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Using Gamification to Effect Learning Behaviors in Intelligent Tutoring System

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Abstract: Engagement and motivation is always a challenge in online learning environments. The benefits of learning environments have proven its history for many years, but effectively engaging users with these environments and motivating them is an active and important research problem. In this work, I will investigate the potential of gamification on motivation and user engagement in an intelligent tutoring system SQL-Tutor. This work is inspired by the growing trend of gamification and its positive effects in various domains.

Keywords: intelligent tutoring system, problem solving, gamification, self-regulation

1. Introduction and Literature Review

The goal of Intelligent Tutoring Systems (ITSs) is to provide individual support to learners according to their needs and abilities. Research shows that learning can be affected by boredom and frustration which lead to low performance for both low and high achievers (Munshi et al., 2018), and abandoned learning activities (Baker et al., 2010). Engagement and motivation are crucial for learning with ITSs (D`Mello et al., 2007). Gamification was introduced as a term with the definition "the use of game design elements in non-game contexts" (Deterding et al., 2011). It is considered as less expensive in contrast to standalone games (Landers et al., 2017). As games are originally intended for enjoyment, gamification is also defined as motivational information systems which combine the efficiency of utilitarian systems and enjoyment of hedonic systems (Koivisto et al., 2019). Adoption of gamification is reported in many fields, particularly in education, health science and crowdsourcing. Hamari and colleagues conducted surveys on gamification research in 2014 and 2019. These analysis revealed that education is an area where gamification is applied mostly and accompanied with positive results. Detailed analysis of these studies showed that they are focusing on behavioural change of learners through the use of gamification and focused only on psychological changes which are engagement, enjoyment and motivation. According to these surveys, most popular gamification elements are points, badges and leader boards and there is a huge lack of empirical evidence in gamification studies.

The theory of gamified learning presented by Landers (2014) specified the two mechanisms of introducing gamification in learning process. One is mediator, which adds game elements to affect learner's behaviour, which in turn increases/decreases learning outcomes. The other is moderator, where game intervention affects learner behaviour (psychologically) which affects the relation between instructional content and learning outcome. In subsequent work of Lander (2017), he provided the mapping of different game elements to psychological theories in order to emphasise that gamification will improve learning outcome if carefully applied with the help of psychological behaviours. On the basis of this theory, Landers and colleagues (2014) conducted an experiment by selecting time-on-task as mediating psychological behaviour and leader board as game intervention and the results were significantly improved learning.

Gamification has been applied mostly to web-based learning environments such as Code academy, Khan academy and Stack Overflow (Marder, 2015; van Roy et al., 2018) but its application in ITSs in not much explored. Few studies conducted are worth mentioning here. Denny and colleagues (2018) conducted a study on Peerwise, a system for peer learning, with points and badges added as gamification intervention. The targeted behaviours were engagement, motivation and self-testing. The

results showed positive effects of gamification, particularly for badges. In another study, Long and colleagues (2014) explored the effects of adding badges to an ITS and mediate the process with re-practising behaviour. The results show partial success, and they figured out that re-practising is not an optimal mediating behaviour to improve learning. In the subsequent study, Long and colleagues (2015) explored the effects of gamification with self-regulating strategies in the ITS. The results showed the positive attitude of students towards achieving badges and other game elements (Long, Aman, & Aleven, 2015). Starting from the mixed findings about the effectiveness of gamification in ITSs, this research project will move forward the debate by empirically investigating the impact of gamification in SQL-Tutor, a mature ITS for teaching Structured Query language (Mitrovic, 2003). Many versions of SQL-Tutor have been released, providing new features and more support such as probabilistic student model (Mayo & Mitrovic, 2000), various problem selection strategies (Mayo, 2001; Mitrovic & Martin, 2004; Mathews, 2012), an animated pedagogical agent (Mitrovic & Suraweera, 2000), positive feedback (Barrow, Mitrovic, Ohlsson, & Grimley, 2008), worked examples (Shareghi Najar, Mitrovic, & McLaren, 2014) and erroneous examples support (Chen, Mitrovic, & Mathews, 2016).

This PhD project will make a number of contributions. First, we will analyse the literature to identify the psychological behaviours that work as mediators or moderators and have effect on learning performance of learners when working with ITS. On the basis of the identified learning behaviours, a gamified learning intervention will be designed and implemented in SQL-Tutor. Second, we will examine the effects of gamification on students' learning outcomes. The last contribution of this research will be to explore the relationship between enjoyment, engagement and motivation of learners with the gamified ITS.

2. Proposed Work

From the brief literature review it is evident that gamification can be promising if applied within correct context. In this project I will focus on *the impact of gamified SQL-Tutor on students' learning behaviours and subsequently their learning outcomes.* Figure 1 shows the overview of this project's theoretical framework.

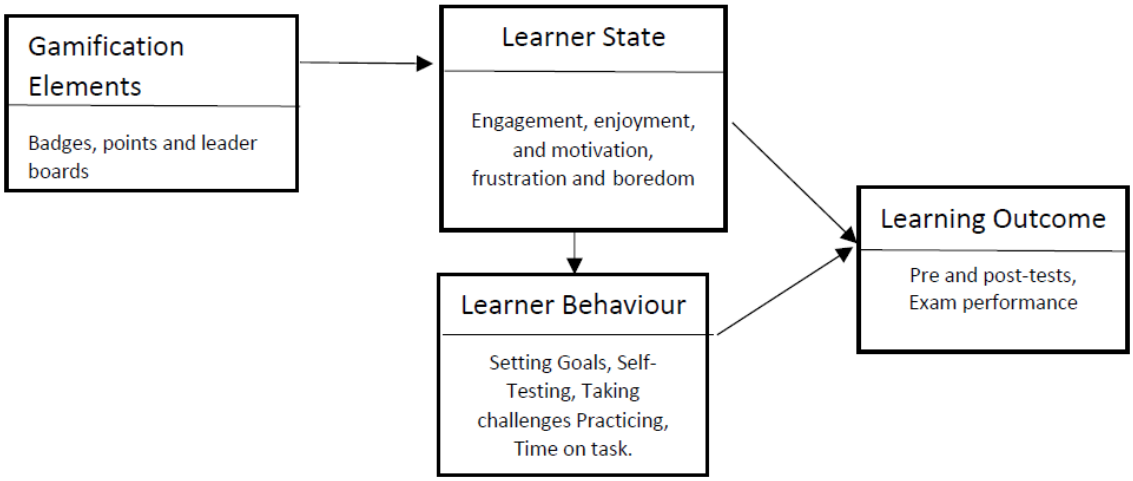

Figure 1. Theoretical framework of the project

This project will be conducted in three phases. The initial phase includes a pilot study which was conducted and I collected data about the students' affective states, their engagement and attention levels while working with SQL-Tutor and its impact on students' performance. The results showed that affect states (enjoyment, frustration, boredom) and psychological behaviours (motivation, engagement and attention) are affecting student's performance while learning from SQL-Tutor. It also revealed that students became frustrated and their engagement reduced while attempting to solve complex problems and in the absence of motivation intervention they left the problem solving. Along with identification, I will further analyse the results to find the required levels of these behaviours for achieving high performance. The learning behaviours are selected on the basis of these learner's psychological states

and will be gamified in SQL-Tutor in next phase. The research question addressed in the pilot study are following:

RQ 1: To what extent do engagement, enjoyment, frustration and boredom affect students' performance while working with SQL-Tutor?

In phase two, I will design and implement badges as a gamification intervention, select learning behaviours to target through gamification and measure the learning outcomes. Badges will act as motivational affordance to increase motivation, engagement, excitement and help learners to keep going in case of negative affective states. On the basis of these psychological behaviours, I will focus on five learning behaviours: goal-setting behaviour, self-testing behaviour, taking conflict/challenge behaviour, practising and time-on-task behaviour. These behaviours will implement in SQL-Tutor with gamification techniques. For example, the goal-setting behaviour will be supported by implementing a badge that will be given when the learner completes five problems in a day, or completes five problems every day for five consecutive days. Self-testing behaviour will be supported by providing badges when students attempt optional quizzes. The conflict/challenge behaviour will be supported by providing badges for solving complex problems and daily challenges. Badges will also be provided on completing problems daily, for completing more difficult problems (e.g., problems requiring the Group by clause) or completing a specific number of problems in one session. These learning behaviours act as mediators between gamification and learning outcomes as suggested by the Landers theory of gamified learning. The research questions addressed in this phase are following:

RQ 2: Do badges influence students to complete more problems, and remain motivated, enjoyed and engaged for longer?

RQ 3: Which learning behaviours act as optimal mediators to increase students' performance in the presence of badge interventions? (This RQ will be investigated in five subquestions, each focusing on a specific learning behaviour)?

On the basis of the finding from the study, I plan to introduce other gamification interventions in the last phase of my project. Leader boards and points are other two popular gaming intervention as mentioned by Hamari, (2019). I will conduct another study in order to compare the effects of various types of gaming interventions along with their gaming attributes and learning behaviours. The research questions addressed in this phase are:

RQ 4: Is a combination of points, badges and leader boards more effective than when those elements are used individually?

RQ 5: Which learning behaviours best combine with points, badges and leader board and yields optimal result in terms of student performance?

3. Research Methodology

To answer the research questions above, I will conduct exploratory research to determine the main aspects of gamification in SQL-Tutor, and develop techniques and procedures to apply gamification effectively. This project will consist of three experiments based on three phases mentioned above and system in context is SQL-Tutor. Phase one consist of pilot study focused on RQ1 started with the demographic questionnaire and then identify and analyse student's affective states and psychological behaviours with the help of iMotions (https://imotions.com) software package. Phase 2 and 3 focusing on RQ2-RQ5, a classroom study will be conducted in each phase which will provide the modified version of SQL-Tutor to one group of randomly selected students (experimental) and standard version of SQL-Tutor to other group of students (control). The data will be quantitative in nature in all three phases and collected through the student logs of SQL-Tutor and exported from iMotions. The effects or learning outcome/performances of students will be measured via pre-/post-tests. This data will be analysed with the help of correlation and regression analysis. At the end of phase 2 and 3 a questionnaire will be provided to get the opinion and future intentions of students on using gamification interventions and learning behaviours. Motivation will analyse both by student interaction with the SQL-Tutor and through the questionnaire provided at the end of each experiment.

References

Baker, R. S., D'Mello, S. K., Rodrigo, M. M. T., & Graesser, A. C. (2010). Better to be frustrated than bored: The incidence, persistence, and impact of learners' cognitive–affective states during interactions with three different computer-based learning environments. *Human-Computer Studies, 68*(4), 223-241.

Barrow, D., Mitrovic, A., Ohlsson, S., & Grimley, M. (2008). Assessing the impact of positive feedback in constraint-based tutors. In International Conference on Intelligent Tutoring Systems (pp. 250-259). Springer, Berlin, Heidelberg.

Chen, X., Mitrovic, A., & Mathews, M. (2016). Do Erroneous Examples Improve Learning in Addition to Problem Solving and Worked Examples?. In International Conference on Intelligent Tutoring Systems (pp. 13-22). Springer, Cham.

D'Mello, S., Picard, R. W., & Graesser, A. (2007). Toward an affect-sensitive AutoTutor. *IEEE Intelligent Systems, 22*(4), 53-61.

Denny, P., McDonald, F., Empson, R., Kelly, P., & Petersen, A. (2018). Empirical Support for a Causal Relationship Between Gamification and Learning Outcomes. Proc. CHI Conference on Human Factors in Computing Systems, Montreal, Canada (p. 311). ACM.

Deterding, S., Dixon, D., Khaled, R., & Nacke, L. (2011). From game design elements to gamefulness: defining "gamification". Proc. 15th Int. Academic MindTrek Conference: Envisioning Future Media Environments, Tampere, Finland (pp. 9-15). ACM.

Hamari, J., Koivisto, J., & Sarsa, H. (2014). *Does gamification work?--a literature review of empirical studies on gamification.* Proc. 47th Hawaii Int. Conf. on System Sciences, 14, pp. 3025-3034.

Koivisto, J., & Hamari, J. (2019). The rise of motivational information systems: A review of gamification research. *International Journal of Information Management, 45*, 191-210.

Landers, R. N. (2014). Developing a theory of gamified learning: Linking serious games and gamification of learning. *Simulation & Gaming, 45*(6), 752-768.

Landers, R. N., Armstrong, M. B., & Collmus, A. B. (2017). How to use game elements to enhance learning: Applications of the theory of gamified learning. *Serious Games and Edutainment Applications* (pp. 457-483): Springer.

Landers, R. N., & Landers, A. K. (2014). An empirical test of the theory of gamified learning: The effect of leaderboards on time-on-task and academic performance. *Simulation & Gaming, 45*(6), 769-785.

Long, Y., & Aleven, V. (2014). Gamification of joint student/system control over problem selection in a linear equation tutor. Proc. Int. Conf. Intelligent Tutoring Systems (pp. 378-387). Springer, Cham.

Long, Y., Aman, Z., & Aleven, V. (2015). Motivational design in an intelligent tutoring system that helps students make good task selection decisions. Proc. Int. Conf. Artificial Intelligence in Education (pp. 226-236). Springer, Cham..

Marder, A. (2015). Stack overflow badges and user behavior: an econometric approach. Proc. IEEE/ACM 12th Working Conference on Mining Software Repositories (pp. 450-453). IEEE.

Mathews, M. M. (2012). "A Framework for Multiple Adaptable Pedagogical Strategies in Intelligent Tutoring Systems."

Mayo, M., & Mitrovic, A. (2000). Using a probabilistic student model to control problem difficulty. In International Conference on Intelligent Tutoring Systems (pp. 524-533). Springer, Berlin, Heidelberg.

Mayo, M., & Mitrovic, A. (2001) Optimising ITS Behaviour with Bayesian Networks and Decision Theory. *Artificial Intelligence in Education*, 12(2), 124-153.

Mitrovic, A., & Suraweera, P. (2000). Evaluating an animated pedagogical agent. In International Conference on Intelligent Tutoring Systems (pp. 73-82). Springer, Berlin, Heidelberg.

Mitrovic, A. (2003). An intelligent SQL tutor on the web. International Journal of Artificial Intelligence in Education, 13(2-4), 173-197.

Mitrovic, A., & Martin, B. (2004). Evaluating adaptive problem selection. In International Conference on Adaptive Hypermedia and Adaptive Web-Based Systems (pp. 185-194). Springer, Berlin, Heidelberg.

Munshi, A., Rajendran, R., Ocumpaugh, J., Biswas, G., Baker, R. S., & Paquette, L. (2018). Modeling Learners' Cognitive and Affective States to Scaffold SRL in Open-Ended Learning Environments. Proc. 26th Conf. User Modeling, Adaptation and Personalization, Singapore, Singapore (pp. 131-138). ACM.

Shareghi Najar, A., Mitrovic, A., & McLaren, B. M. (2014). Adaptive Support versus Alternating Worked Examples and Tutored Problems: Which Leads to Better Learning?. In International Conference on User Modeling, Adaptation, and Personalization (pp. 171-182). Springer, Cham.

van Roy, R., Deterding, S., & Zaman, B. (2018). Uses and Gratifications of Initiating Use of Gamified Learning Platforms. Extended Abstracts of the 2018 CHI Conference on Human Factors in Computing Systems (p. LBW565). ACM.