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Gamification for Learning by Modelling in Interactive Learning Environments

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Abstract. Learning analytics aims to optimise learning, typically by providing students meaningful insight in their own learning behaviour. Gamification deploys game mechanics to increase motivation and thereby boost the learning process. In our work, we use learning analytics to implement game mechanics that create a motivating learning experience. The educational context concerns students that engage in model-building to develop systems thinking expertise. Three mechanics have been implemented: badges, leaderboard and life. The gamification add-on was evaluated during high school physics classes. Data mining showed that gamification resulted in significantly higher self-reported scores on enjoyment but inferior student-created models. A strong correlation between delete-behaviour and correctness of the created models was also found.

1 Introduction

Gamification implements game mechanics in non-game contexts to induce motivation [2, 4]. Mixed results are found regarding the effectiveness of gamification for education [5, 6]. Learning Analytics (LA) uses machine learning to mine student data and provide feedback (typically via dashboards) to help students improve their learning behaviour [3].

Learning by constructing models is an effective way to learn, but requires perseverance. The aim of our research is to increase the motivation of students engaging in modelling tasks by implementing game mechanics that utilise real-time student behaviour data. Instead of showing LA results via dashboards, this information is used to drive the mechanics. The mechanics are implemented for DynaLearn [1], an instrument for *learning by modelling* used in secondary education that focusses solely on *conceptual* models (as opposed to numerical).

2 Implementation and Evaluation study

The game mechanics are implemented using a norm model, which specifies the desired assignment outcome. Three mechanics are implemented: badges, leaderboard and life. *Badges* are awarded to students if their behaviour matches certain desired behaviours (milestones). The application of badges was optimised to ensure a constant stream of positive feedback while doing an assignment. For the *leaderboard*, the score gets calculated and updated every time a student performs an action. A maximum score is obtained by minimising total number of actions, maximising components consistent with the norm model, and minimising mistakes ($\texttt{score} = (\sqrt{\texttt{penalize\_steps}} * \texttt{completeness} * \texttt{correctness}) *$

100). This ensures that the score reflects the desired goal: a model built precisely according to the specifications of the assignment results in a high score (note that, $penalize\_steps = min\_actions\_norm/total\_actions$). The goal of the *life* mechanic is to have students deliberately think about their next action, as opposed to adding components without much thought. If an action is inconsistent with the norm model, the students loses a life. Upon losing all lives, the game is over and the student has to restart on a blank canvas.

Two groups participated in the evaluation: the control group ($n = 11$), who used the unaltered DynaLearn environment, and the treatment group ($n = 24$), who used DynaLearn enhanced with the gamification module. Evaluation was performed comparing two high school physics classes, where students completed a physics assignment in DynaLearn. The evaluation consisted of tracking student's modelling behaviour data using LA to identify differences between the groups, and a survey that measured the situational awareness and motivation.

3 Results and Conclusion

The data resulting from student behaviour was mined after assignment completion. Analysis showed that the treatment group created lower quality models compared to the control group. Also, the treatment group performed a significantly lower number of delete actions compared to the control group. The total number of actions was also lower (albeit not significant) for the treatment group. The standard deviation for the total number of actions was relatively high in the treatment group, which indicates an uneven activity distribution in the group.

A positive correlation between delete-behaviour and correctness of the student-created models was found for both groups. Students that perform a higher number of delete actions are more likely to create superior models. Analysing the survey questions showed that the treatment group scored higher on Q3 ('Ik zou nog zo een les willen volgen.'), indicating that they enjoyed the game mechanics.

Overall, the data suggest that the gamification resulted in more fun but inferior student-created models, and hence less learning.

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