Adaptive chemistry game

Bachelor Thesis
Artificial Intelligence
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Video Games and Education

- Growing video game industry
- Educational games not evidence based
- Not much research on adaptive algorithms

Research Question

“Will a game teaching chemistry (molecular structures and names) with an adaptive algorithm improve learning compared to the same game without an adaptive learning algorithm?”

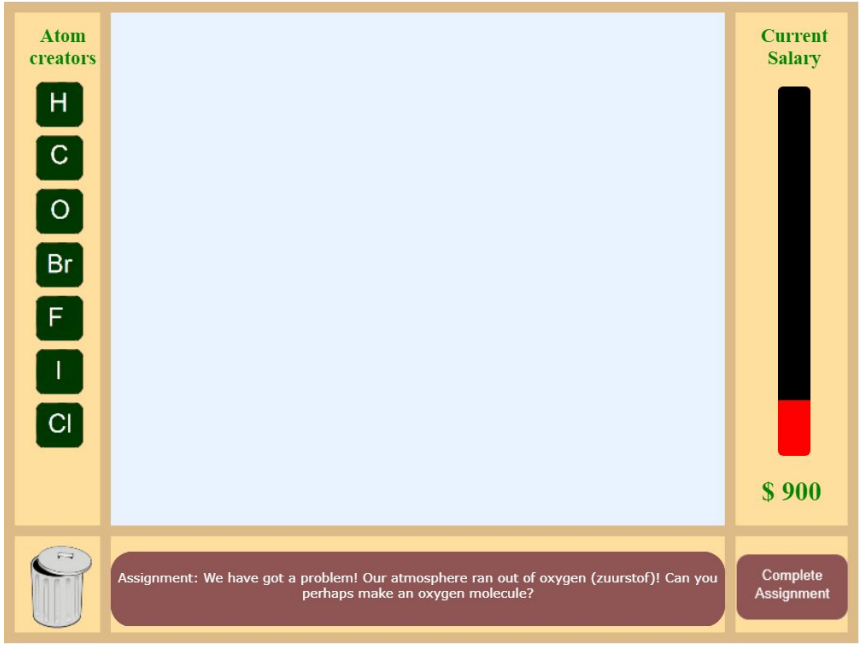
Hypothesis: The chemistry game with an adaptive algorithm improves learning compared to the same game without an adaptive learning algorithm.

Cognitive psychological aspects of an educational game

- Active learning [1]
- Engagement (Intrinsic motivation and extrinsic motivation)[1]
- Meta-memory [2]
- Immediate feedback [3]
- Spacing effect [4]
  - massed learning complex concepts
  - spaced learning easy concepts

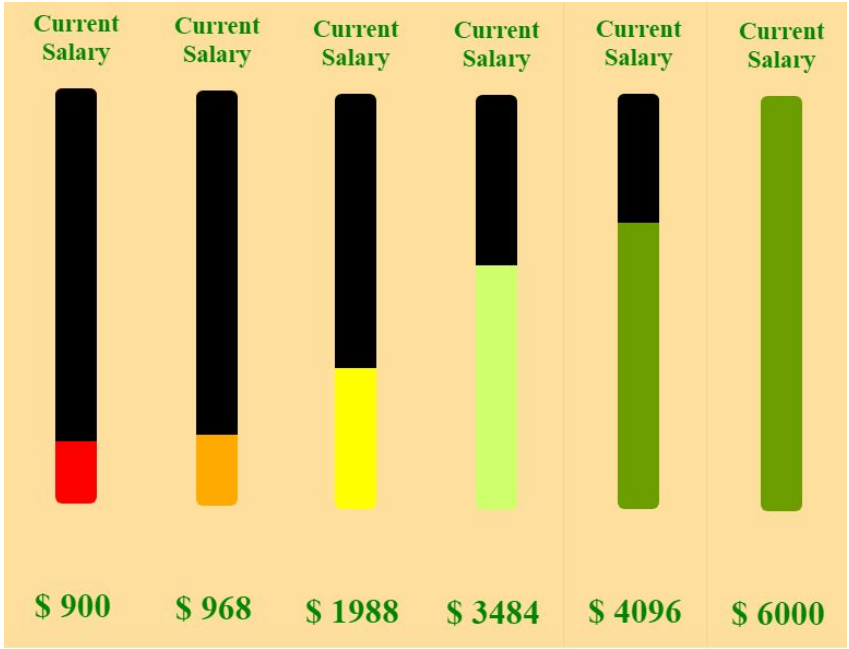
Game Demo

https://chemistrygame-eca18.firebaseapp.com



Salary bar

- Based on Parasocial display (Extrinsic Motivation)
- Meta-memory



Adaptive vs Random version

Adaptive	**Random**
Order is important (Linear)	Order is not important (flashcards)
Spacing questions	Massing questions
Assistant’s aid	Only feedback

Evaluating answers

- Not just right or wrong
- Score based on valid properties of molecule structure

Score	rightAmount	rightType	rightUnique	rightConnections
1	True	True	True	True
0	True	True	True	False
-0.2	False	False	True	True
-0.4	True	False	True	False
-0.6	False	False	True	False
-0.8	True	False	False	False
-1	False	False	False	False

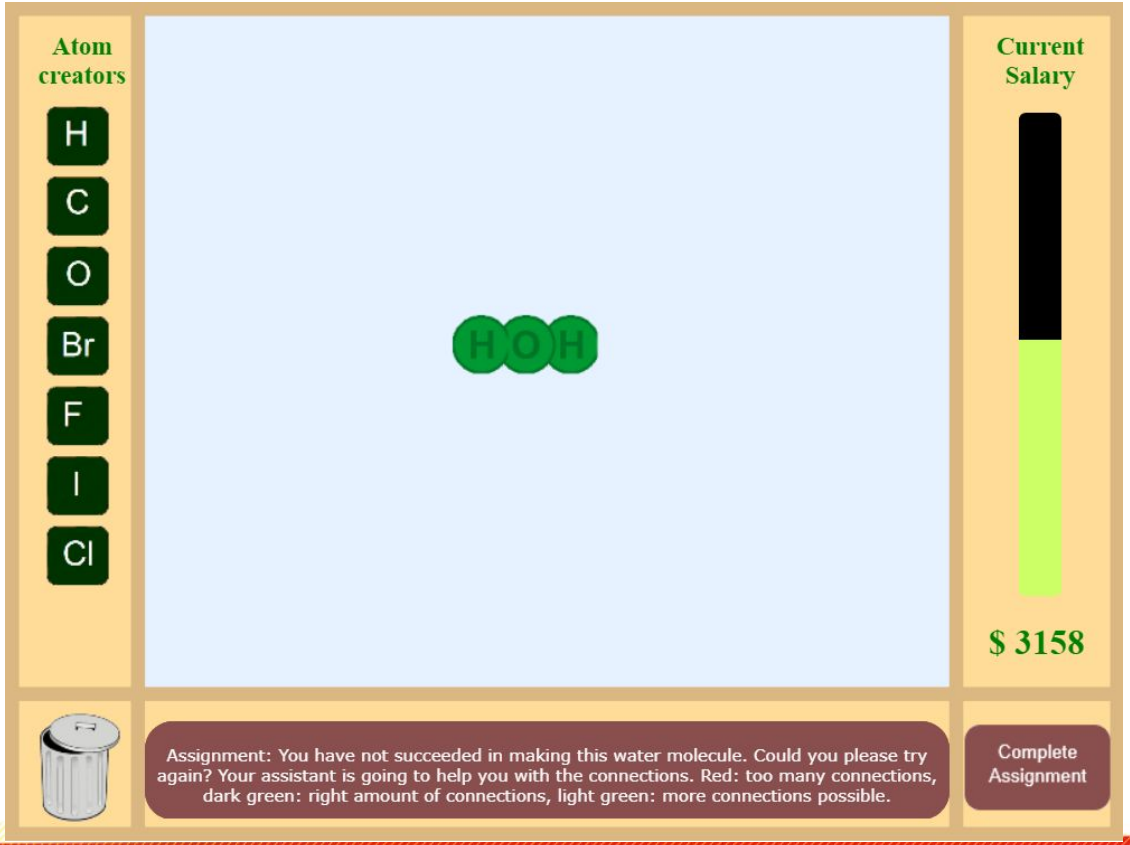
Repetition for adaptive version

- Spacing incorrect questions
- Relatively hard questions first
- Relatively easy questions later

Score	Amount of questions asked before repetition
1	not repeated
0	5
-0.4/-0.2	4
-0.8/-0.6	3
-1	2

Example of Assistant's aid

- incorrect connections



Research

Participants
- 31 participants (14 random, 17 adaptive)
- 23.9 Average age
- Randomly assigned to version

Procedure:
- Play game at once
- Read feedback carefully
- Questionnaire

Measurements:
- time for each question
- score for each question

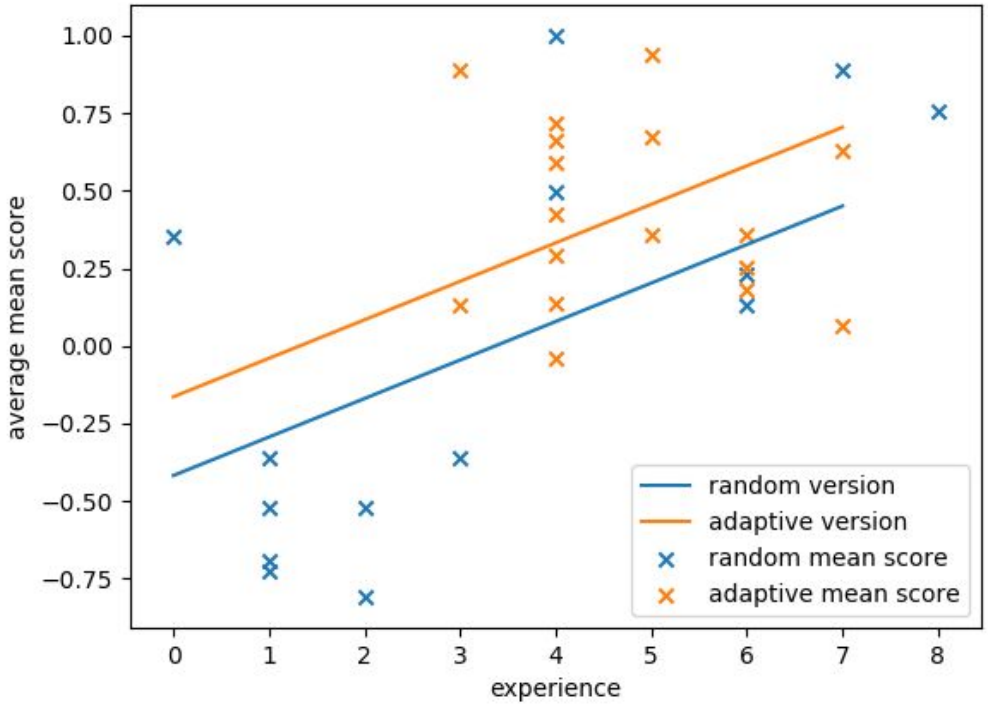
Results

- One sided t tests on
  - mean score
  - mean time
- Mean score significantly higher in the adaptive group than in the random group ($p = 0.01$)
- Mean time not significantly lower in the adaptive group than in random group ($p = 0.86$)

Results

- Linear regression

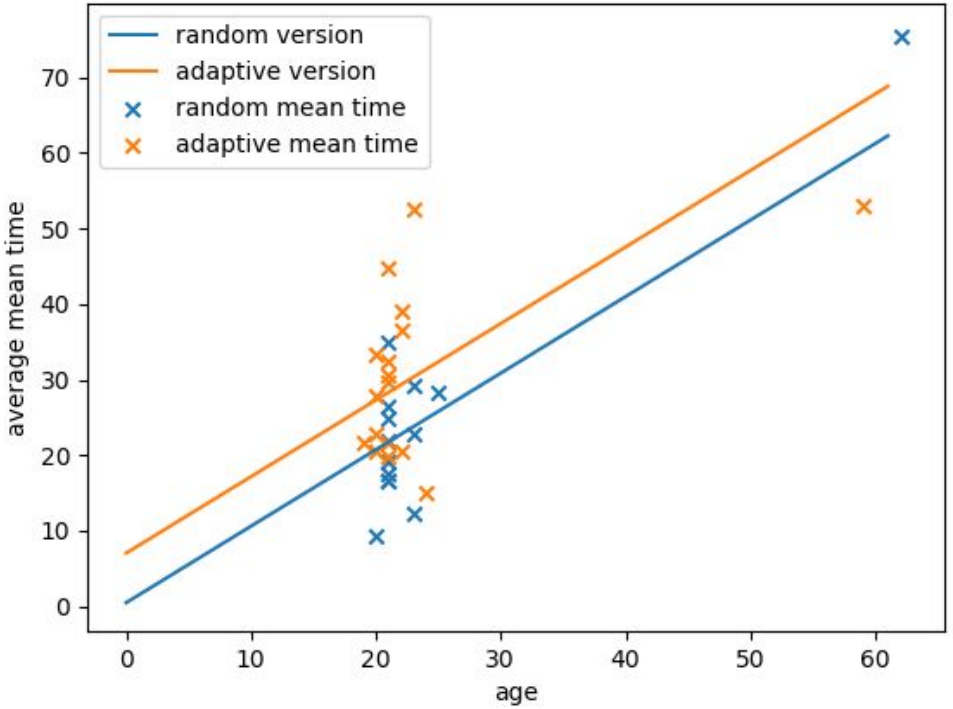
	coefficient	p value
intercept	-0.42	-
experience	0.12	0.00
version	0.25	0.02



Results

- Linear regression

	coefficient	p value
intercept	0.48	-
age	1.01	0.00
version	6.56	0.29



Conclusion

Adaptive version of game has influence on mean score

- version is adaptive to knowledge
- version is easier

Adaptive version of game does not influence mean time significantly

- players try to make unknown molecule
- players may take a break

The more experience the higher the mean score

The adaptive version of the game improves scores of players, however it is not proven that this version also improves learning.

Discussion

- Uncontrolled environment
- Not tested on learning increment

- Cognitive psychological aspects

Take home message

- Educational games could have a major impact on learning
- However further research should be done

References

1. Kathy Hirsh-Pasek et al. “Putting education in “educational” apps: lessons from the science of learning”. In: Psychological Science in the Public Interest 16.1 (2015), pp. 3–34.

2. Bennett L Schwartz et al. “Four principles of memory improvement: A guide to improving learning efficiency”. In: IJCPS-International Journal of Creativity and Problem Solving 21.1 (2011), p. 7

3. Michael L Epstein et al. “Immediate feedback assessment technique promotes learning and corrects inaccurate first responses”. In:The Psychological Record 52.2 (2002), p. 187

4. Lisa K Son. “Spacing one’s study: evidence for a metacognitive control strategy.” In: Journal of Experimental Psychology: Learning, Memory, and Cognition 30.3 (2004), p.601.