Adaptive Educational Content Generation: An Overview

“Which educational games have successfully used PCG? And which of them deployed adaptive PCG, based on a player model?”

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1 - Introduction

Procedural Content Generation (PCG) uses algorithms to create game content like levels, maps, and characters dynamically, enhancing replayability and reducing development costs. In educational games, PCG offers innovative ways to improve learning experiences by creating dynamic and engaging environments. However, the key challenge is ensuring that generated content is appropriately challenging to aid learning. Adaptive Procedural Content Generation (APCG) goes a step further by tailoring content based on player models, enhancing personalized learning and skill development.

2 - Subquestions

This research explores several key questions regarding the use of PCG in educational games:

- How can we measure the success of PCG implementation?
- What impact does PCG have on users' academic performance?
- Are there common characteristics among games that successfully use PCG?
- What advantages does APCG offer over traditional PCG?
- In what areas does APCG particularly excel?

3 - Methodology

The primary research method employed is literature review.

- Broadly collecting papers
- Sourcing, reading, tagging and binning where applicable
- Ranking papers based on relevance.
- Gathering examples of PCG being applied.
- Taking a closer look at the adaptive PCG-related cases
- Drawing conclusions and presenting findings

5 – Conclusion

The existing literature body for adaptive PCG in education is not very exensive at this point in time. As only a handful of papers seem to exist on succesful implementations. Most PCG-related papersfocus on non-adaptive or non-educational use cases.

Though there seem to be benefits, the benefits on long term learning outcomes seem inconclusive and will require further research.

Found implementations are primarily focused on young learners.

More research that incorporate modern AI methods into adaptive PCG will also be interesting.

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4 – Discussion

How can we measure successful PCG use?: *Various methods exist as it depends on a lot of variables. An example would be the impact on the play style of the players.*

In other contexts the generated content can be evaluated for diversity [1]

Impact on academic performance: *Though there is a lot of potential for improving learning outcomes, unfortunately the benefits on long term academic performance are not very clear so far in the literature. [3]*

In which fields/topics does PCG find most utility: *Mathematics education seems to benefit in particular as many implementations use PCG to generate educational content.*

What are the benefits of adaptive PCG over traditional PCG?: *Adaptive PCG allows teaching material to adjust itself to the student’s learning tempo. [2]*

Areas where APCG excels?: *APCG excels in creating personalized, adaptive learning experiences, maximizing engagement, and facilitating deeper learning.*

6 – References

[1] E. Andersen, “Optimizing adaptivity in educational games,” Proceedings of the International Conference on the Foundations of Digital Games. ACM, May 29, 2012. doi: 10.1145/2282338.2282398.

[2] J. Zhu and S. Ontañón, “Player-Centered AI for Automatic Game Personalization: Open Problems.” arXiv, 2021. doi: 10.48550/ARXIV.2102.07548.

[3] K. Park, B. Mott, W. Min, E. Wiebe, Kristy Elizabeth Boyer, and J. Lester, “Generating Game Levels to Develop Computer Science Competencies in Game-Based Learning Environments,” Lecture notes in computer science, pp. 240–245, Jan. 2020, doi: https://doi.org/10.1007/978-3-030-52240-7_44.