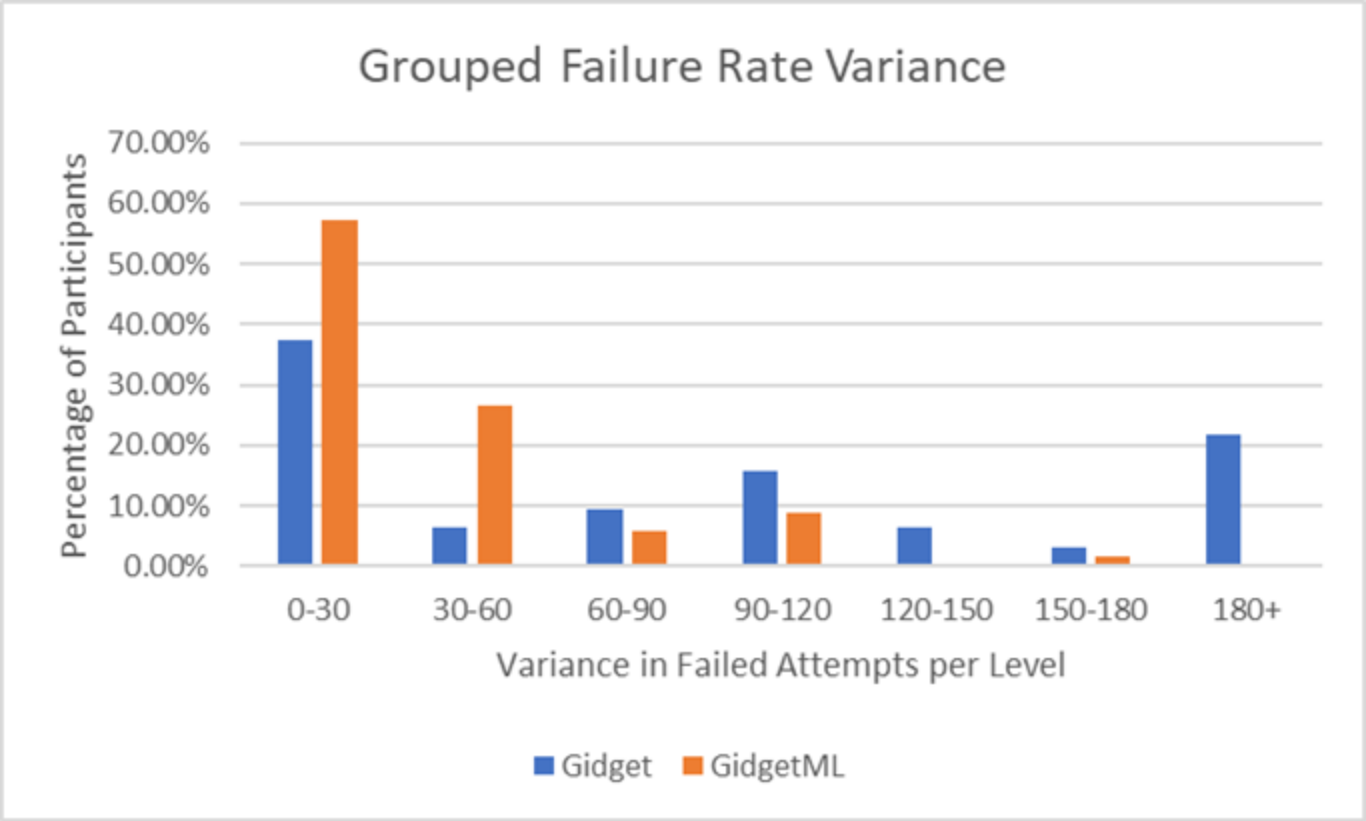
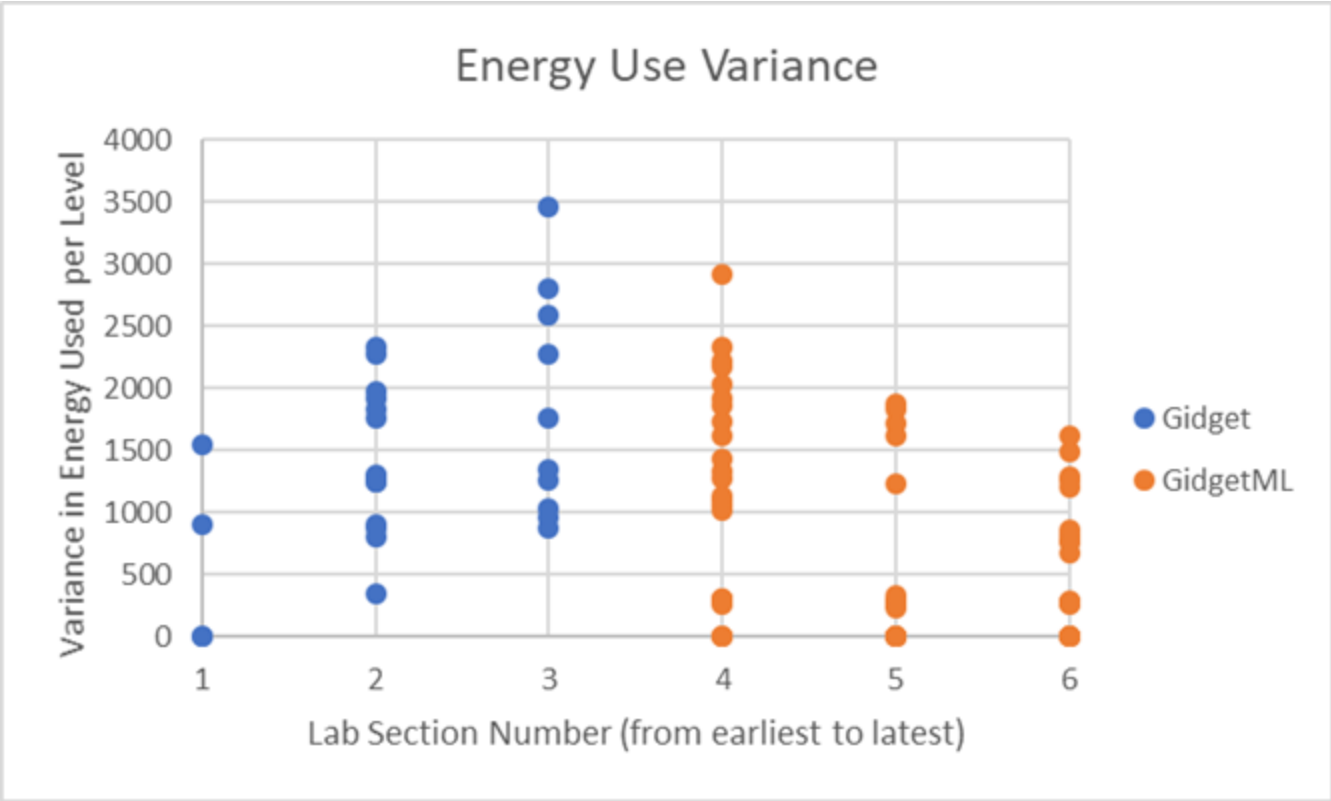


Variance of Energy Usage



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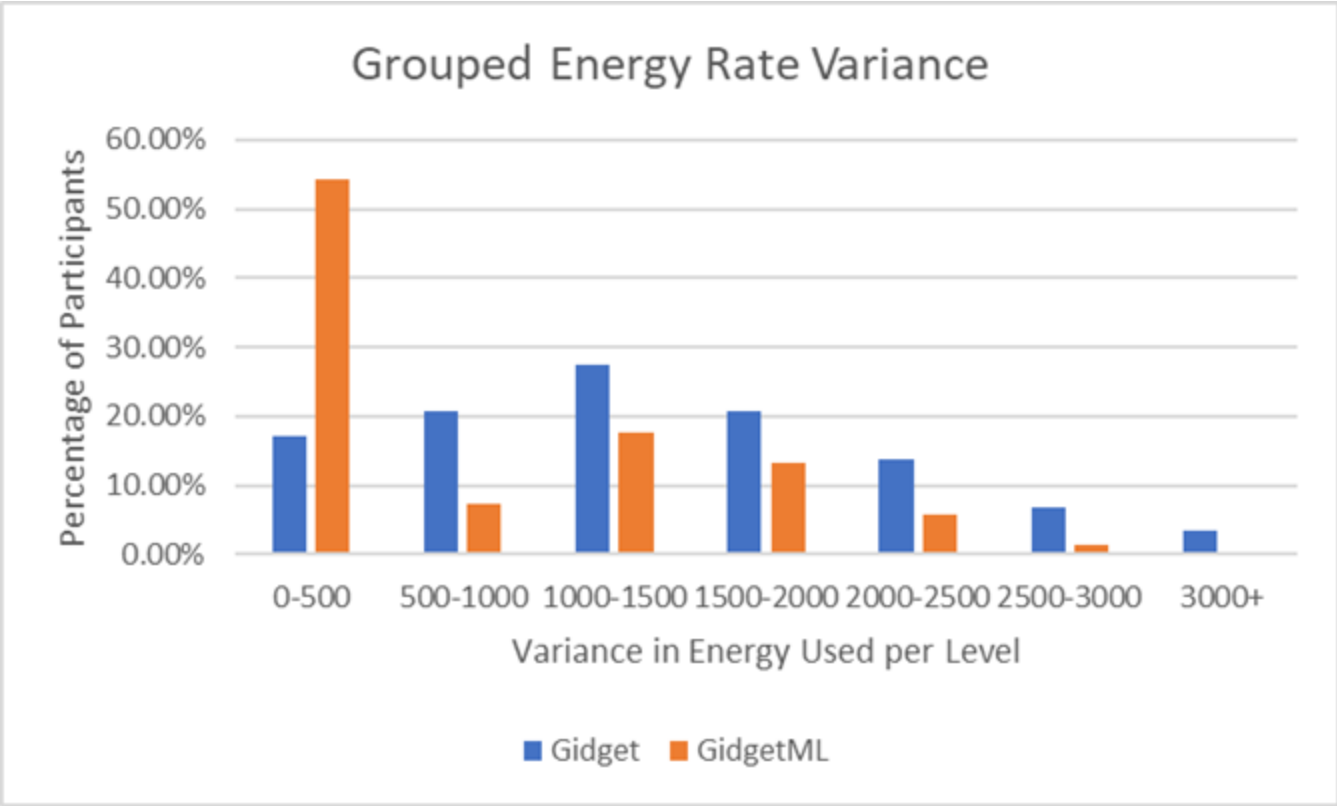


GidgetML Findings

- Our findings support the benefits of GidgetML, a **personalized** version of Gidget
  - The reduction in failure and efficiency variance seen in GidgetML is a strong indicator that the personalized levels are appropriate for the learners' individual competencies.
  - Furthermore, the variance continued to decrease as more data was collected and fed into the model

- Our approach to personalizing GidgetML did not require substantial alterations to the game's source code

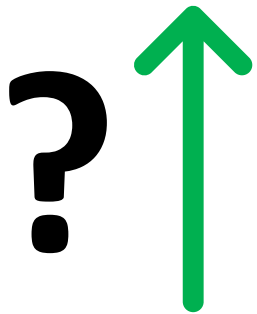
FUTURE DIRECTIONS:
Personalizing game play vs. feedback

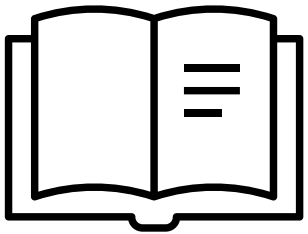
Adaptive RoboBUG

- We've created two separate versions of RoboBUG – one that adapts the game play and one that adapts the feedback (hints).
- Planned study in Fall 2025

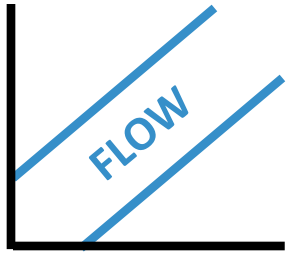
FUTURE DIRECTIONS: Personalized Learning in Games with LLMs

What are the benefits of using **LLMs** to personalize serious games?





Learning



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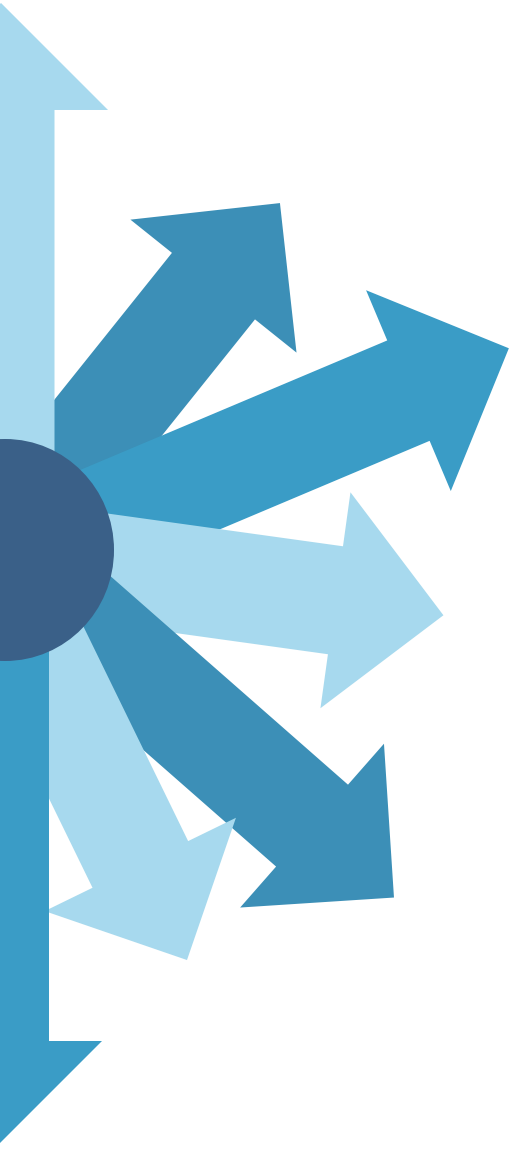

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