ADAPTIVE GAMIFICATION MODELS IN HIGHER EDUCATION: IS THERE A PLACE FOR SELF-REGULATED LEARNING?

M. Raleiras[1], J. Viana[2], F. Costa[2]

[1]*Instituto de Educação da Universidade de Lisboa (PORTUGAL)*
[2]*UIDEF, Instituto de Educação da Universidade de Lisboa (PORTUGAL)*

Abstract

Despite a growing body of research literature in gamification models, there is little systematic analysis and understanding of what makes up effective approaches to gamification. While generally positive, the impact of gamified interventions on student participation engagement depends on whether the student is motivated intrinsically or extrinsically. Self-Regulated Learning skills of time management, metacognition, critical thinking, and effort regulation were found to have significant positive correlations with academic success in online settings and to improve students' satisfaction and learning persistence. These strategies can be taught to students and promoted by learning environments. Gamification as an educational strategy can contribute to developing these skills. In this paper, we present a review of adaptive gamification models for Higher Education and analyzed how they integrate Self-Regulated learning skills.

Keywords: Adaptive gamification, personalized learning, self-regulated learning.

1 INTRODUCTION

Gamification is the application of game elements to non-game environments [1] to promote learners' engagement, action, learning, and problem-solving skills [2]. The growing interest in this strategy has encouraged researchers to study the real benefits of gamification in educational contexts. The results of several of these studies show a globally positive impact on engagement and motivation [3, 4]. However, different authors have pointed out the need to address learners' contextual and personal differences [5, 4], which lead to the growing interest in research on adaptive gamification, i.e., gamification systems tailored to different learners. This approach seems to optimize gamification effects when compared to the "one size fits all" design of standard approaches [6].

From a socio-constructivist perspective, gamification benefits can be assessed beyond engagement and motivation. Like [7] we consider that certain elements of gamification have the potential to improve self-regulation and metacognition skills in learners.

Zimmerman [8] defines Self-Regulated Learning (SRL) as the ways students control their thoughts, feelings, motivation, and learning behaviors planned and cyclically adapted to the accomplishment of their academic goals. This definition considers learning as the result of what happens when students are actively and strategically engaged in learning and not something that happens in reaction to teaching activities [9]. SRL is not a fixed trait that some students possess and others don't. It is a set of skills that can be taught to students [10] and developed through experience and real-world practice [11]. These skills allow the student to concentrate on a given task, to explore the task's elements and the conditions for completion. To establish goals and select the proper strategies, learners need to identify their current position within the ongoing educational process and use the resources available to them [11].

The relationship between SRL and academic achievement has proven to be significant and positive. Different studies confirm that those who exhibit higher metacognitive awareness achieve higher performance over the long term than those that do not [11, 12, 13]. As Zimmerman and Schunk's research has shown [14, 15] self-regulators tend to set better learning goals, implement effective learning strategies, monitor and assess their goal progress, establish a productive environment for learning, seek assistance when it is needed, expend effort and persist better.

Since for many years SRL has been an important topic of research, there are currently different frameworks and systems of categories of SRL strategies that learners can apply to regulate their learning. For instance, Pintrich model [16] considers (i) cognitive strategies in the acquisition, storage, and retrieval of information, such as rehearsal, critical thinking, organization, and elaboration; (ii) metacognitive strategies to plan, monitor, and regulate their learning process to accomplish a goal,

like goal-setting, strategic planning, self-monitoring, and self-evaluation; and (ii) resource management strategies to manage the learning environment and external resources like time management, help-seeking, effort regulation, and organizing the study environment. Zimmerman's initial model [17] is a 14 categories system of strategies composed by self-evaluation; organizing and transforming; goal-setting and planning; seeking information; keeping records and monitoring; environmental structuring; self-consequences; rehearsing and memorizing; seeking social assistance peers; seeking social assistance teachers; seeking social assistance adults; reviewing records tests; reviewing records notes; reviewing records textbooks.

Feedback is an important pedagogical element that contributes to metacognition awareness and SRL skills training. The feedback system provided by Gamification strategies is usually done in rapid cycles that can stimulate the reflection of learners' awareness about their learning process and maintain a positive relationship with errors. In gamification, errors and failure are seen as steps on the journey of practice, experience, reflection, and learning [3].

In research on strategies to support learners' online education, [18] created a system of categories that combines different theoretical perspectives on SRL. This system includes (i) goal-setting (setting educational goals or sub-goals); (ii) strategic planning (sequences, timing, and completion of activities directed at learning goals); (ii) self-evaluation (setting quality standards and criteria for progress; (iv) task strategy (organizing, planning, and transforming one's own study time and tasks; (v) elaboration (combining new knowledge with prior knowledge and constructing meaning from learned materials); and (vi) help-seeking (asking the instructor or peers for help, or consulting external help and resources).

In a study about SRL strategies and Gamification and [12], the following categories were identified: (i) self-monitoring and reflection: in games, rewards can engage students in self-monitoring and reflection; (ii) planning and strategy: game elements can help students to practice planning, consider the resources they need and how to apply them; (iii) self-evaluation and assessment: rewards can be based on the frequency of self-assessment like self-evaluation quizzes, and use of comparisons; (iv) collaboration and group dynamics: social dynamics including exploration, collaboration, and competition, game dynamics that engage users in team or group related activities; (v) game aesthetics: game aesthetics that convey feelings of autonomy and competence.

In this paper, we present a review of the research literature about adaptive gamification systems for Higher Education. Our review aimed to understand how adaptive and/or personalized gamified learning systems can help higher education students develop Self-Regulated Learning Strategies. This was achieved by a meta-analysis of the selected papers from a theoretical framework of strategies that can promote the development of self-regulated learning skills to be developed.

Our research objectives are:

- O1. To understand if SRL skills are part of adaptive gamification systems in Higher Education;
- O2. To identify strategies for SRL encouraged in current adaptive gamification models for Higher Education;

We aim to achieve these objectives by answering the following questions:

- Q1. How adaptive gamification models in higher education promote the development of SRL skills?
- Q2. Which SRL skills are explicitly important in adaptive gamification systems?
- Q3. How do these skills relate to the elements of the game?

The rest of this paper is as follows: in section two, we describe the research methodology and the procedures for the conducted review; in the next section we present the results of our review and try to answer the research questions; and, finally, we present our main conclusions.

2 RESEARCH METHODOLOGY

The first step of the review was to select the databases and queries for the search. We decided to use only major scientific digital libraries of peer-reviewed papers (Science Direct, IEEE, Web of Science, and Google Scholar) and the search string: (”Adaptive Gamification” OR ”Personalized Gamification”) AND (”Higher Education”). We limited the query to the last 5 years (2015-2020) to retrieve the most recent developments in this area. This originated a large initial number of references and it was

necessary to remove references that did not match our purpose. This search was performed in April 2020 and the first result numbers are presented in Table 1.

Table 1. References initially selected from each library.

Science Direct	IEEE	WoS	Scholar	Total
55	2	16	30	103

The second step was the selection process of the papers found. For this round, we excluded papers without not describing a framework or model for adaptive gamification, papers about gamification but not adaptive gamification, papers about adaptive systems but not gamification, and papers for educational levels other than higher education. After this procedure, our list had 20 relevant papers published in peer-reviewed journals or conference proceedings from 2015 to 2020.

All papers were analyzed through the lenses of our research questions. For each paper, we identified applicable concepts within the literature. The emerging categories of SRL strategies have been: (1) Self-assessment; (2) Feedback; (3) Error management; (4) Hints/Guidance; (5) Collaboration; (6) Goal-setting; (7) Progress visualization.

3 RESULTS

3.1 SRL strategies in adaptive gamification

3.1.1 Feedback

Feedback is the most common element in adaptive gamification models [20, 23, 25, 27, 28, 30, 33, 34, 35] that can contribute to the development of students' metacognition awareness and monitoring of learning. In [20] the authors describe a framework for user-centered gamification where feedback returns relevant information to the user and generates an engagement cycle. This cycle increases students' motivation to perform a certain activity that provides feedback and this feedback reinforces their motivation to perform new activities. Besides this, badges and rewards also have a feedback effect reinforcing the defined rules.

In research by [25], the element of adaptivity in gamification is feedback itself. An intelligent instructor provides adaptive feedback to the collaborative behavior of the students. The results of the experiments performed showed that the adaptive feedback significantly improved the performance of the students. Adaptive feedback is also the focus of [23] where an engine monitors the state of the learner's session and compares it to the states defined. Whenever a match is found it activates the corresponding action.

Quality of feedback provided is a concern in other papers. The model by [27] uses the theoretical guideline of providing positive, competence-related feedback. The authors state that feedback should be meaningful and positive, and should make the user feel capable and not perceived as a punishment [27, 35]. Immediate and positive feedback is also a guideline for adaptive gamification [33].

Feedback can be directed to certain behaviors or derived from a task [34]. A good feedback system can provide the player with more useful information instead of telling them whether what they did was right or wrong. It is even better if the feedback provides information on how to solve the problem and gain insight into how to solve such problems in the future [28]. Another function of feedback is to help users know how much progress they've made [29].

3.1.2 Progress visualization

Another common element in adaptive gamification models that can improve Self-Regulated learning skills is progress visualization and activities mapping that helps the student to be aware of what needs to be done. In the case of KOLEGEA [19], participants acknowledged that both the prospect to achieve medical expertise badges for KOLEGEA activities, as well as the clear mapping of their KOLEGEA activities to the competencies motivate them to use the platform. The possibility to visualize the user's evolution over time, helps the student to feel that he is progressing in the learning process [20].

Table 2. Adaptive gamification systems reviewed

System	Subject	1	2	3	4	5	6
KOLEGEA [19]	Medical training			•	•	•	
5W2H [20]	Algorithms	•			•	•	
[21]	Software Engineering						
AGLS [22]	Computer Science						
[23]	Data Structure	•		•			
[24]	Computer Science						
[25]	Computer Science	•					
[26]	Computer Science						
[27]	Software Engineering	•			•		
Cubicle [28]	Engineering	•	•	•			•
[29]	-					•	
[5]	Software Engineering						
[30]		•				•	
AdaptWeb [31]						•	
[32]							
Topolor 2 [33]		•				•	
[34]	Dynamic Web-Based Systems and Collaborative Filtering	•			•	•	
[35]	Technical English	•			•		
[36]	-			•			
[37]							

(1) Feedback; (2) Error management; (3) Hints/Guidance; (4) Collaboration; (5) Progress visualization; (6) Strategical planning;

Progress visualization is also a form of feedback. An important part of providing feedback to users is to let them know how much progress they've made, either in-game or learning [30]. This can also generate a sense of progress, competition, and achievement [31].

The visualization of progress can include rankings, social status, and comparisons [31, 33]. Topolor 2 supports various visualizations of individuals and communities for students to feel competent and related and the AdaptWeb homepage shows the top five students. Leaderboards can also be used for visualization of individual progress and students' public ranking [36].

3.1.3 Hints and guidance

The resource to hints and guidance given to the user is present in some papers. This can happen in the form of adaptive incentives, as the user is pointed to the next most feasible action based on the smallest point gap to the next achievement [20], or to adjust the game difficulty for individual users [28]. A good hint system could reduce a player's frustration and increase their engagement. In another research, a feature was implemented to guide the teacher [23]. This system helps to identify the doubts of the learners and helps teachers to reflect upon their lessons.

In [36], the adaptive system detects user disengagement, sends an alert to the adaptation engine before the user leaves. When the adaptation engine receives an alert about the low engagement level, it updates the information of the player model in the same base, selects the functionality which best fits the user's needs, and introduces it in the learning environment.

3.1.4 Collaboration

The KOLEGEA platform [19] aims to support physicians in training through online sharing of medical patient cases (anonymized) from their work practice. Additionally, the platform offers to join learning

groups, add articles and comments to the forum as well as explorative search queries through a knowledge browser.

Collaborative learning and social interaction are also promoted by [27]. This system is aimed to gamify a computer-supported collaborative learning environment used by software engineering students who practice working as engineering teams.

Another proposed system values [34] the opportunity to discover and join learning communities, the connection of interest and goals between students and communities, tools for interaction, collaboration, discussion and mutual assistance.

The interaction between users is considered as competitions and cooperations [20] that should be reinforced. The student's communication with others or with the teacher is important to measure their engagement.

3.1.5 Error management

In Cubicle [25], students are encouraged to self-directed learning via a trial-and-error approach and new levels or game mechanics provide tutorials and in-game assistance for players to facilitate the learning process.

3.1.6 Strategical planning

The system Cubicle promotes strategical planning by students while learning about spatial visualization. The game starts with the player trapped in a dungeon maze. The player starts from a large center room with multiple smaller adjoining rooms. To escape, he needs to navigate through the maze and unlock all the rooms. A chain of locked rooms contains different levels in that game module. Finishing the game task in the room is the only way to unlock the door to the next room.

4 CONCLUSIONS

In this paper we aimed at identifying adaptive gamification that can promote self-regulated learning in Higher Education Students with the premise that these skills can not only increase students' performance but are also transferable to other contexts of life-long learning. We conducted a literature review to screen research papers describing adaptivity models and to conduct a meta-analysis from the SRL perspective. We conclude that adaptive gamification models can include incentives for the development of SRL skills. Currently, this happens mostly through feedback and progress visualization.

Feedback can be delivered immediately, by points and badges and can be directed to the task or behaviors. The quality of feedback must not be neglected for it to be effective in helping the students to gain awareness of their strengths and to assist the educational strategic planning. Progression visualization is another strong benefit from gamification. Whether by leaderboards, progress bars, or communities, students can improve goal-setting, time-management, resources management.

ACKNOWLEDGMENTS

This paper is supported by national funds through Fundação para a Ciência e a Tecnologia (FCT), Portugal, in the frame of the Project GameCourse – Improving College Learning with Gamification (PTDC/CCI-CIF/30754/2017).

REFERENCES

[1] S. Deterding, et al. “Gamification: Toward a definition”, In *CHI 2011 gamification workshop proceedings*. Vancouver BC, Canada, 2011.

[2] K. Kapp, *The Gamification of Learning and Instruction: Game-based Methods and Strategies for Training and Education*. Wiley, 2012.

[3] P. Buckley and E. Doyle, “Gamification and student motivation,” *Interact Learn Envir*, vol. 24, no. 6, pp. 1–14, 2014, doi: 10.1080/10494820.2014.964263.

[4] A. Knutas, R. van Roy, T. Hynninen, M. Granato, J. Kasurinen, and J. Ikonen, “A process for designing algorithm-based personalized gamification,” *Multimed Tools Appl*, vol. 78, no. 10, pp. 13593–13612, 2019, doi: 10.1007/s11042-018-6913-5.

[5] G. Barata, S. Gama, J. Jorge, and D. Gonçalves, “Gamification for smarter learning: tales from the trenches,” *Smart Learn Environ*, vol. 2, no. 1, p. 10, 2015, doi: 10.1186/s40561-015-0017-8.

[6] M. Böckle, J. Novak, and M. Bick, “Towards Adaptive Gamification: A synthesis of current developments,” in *Proceedings of the 25th European Conference on Information Systems (ECIS), Guimarães, Portugal, June 5-10*, 2017, pp. 158–174.

[7] Tang, L. M., J. Kay, “Gamification: metacognitive scaffolding towards long term goals?”, in *UMAP workshops*, 2014.

[8] B. J. Zimmerman, “Becoming a Self-Regulated Learner: An Overview,” *Theor Pract*, vol. 41, no. 2, pp. 64–70, 2002, doi: 10.1207/s15430421tip4102_2.

[9] Y. J. Joo, S. Joung, and J. Kim, “Structural relationships among self-regulated learning, learning flow, satisfaction, and learning persistence in cyber universities,” *Interact Learn Envir*, vol. 22, no. 6, pp. 752–770, 2014, doi: 10.1080/10494820.2012.745421.

[10] T. J. Cleary, & B. J. Zimmerman (2012) “A Cyclical Self-Regulatory Account of Student Engagement: Theoretical Foundations and Applications”, in *Handbook of Research on Student Engagement,* (S. Christenson, A. Reschly A., C. Wylie C), pp.237-257, Boston, MA: Springer.

[11] J. Broadbent and W. L. Poon, “Self-regulated learning strategies & academic achievement in online higher education learning environments: A systematic review,” *Internet High Educ*, vol. 27, pp. 1–13, 2015, doi: 10.1016/j.iheduc.2015.04.007.

[12] L. M. Tang and J. Kay, “Gamification: metacognitive scaffolding towards long term goals?” in *UMA Workshops*, 2014.

[13] S. Vanslambrouck, C. Zhu, B. Pynoo, K. Lombaerts, J. Tondeur, and R. Scherer, “A latent profile analysis of adult students’ online self-regulation in blended learning environments,” *Comput Hum Behav*, vol. 99, pp. 126–136, 2019, doi: 10.1016/j.chb.2019.05.021.

[14] B. J. Zimmerman, D. H. Schunk. *Motivation and self-regulated learning. Theory, research and applications*, pp. 267-295, Routledge, 2012.

[15] D. Schunk & Zimmerman, B. J. *Self-regulation of learning and performance: Issues and educational applications*. Lawrence Erlbaum Associates, Inc, 1994.

[16] P. R. Pintrich, “The role of goal orientation in self-regulated learning”. In *Handbook of self-regulation* (M. Boekaerts, P. R. Pintrich, & M. Zeidner), pp. 451-502, San Diego: Academic Press. 2000, http://dx.doi.org/10.1016/B978-012109890-2/50043-3.

[17] B. Zimmerman, Martinez Pons, M., “Development of a structured interview for assessing student use of self-regulated learning strategies”, *American Educational Research Journal*, 23(4), pp. 614–628, 1986.

[18] R. F. Kizilcec, M. Pérez-Sanagustín, and J. J. Maldonado, “Self-regulated learning strategies predict learner behavior and goal attainment in Massive Open Online Courses,” *Comput Educ*, vol. 104, no. Review of Educational Research 73 3, pp. 18–33, 2017, doi: 10.1016/j.compedu.2016.10.001.

[19] M. Böckle, I. Micheel, M. Bick, and J. Novak, “A Design Framework for Adaptive Gamification Applications,” 2018, doi: 10.24251/hicss.2018.151.

[20] C. T. Klock, I. Gasparini, and M. S. Pimenta, “5W2H Framework: a guide to design, develop and evaluate the user-centered gamification,” p. 14, 2016, doi: 10.1145/3033701.3033715.

[21] A. Knutas, R. van Roy, T. Hynninen, M. Granato, J. Kasurinen, and J. Ikonen, “A process for designing algorithm-based personalized gamification,” *Multimed Tools Appl*, vol. 78, no. 10, pp. 13593–13612, 2019, doi: 10.1007/s11042-018-6913-5.

[22] L. F. Daghestani, L. F. Ibrahim, R. S. Al-Towirgi, and H. A. Salman, “Adapting gamified learning systems using educational data mining techniques*,” Comput Appl Eng Educ*, 2020, doi: 10.1002/cae.22227.

[23] V. Naik and V. Kamat, “Adaptive and Gamified Learning Environment (AGLE),” *2015 Ieee Seventh Int Conf Technology Educ* T4e, pp. 7–14, 2015, doi: 10.1109/t4e.2015.23.

[24] M. A. Hassan, U. Habiba, F. Majeed, and M. Shoaib, “Adaptive gamification in e-learning based on students’ learning styles,” *Interact Learn Envir*, pp. 1–21, 2019, doi: 10.1080/10494820.2019.1588745.

[25] M. Awais, U. Habiba, H. Khalid, M. Shoaib, and S. Arshad, “An adaptive feedback system to improve student performance based on collaborative behavior,” Ieee Access, vol. 7, pp. 1–1, 2019, doi: 10.1109/access.2019.2931565.

[26] K. M. Mbabu, R. O. Oboko, and S. Kamunya, “An Adaptive Gamification Tool for E-learning Platform,” *Open J Information Technology*, vol. 2, no. 2, pp. 41–52, 2019, doi: 10.32591/coas.ojit.0202.03041m.

[27] Knutas, J. Ikonen, D. Maggiorini, L. Ripamonti, and J. Porras, “Creating Student Interaction Profiles for Adaptive Collaboration Gamification Design,” *Int J Hum Cap Information Technology Prof Ijhcitp*, vol. 7, no. 3, pp. 47–62, 2016, doi: 10.4018/ijhcitp.2016070104.

[28] Z. Xiao et al., “Cubicle: An Adaptive Educational Gaming Platform for Training Spatial Visualization Skills,” pp. 91–101, 2018, doi: 10.1145/3172944.3172954.

[29] B. Herbert, D. Charles, M. McNeill, A. Moore, and M. Charles, “Dynamic Virtual Learning Landscapes to Enhance Student Reflective Processes.”

[30] N. Zaric, S. Scepanović, T. Vujicic, J. Ljucovic, and D. Davcev, *ICT Innovations 2017, Data-Driven Innovation. 9th International Conference, ICT Innovations 2017, Skopje, Macedonia, September, Proceedings*,” pp. 265–273, 2017, doi: 10.1007/978-3-319-67597-8_25.

[31] T. Klock, L. F. da Cunha, M. F. de Carvalho, B. E. Rosa, A. J. Anton, and I. Gasparini, “Gamification in e-Learning Systems: A Conceptual Model to Engage Students and Its Application in an Adaptive e-Learning System,” in *International Conference on Learning and Collaboration Technologies*, pp. 595–607, 2015, doi: 10.1007/978-3-319-20609-7_56.

[32] I. Danka, “Motivation by gamification: Adapting motivational tools of massively multiplayer online role-playing games (MMORPGs) for peer-to-peer assessment in connectivist massive open online courses (cMOOCs),” *Int Rev Educ*, pp. 1–18, 2020, doi: 10.1007/s11159-020-09821-6.

[33] I. Cristea, Shi, L., “Motivational gamication strategies rooted in self-determination theory for social adaptive E-Learning,” *Lecture Notes in Computer Science*, pp. 294-300, 2016.

[34] F. Roosta, F. Taghiyareh, and M. Mosharraf, “Personalization of Gamification-elements in an E-Learning Environment based on Learners ’ Motivation,” in *8th International Symposium on Telecommunications (IST)*, 2016.

[35] A. Knutas, R. van Roy, T. Hynninen, M. GRanato, J. Kasurinen, and J. Ikonen, “Profile-Based Algorithm for Personalized Gamification in Computer-Supported Collaborative Learning Environments,” in *1st Workshop on Games-Human Interaction*, 2017.

[36] Monterrat, É. Lavoué, and S. George, “Toward and adaptive system for learning environments,” pp. 115–129, 2015, doi: 10.1007/978-3-319-25768-6_8.

[37] D. Codish and G. Ravid, “Adaptive Approach for Gamification Optimization”, In *Proceedings of the 2014 IEEE/ACM 7th International Conference on Utility and Cloud Computing (UCC ’14).* IEEE Computer Society, USA, 609–610, 2014. DOI:https://doi.org/10.1109/UCC.2014.94