

# Incorporating Learning Analytics in an Educational Game to Provide Players with Information about how to Improve their Performance\*

J. X Seaton, Sabine Graf, Maiga Chang, & Arta Farahmand

School of Computing & Information Systems

Athabasca University

Edmonton, Canada

j.xseaton@gmail.com, sabineg@athabascau.ca, maigac@athabascau.ca, & arta.farahmand@gmail.com

**Abstract**—Educational games aim to balance learning and playing. However, for people to benefit from an educational game, they must be encouraged to play the game often. Providing players with information about how to improve their performance could help in achieving this goal. This paper examines how a learning analytics dashboard can be incorporated into an educational game to encourage players to play more often and continuously. The proposed dashboard provides players with a variety of information such as how their performance and skills change over time. Such information allows players to see their performance and play habits, and find strategies on how to improve their performance, and therefore their learning, in the game.

**Keywords**—learning analytics; educational game; dashboard; metacognitive skills

## I. INTRODUCTION

A challenge to educational games is that it can be hard for a player to connect the feedback in a game to how they can further improve in the game. As players progress to more challenging problems, often they learn by failing and re-attempting the challenge. Feedback about a failed attempt can obscure how that failed attempt helped the player become better at playing the game.

Incorporating learning analytics through visualizing gameplay data, including the player’s scores, position, or decisions made in the game, can provide meaningful information about how the player progressed through the game [1]. For example, the game CMX is an educational Massively Multiplayer Online Role Playing Game (MMORPG) that teaches computer programming [2]. The game incorporates learning analytics by creating reports for instructors about how players are progressing within the game (e.g., how many learning activities students have completed, how many errors they made, etc).

Educational games can also use learning analytics to provide feedback to learners. For example, the educational game eAdventure [3] provides students with reports that assess their learning. eAdventure provides learners with information about how they are doing in the game, including how much time they are spending playing the game; the time it took them to finish the game (or a subsection of the game), and their score in the game.

\* The authors wish to acknowledge the support of Canadian Internet Registration Authority (CIRA)’s Community Investment Program, Natural Sciences and Engineering Research Council of Canada (NSERC), and Athabasca University.

While most related works use learning analytics in games with the purpose of assessing and reporting on students’ performance and progress, the aim of this paper is to introduce a learning analytics dashboard that focuses on motivating players and helping them to understand how they can perform better in the game. The dashboard has been evaluated in a proof of concept evaluation with three months of simulated gameplay data.

## II. LEARNING ANALYTICS DASHBOARD

The learning analytics dashboard has been incorporated into an educational game that aims to improve players’ metacognitive skills. The game consists of ten subgames, which each targets improving a metacognitive skill. In the game, players play matches of three subgames against other players. Both players are scored by how they performed individually and against their opponent based on their performance score in each subgame. The player that performs best over a match receives points and the loser loses points, which allow players to be ranked against other players. In addition, a metacognitive skill score is calculated based on the player’s performance score in each subgame. The player’s metacognitive skill score is calculated as a percentage value of his/her performance across all subgames that target the same metacognitive skill.

The learning analytics dashboards presented in this paper utilize two different charts: (1) line graphs, which visualize metacognitive skill scores; and (2) scatter plots, which visualize performance scores. The dashboard also features two tabs: (1) a “Brain” tab, which visualizes data about each metacognitive skill; and (2) a “Game” tab, which visualizes data about subgames. The player can filter the data displayed by toggling on and off metacognitive skills or subgames; and changing the date range displayed (see Fig. 1).

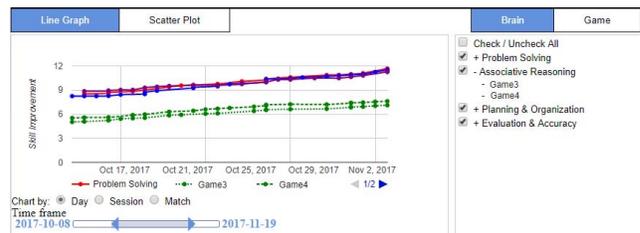


Figure 1. Line graph of metacognitive skill improvement with Associative Reasoning exploded

In the following paragraphs, different visualizations of the dashboard as well as their use cases and benefits for players are explained in more detail.

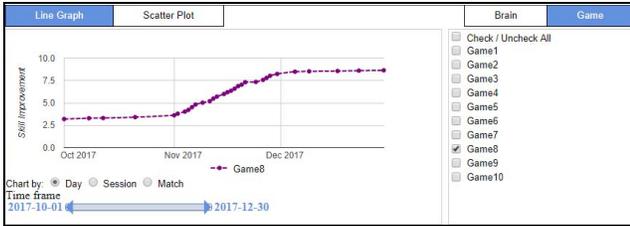


Figure 2. A line graph depicting a player who played more subgames in November compared to October and December

Metacognitive skills from one area do not necessarily translate to other areas [4]. In the dashboard, players are able to see an exploded view of a metacognitive skill to understand how each subgame contributes to their metacognitive skill score. Fig. 1 depicts a line graph that displays a player's metacognitive skills over time. The depicted player has lower scores in subgames that target associative reasoning. The associative reasoning line is exploded to show that subgame 3 and 4 contribute to the skill score. The player can use this information to determine that he/she needs to develop strategies to improve his/her performance in subgame 3 and 4. Showing the player that both subgames target the same metacognitive skill also indicates that strategies that work in one subgame could possibly be applied to the other subgame.

Skill development is dependent on many factors, but an important element is regular practice. Fig. 2 depicts data from a player who played subgame 8 only a few times in October, then plays it frequently in November, and then infrequently again in December. Although his/her skill improves across the three months, there is greater improvement in the month where he/she plays often and less improvement in the months where the player plays only a few times. This shows him/her that if he/she wants to improve his/her in-game performance faster, he/she should play often rather than erratically.

Performance of higher cognitive tasks can vary by time of day [5]. Fig. 3 shows the scatter plot of a player's performance in subgame 4 by the time of day it was played. The visualization shows that his/her performance is relatively lower in the morning and during the day, and increases towards the evening. Therefore, this chart can help a player to identify which times are better for him/her to play the game.

Performance in cognitive tasks is influenced by familiarity with the task [6]. Players may perform poorly at cognitive task in the beginning or after a longer break, not because they are unskilled, but because they are unsure

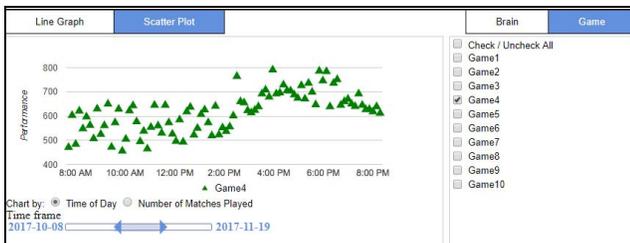


Figure 3. A scatter plot depicting a player performing better in the evening.

about what they need to do. In the context of the investigated game, this could mean that a player might need to warm-up by playing multiple matches and subgames in one play session. In Fig. 4 the chart depicts a scatter plot of performances in subgame 2 based on how many games were played in a play session. The player's performance increases consistently within a play session, which can be seen by how the points become darker in a session. However, after a longer lapse in play, the points become much lighter indicating a drop in performance. Seeing the performance of subgames played in the same session can help players understand increases and decreases in their performance (e.g., need to re-familiarize, consequence of lapse, etc.).

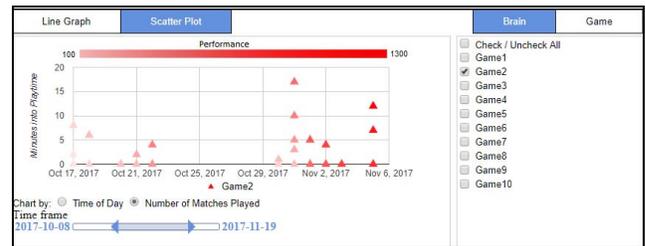


Figure 4. Scatter plot of subgame performance by matches played in session

### III. CONCLUSION

This paper presented how learning analytics can be incorporated into an educational game. The purpose of the introduced learning analytics dashboard is to provide players with information about how they can improve their in-game performance by allowing them to see and analyze their play habits and how those habits may affect their performance. Future work will focus on players' perceived usability and acceptance of the learning analytics dashboard. We also plan to investigate how players use the dashboard while playing, and if their play habits change after using the dashboard.

### REFERENCES

- [1] Á. Serrano-Laguna, I. Martínez-Ortiz, J. Haag, D. Regan, A. Johnson, and B. Fernández-Manjón, "Applying standards to systematize learning analytics in serious games" in *Computer Standards & Interfaces*, vol. 50, Feb 2017, pp. 116-123.
- [2] C. Malliarakis, M. Satratzemi, S. Xinogalos, "Integrating learning analytics in an educational MMORPG for computer programming," *Proc. IEEE 14th International Conference on Advanced Learning Technologies (ICALT)*, IEEE, Jul. 2014, pp. 233-237.
- [3] M. Freire, Á. del Blanco, B. Fernández-Manjón, "Serious games as edX MOOC activities," *Proc. Global Engineering Education Conference (EDUCON)*, IEEE, Apr. 2014, pp. 867-871.
- [4] G. Schraw, "Promoting general metacognitive awareness" in *Instructional Science*, vol. 26, Mar 1998, pp. 113-125.
- [5] D. Goldstein, C. S. Hahn, L. Hasher, U. J. Wiprzycka, and P. D. Zelazo, "Time of day, intellectual performance, and behavioral problems in morning versus evening type adolescents: Is there a Synchrony effect?" in *Personality and Individual Differences*, vol. 42 no. 3, Jan. 2018, pp. 431-440.
- [6] A. Collie, P. Maruff, D. G. Darby, and M. McStephen, "The effects of practice on the cognitive test performance of neurologically normal individuals assessed at brief test-retest intervals" in the *Journal of the International Neuropsychological Society*, vol. 9, Mar. 2003, pp. 419-428