Online Interactive Learning Platforms in STEM Education: A Study of Motivation and Engagement

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The Need

The low performance and retention in STEM classes are frequently attributed to lack of engagement and motivation. The need for more engaging and effective STEM education is especially critical for the underrepresented STEM students, who have lower graduation rates. Gamification offers a promising framework for educational interventions that can lead to increased motivation and engagement of students. It aims at making learning experiences more engaging and game-like, by using game design principles, and game mechanics. However, the increasing use of gamified learning requires a more systematic study to validate existing evidence and provide guidance for further exploration.

Guiding Questions

This research aims at generating empirical evidence for the efficacy and appropriateness of using gamification to improve student motivation, engagement, and academic performance.

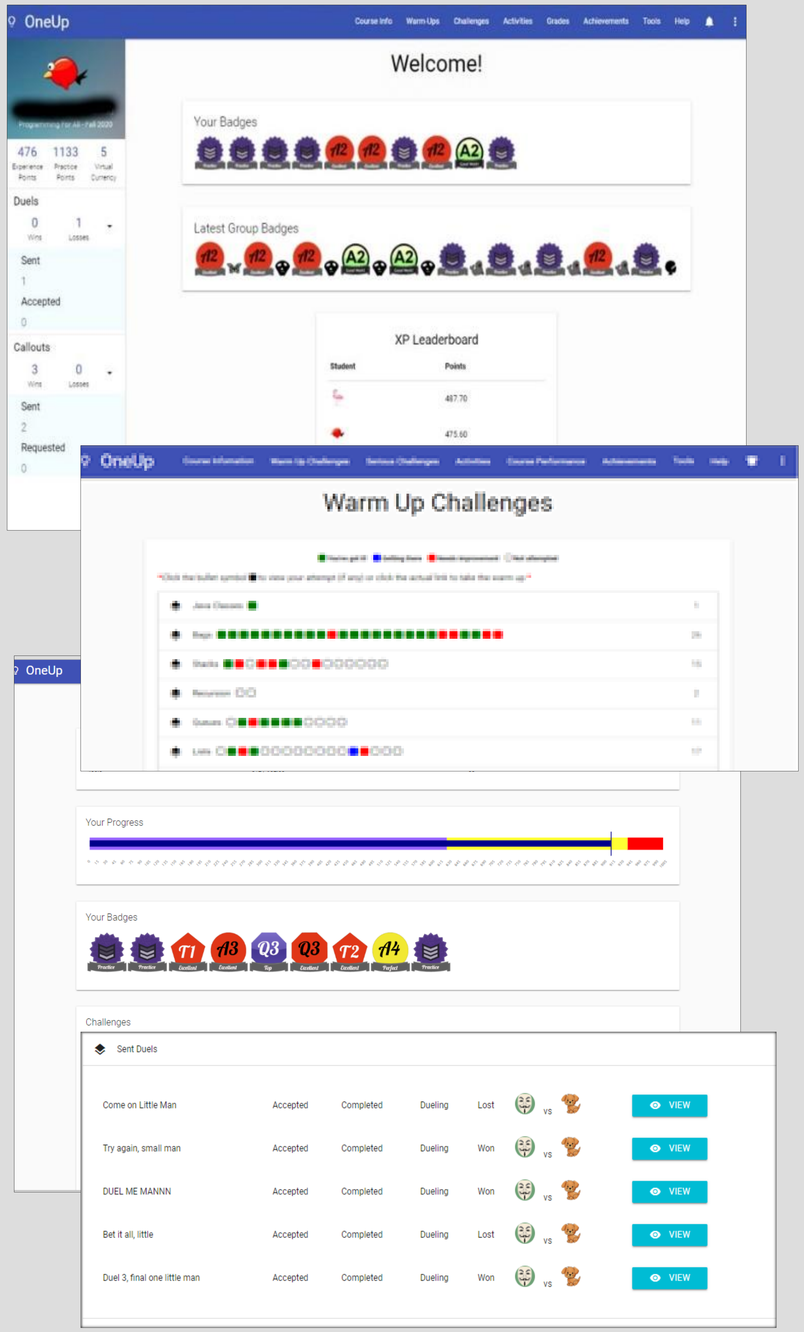
The practical enquires guiding the work were: (1) Conducting empirical studies on the application of gamification in different learning contexts; (2) Software development for extending the OneUp course gamification platform to be used in the studies; and (3) Content development for gamifying STEM courses.

The guiding questions include:

- What are the effects of individual game elements and combinations thereof in learning context?
- Do motivational factors based on Self-Determination Theory impact the effects of gamified learning?
- What are the effects of gamification on different demographics groups?

Experiments

- Using OneUp gamification platform for gamifying the courses
  - OneUp supports experience points, skill points, levels, progress bar, avatars, badges, leaderboard, virtual currency, goal setting, learning dashboard
  - It is highly configurable; rule-based game engine controlled
- Based on Self-Determination Theory; focus on exploring how the primary psychological needs of autonomy, competence, and relatedness can inform gamification design
- 4 experiments conducted including 15 studies



Project Outcomes

- Extending OneUp with support for creating time-interval based game rules, multiple (rule-based) leaderboards, (rule-based) personalized content unlocking, hints, leveling, Parson's problems, multi-part dynamic problems, flash cards, chat rooms, and challenging classmates for duels or callouts
- Creating website for STEM content crowdsourcing
- Conducted studies:
  - 15 instructors from 10 universities (incl. 3 HBCUs and 2 non-US) created content and gamified their courses including Intro to Programming, Programming for All, Data Structures, Intro to Comp. Soft. Systems, Cybersecurity Fundamentals, Computer Networking, Software Security Testing, Discrete Structures
  - Four of the studies used a single game element – badges or VC; the remaining – different combinations of elements
  - The impact of gamification on students' engagement, motivation, and academic performance was evaluated based on data collected from the designed motivational survey through a pre- and post-tests, the OneUp logs, and students' course grades
- Overall results
  - Gamification intervention intensified significantly students' practicing
  - Gamification did not change the intrinsic motivation of the students to practice
  - Possible reason is that VC fostered internalization of the learning-related extrinsic motivators' values, which resulted in increased engagement in the learning activities
- Results reported at 10 conferences and in 2 journal articles.

Broader Impact

The conducted series of experimental studies realize a large-scale evaluation of the effect of gamification in STEM context. The OneUp course gamification platform is not discipline-specific and can support well gamification of various courses. The results of the studies conducted so far consistently showed that educational gamification could be an effective instructional intervention for improving students' learning experiences and increasing their engagement and academic performance in various disciplines.

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