frontiers | Frontiers in Education

EDITORIAL
published: 27 April 2022
doi: 10.3389/feduc.2022.911074

# Editorial: Adaptivity in Serious Games Through Cognition-Based Analytics

*Herre van Oostendorp*[1]*, *Sander Bakkes*[1] and *Michael Kickmeier-Rust*[2]

[1] Department of Information and Computing Sciences, Utrecht University, Utrecht, Netherlands, [2] Institute of Competence Diagnostics, University of Teacher Education St. Gallen, St. Gallen, Switzerland

**Keywords: adaptivity, serious games, analytics, cognition, model-based**

## Editorial on the Research Topic

## Adaptivity in Serious Games Through Cognition-Based Analytics

Computer games that are used for the purpose of learning, training, and instruction are often referred to as serious games. The last decade has impressively shown that serious games contribute considerably to the motivation but also the (educational) achievements of participants (Wouters, 2017). Enhancing the effectiveness of in-game analytics is a key issue in serious games research, as it is indispensable to better understand how a participant is performing in a game during playing. Cognition-based analytics, in particular, can help to characterise their proficiency, e.g., by distinguishing conscientious, goal-directed players from chaotic, explorative players. It can also be an instrument in improving the game, e.g., it can be detected where confusion arises and, most importantly, it can be used to dynamically improve (adapt) the game to the in-game performance of the player, in order to enhance learning.

Adaptivity in serious games consists of two main steps (Jameson, 2003). The first step assesses the status of the player by means of in-game behaviour analytics and includes creation of a user (player) model. The second step involves using this information to provide the actual adaptivity to support the player. There is not much systematic knowledge on the dimensions of adaptation as part of the second step (Lopes and Bidarra, 2011; Bakkes et al., 2012). While in the current topic we focus on the first step—and particularly on in-game analytics—we refer the interested reader to Lopes and Bidarra (2011), who provide an overview of several dimensions on which the content of games can be adapted dynamically.

In this Research Topic, we first present two studies on unobtrusive on-line assessment of in-game performance. The first example involves the motivational power of a game for the training of rules of Czech language grammar (Brom et al.). They distinguish a great number of basic variables like time-on task (i.e., time spent on playing without restriction), answer accuracy, number of player sessions and connect these variables to higher-order psychological concepts such as interest, persistence, and degree of distraction. A challenge addressed in this work is what basic indicators—in-game analytics—should be measured and how they should be related to higher-order concepts. Clearly, a psychological theory of the underlying information processing is needed. The second study by Steinrücke et al. concentrates on knowledge and skill acquisition. It is dedicated to developing an unobtrusive method in a crisis management training to measure stress and information literacy skills of players. The article illustrates the development of player/user models in this context.

It is useful to have available a recent review of studies on in-game analytics and adaptivity. That has been done in the study of Ninaus and Nebel. They provide us an overview of in-game analytics and their theoretical underpinning.

OPEN ACCESS

***Edited and reviewed by:***
*Clifford A. Shaffer,*
*Virginia Tech, United States*

***Correspondence:**
*Herre van Oostendorp*
*H.vanOostendorp@uu.nl*

***Specialty section:***
*This article was submitted to Digital Education, a section of the journal Frontiers in Education*

***Received:*** *01 April 2022*
***Accepted:*** *12 April 2022*
***Published:*** *27 April 2022*

***Citation:***
*van Oostendorp H, Bakkes S and Kickmeier-Rust M (2022) Editorial: Adaptivity in Serious Games Through Cognition-Based Analytics. Front. Educ. 7:911074. doi: 10.3389/feduc.2022.911074*

There are many in-game analytics and many game analytics systems, however, often the game analytics used are based on shallow interaction data (Perez-Colado et al., 2018) and their success in predicting learning is limited or even unknown. We can distinguish bottom-up vs. top-down approaches. In our view game analytic measures as used in the bottom-up approach are often (too) data-driven and system-driven, and not enough theory-driven. In contrast, in a top-down approach the analytics are based on cognitive task analysis that is based on analyses of the cognitive processes and cognitive problems that players encounter during progressing and navigating through a serious game (Ferguson and Van Oostendorp, 2020). We will give an illustration of both approaches.

One the one hand, Sevcenko et al. present a study of a theoretically informed top-down development of using in-game metrics. Their results indicate that it seems indeed possible to use simple in-game metrics to reliably assess and predict cognitive load when it is based on a theory-driven approach. They claim that a theoretical top-down approach may be key to find parsimonious yet reliable and generalizable solutions. Therefore, a suitable theoretical framework is chosen in the first place. In their case, the TBRS model (Barrouillet et al., 2004) serves as a foundation and specifically emphasizes the role of time pressure as the origin of cognitive load. The article revealed that the approach is particularly useful for predicting workload in time-critical situations such as serious game scenarios similar to the current one.

In contrast, the contribution of Sandeep et al. focuses on bottom-up approaches. The authors compare Machine Learning models, including Bayesian models and Deep Learning techniques, and demonstrate that Hidden Markov models appeared to be most accurate in predicting participants' performances as opposed to other approaches. Moreover, the approaches enable presenting learners with appropriate learning challenges as a function of prior task performance. These outcomes support the great potential of Machine Learning approaches as appropriate methods to personalize games using tasks that require adaptively determined tasks and challenges.

Overall, the contributions to recent research presented in this Research Topic come from different disciplines: psychology, educational science, cognitive science, AI and computing science. They cover the entire spectrum, from reviewing empirical studies, systematic reviewing theoretical descriptive study, using machine learning and Markov modelling approaches, computing-oriented user-centred system designs to empirical studies. Adaptivity in games is still a relatively new research area where still much progress can—and must—be made. The research articles offer hereto many useful new insights, especially with regard to allegedly opposition of top-down and bottom-up approaches.

## AUTHOR CONTRIBUTIONS

All authors listed have made a substantial, direct, and intellectual contribution to the work and approved it for publication.

## REFERENCES

Bakkes, S., Tan, C. T., and Pisan, Y. (2012). "Personalised gaming: a motivation and overview of literature," in *Proceedings of the 8th Australasian Conference on Interactive Entertainment: Playing the System,* 1–10.

Barrouillet, P., Bernardin, S., and Camos, V. (2004). Time constraints and resource sharing in adults' working memory spans. *J. Exp. Psychol. Gen*. 133, 83–100. doi: 10.1037/0096-3445.133.1.83

Ferguson, C., and Van Oostendorp, H. (2020). Lost in learning: hypertext navigational efficiency measures are valid for predicting learning in virtual reality educational games. *Front. Psychol.* 11, 578154. doi: 10.3389/fpsyg.2020.578154

Jameson, A. (2003). "Adaptive interfaces and agents," in *Human-Computer Interaction Handbook*, eds Jacko, J. A., and Sears, A. (Mahwah, NJ: Erlbaum), 305–33.

Lopes, R., and Bidarra, A. (2011). Adaptivity challenges in games and simulations: a survey. *IEEE Trans. Comput. Intell. AI Games* 3, 85–99. doi: 10.1109/TCIAIG.2011.2152841

Perez-Colado, I., Alonso-Fernandez, C., Freire, M., Martinez-Ortiz, I., and Fernandez-Manjon, B. (2018). "Game learning analytics is not informagic," in *2018 IEEE Global Engineering Education Conference (EDUCON)*, Tenerife: IEEE, 1729–1737.

Wouters, P. and Van Oostendorp, H. (2017). "Overview of instructional techniques to facilitate learning and motivation of serious games," in *Instructional Techniques to Facilitate Learning and Motivation of Serious Games*, eds P. Wouters and H. van Oostendorp (Cham, Swiss: Springer), 1–16.

**Conflict of Interest:** The authors declare that the research was conducted in the absence of any commercial or financial relationships that could be construed as a potential conflict of interest.