Physics Cards Games - What's New? From "Newton's Laws" to the challenges identified in a large-scale implementation

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Abstract. This workshop will consist of: a) a hands-on experience with the *Newton's Laws* game, following the *Phys-Cards* design principles: a summative activity to help students organize what they have learned and connect externally different scenarios with the underlying physics principles (similar to the "Circular Motion" game presented at GIREP 2023); b) a "bird's eye" view: results covering three years' experience with four *Phys-Cards* games implemented in a national network of Professional Learning Communities (PLCs) for high school physics teachers (~300 teachers). We will discuss the teachers' perspectives on the benefits and challenges involved in classrooms implementation.

Rationale and Background

The literature indicates that integrating games into physics instruction promotes student engagement and fosters interactive learning [1]. It can enhance knowledge and cognitive processes such as problem solving, spatial skills and creativity, as well as promote collaborative learning and teamwork [2]. Gamification allows students to enjoy their learning process and increase their motivation to learn physics, a subject that is often considered difficult and abstract [3]. However, for a game to be more than fun and contribute to physics learning, it must address learning goals and be designed according to research-based pedagogical principles [4].

Four *Phys-Cards* games have been developed by the PER group at the Weizmann Institute of Science to address the difficulties in knowledge organization as pointed out by Chi et al. [5]: students tend to focus on the surface features of problems rather than on the underlying physics principles. The *Phys-Cards* games are designed as hands-on classroom activities, last about 45 minutes, are conducted in teams, and involve several elements of gamification, such as a competition, clues, levels, and a storyline. Each *Phys-Cards* game focuses on a specific topic: Newton's Laws, Circular Motion, Electric Circuits, and Electric and Magnetic Fields. They serve as a summative activity to help students organize what they have learned by sorting and categorizing different real-world scenarios into schematic representations, thus making connections between externally different situations and recognizing their similar underlying physics principles. For example, the *Phys-Cards* game on Circular Motion (GIREP 2023 workshop) asks students to relate various real-world scenarios to the corresponding force diagrams and motion equations.

There is little research on the challenges teachers face when trying to implement gamification in general [1;6], and in physics instruction in particular. We have examined teachers' perspective of the *Phys-Cards* games over the last three years, during which time teachers experienced the *Phys-Cards* games in a national network of Professional Learning Communities (PLCs) for high school physics teachers (~300 teachers) [7]. They played each game in the PLC meeting and discussed the rationale and potential learning outcomes; they then implemented the games in their classrooms and later reflected collaboratively on their experiences.

A study of teachers' attitudes towards the use of games (presented at the GIREP 2023 workshop) showed a variety of responses, from those who were enthusiastic about making lessons more interesting and increasing students' motivation and conceptual understanding while having fun, to those who viewed physics lessons as "serious", whereas "playing games is fun", time-consuming, and difficult to manage in the classroom. In the workshop we will share our latest findings on teachers' perspectives on the benefits and challenges of implementing the *Phys-Cards* games.

Workshop Activities

Participants will play the Phys-*Cards* game on Newton's Laws (see Fig. 1), designed along the *Phys-Cards* guidelines to support knowledge organization [5].

Fig. 1. Examples from the Newton's Laws *Phys-Cards* Game

The workshop is designed to be interactive and is aimed at participants who attended the workshop last year as well as those who did not. After playing the *Phys-Cards* game on Newton's Laws, we will present an exemplary "solution" to this game and highlight the underlying physics concepts and principles. Playing the *Phys-Cards* game in the workshop will provide a basis for reflection on the pedagogical rationale and the design principles of the games, and a discussion on how they meet the learning goals mentioned above. We will present results from three years of experience with the *Phys-Cards* games in the PLCs and in the classrooms, that examined teachers' perspectives on the implementation of these games in the high school physics classrooms. In particular, we will elaborate on the challenges related to dealing with students’ expectations, time constraints and the monitoring of students’ progress in different groups. Finally, the participants will be able to share their own experiences and ideas about integrating games into physics instruction.

Conclusions

Based on the experience with the *Phys-Cards* game in the workshop, including a real sense of the hands-on teamwork, group dynamics, and competition in trying to solve the task, the participants will have better insights into the possibilities and challenges of gamification in the physics classroom as a means to promote collaborative learning and conceptual understanding.

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