SCHOLA LUDUS serious educational games

The problem of mechanic balancing in virtual and real games

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Abstract—**The SCHOLA LUDUS approach to educational games will be presented in this contribution by the game Duel on a labile salver in comparison with several free virtual games focused on mechanic balancing.**

The game Duel on a labile salver is focused on physics, specifically on understanding rotational effect of force and role of friction. The key developed concepts are: centre of mass, moment of force, system, (non-)equilibrium, sensitivity and stability. Several virtual games based on similar task - to balance the lever - can be found in internet. Can we use them to learn physics? What is the difference between the virtual and real game?

Keywords- physics, educational game,teaching method

I. INTRODUCTION
SCHOLA LUDUS SERIOUS EDUCATIONAL GAMES

In the project SCHOLA LUDUS playing is identified as a basic form of cognition, a pro-scientific activity directed to creative learning and teaching. There are three basic "strategies of authentic learning by playing" applied within the frame of SCHOLA LUDUS pro-scientific education: the strategy of authentic learning by spontaneous playing, the strategy of authentic learning by directed playing and the strategy of authentic learning by playing with great creation [1, 2]

The main goal of SCHOLA LUDUS educational games is to develop complex creative thinking, operational knowledge and competencies of the learner. Verbal, conceptual, sensor-motor and emotional learning, as well as learning by experience are applied concurrently. By playing the educational game students interiorize their experience – they become aware of their knowledge and fix it in relation to applied personalized tasks.

The art is to perform the activity in such manner that students perceive the educational game as an activity, that give them excitement, amusement and relaxation. The educational goal should be achieved as if "by the way".

Educational games utilize social needs of addressees: the ambition to belong to a group and, at the same time, the competitiveness, the ambition to excel and to gain acknowledgement of the group. The affective component of the game is important as well. Getting wonder, enjoyment of the success and elimination of the fear from the prospective failure allow building a positive attitude to learning.

Voluntary engagement into the game, solving problems contained in the game, spontaneity and ingenuousness allow the teacher to discover current students' conceptions about phenomena represented in the game, to observe operational knowledge and competencies. Perceptive teacher observing students in the game can discover also the zone of proximal development. Knowing this zone is a necessary assumption to individualized teaching.

Educational games create conditions that students pass from the unconscious learning of the key subject, through subjects' thematisation to conscious learning – students discover the problem, accept the problem as their own and solve it [1]. The game allows their addressees to perceive learning as an adventure.

II. BASIC CHARACTERISTICS
OF SCHOLA LUDUS EDUCATIONAL games

SCHOLA LUDUS educational games are characterized through attributes:

- Goals of the game from teachers' perspective – what global and subject didactic goals are followed in the game according to students' competencies and according to building and development of students' values and knowledge (note: goals from teachers' and students' perspectives are different in the beginning).

- The key learning subject and corresponding key concepts, attendant concepts and universal concepts that can be developed through the game - it is possible to divide developed concepts into concepts concerning investigated phenomena and systems and concepts concerning thinking processes and operational skills to solve problems.

- Incorporating the game into teaching process – suggestions on utilization of the game in the perspective of school subjects' goals and content as well as in the perspective of teaching process design.

- Further characteristics are: form of the game, game rules, description of the game procedure, goals of the

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game from students' perspective, and equipment of the game (usually accessible at home or easy to made).

III. CHARACTERISTICS OF THE EDUCATIONAL GAME DUEL ON A LABILE SALVER

The game Duel on a labile salver is based on manipulation with real objects. Concrete learning is a necessary step in construction of a new concept, step that should not be skipped.

A. Goals of the game from teachers' perspective

- Utilize innate competitiveness of students to motivate and stimulate their investigation of principles on the buoyancy on the lever and cognition.

- To give students the opportunity to build key physical concepts through personal experience and to understand these concepts in mutual relations as well as in relation to concrete physical conditions.

- Develop students' strategic thinking.

- Develop students' argumentation and communication.

1) The key learning subject
Centre of mass in motion, part: Rotational effect of a force and role of friction in balancing the lever.

2) Developed concepts

a) The key concepts
Centre of mass of a body, centre of mass of a system. Fulcrum. Point of rotation, axis of rotation. Rotational effect of a force. Moment of force. Resultant moment of the force system.

b) Attendant concepts
The decomposition of the force. Resolution of force into components. Force point of application and force arm. Force effect. Friction. Lever.

c) Universal concepts
Complex system. Ties in the system. Initiatory (physical) conditions. Boundary (physical) conditions. Non-equilibrium and equilibrium. Area of stability. Labile/stabile system. Open physical system, external action, change of the system. Accuracy. Rules, criteria, victory, definiteness, strategy, step, chance.

B. Incorporation into the teaching process
Target group: upper secondary students.

The game Duel on a labile salver can be used in teaching thematic area "Force and motion" on upper secondary level. It is an activity conduced to building of operational knowledge related to the above mentioned key concepts. The game can be used also on the lower secondary level as a motivation to build concepts centre of mass and rotational effects of a force.

C. Goals of the game from the students' perspective:
Early goal: To win in competition. To put a body on a labile salver without overbearing the salver. To build up the most difficult condition for the rival that she/he have to overbear the salver.

Definitive goal: To apply all the knowledge relevant to the subject of cognition gained in time of the game (or beforehand).

D. Applied learning strategies
Authentic learning by directed playing. Guided discussion.

E. Time demand
One lesson for a game with continuous and conclusive discussion.

F. Form of the game
Tournament, indoor game, game with real objects on a table.

G. Equipment needed for a class of 32 students
16 salvers; bases (e.g. furniture clip anchors, or spherical buttons) - 16 with larger diameters, 8 with smaller diameters; approximately 250 bodies (e.g. pieces of wood, small stones, little toys).

Figure 1. Example of the game Duel on a labile salver

H. Game rules, description of the game procedure
Students divide into pairs. One student is chosen to draw a list of the pairs on the board. Meanwhile, the teacher explains the rules and distributes the equipment.

The game runs in a refusing manner in several rounds. The game's difficulty increases. Competitors put one of shared bodies on the labile salver (or remove it) by rotation. The round is won by the student who did not overbear the salver; whose latest move did not induce the salver touch the table. In the case when both competitive students successfully use all the shared bodies without overbearing the salver, they can use additional bodies or they both go forward to the next round. The winners of the round form new competitive pairs. The tumbled students can instigate remaining competitors, continue to play without competition or think over raised problems. The game's difficulty increases in each bout.

Round 1: The rivals put, using rotation, one of the shared bodies on the labile salver balanced on a larger base so that the salver does not overbear. (What are the consequences of putting the body on a labile salver?)

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Round 2: The same procedure as in 1st round. (Why does the second round last for a longer time than the first one?)

Round 3: The base is changed. The rivals put using rotation one of the shared bodies on the labile salver balanced on a smaller base so that the salver does not overbear. (Why does the third round last for a shorter time than the second one? Why is it more difficult?)

Round 4: The rivals remove using rotation one of the shared bodies from the labile salver balanced on a larger base so that the salver does not overbear. (Is it easier to put the bodies on the salver or remove them from it? Why?)

Round 5: The rivals remove by rotation one of the shared bodies from the labile salver balanced on a smaller base so that the salver does not overbear.

Top question: What are the possible concepts of increasing, respectively decreasing the difficulty of the game?

Note: Other alternatives are possible.

Figure 2.   Performance of the game Duel on a labile salver

IV.   VARIATIONS OF THE GAME AND THEIR IMPORTANCE FOR COGNITION

It is possible that students would change the game's rules. Acceptation of such changes depends on consensus of all participants. For example:

- Is it allowed to put bodies at each other?

- Is it allowed to declare off the order – miss out the move? If yes – it would be useful to limit how many times, e.g. the competitor may not miss two following moves.

- Is it possible to shift the body placed before instead of put additional body? This opens new opportunities and implies a longer duel.

The last two changes in game's rules imply the necessity to change the criteria for winning the duel. The winner is that competitor who puts on/removes from the salver more bodies; or who puts on/removes from the salver bodies with the higher total weight.

There are many possible variations of the game. Duel means a combat with rival, but metaphorically also combats with own expectations, preconceptions, knowledge and skills. The game can be performed also as a competition of individuals: Who put more bodies on the salver? Who put all available bodies on the salver in the shortest time? Competition of groups is possible as well: Which group put the most bodies on the salver? The change from duel with rival to combat with oneself means changing the game strategy. While in first case the goal is to balance the salver and arrange the worst condition to the rival, the second case is based on personal (or group) liability for development of a complex system.

Application of different game's versions is not only a diversification. It allows deeper understanding of physical relations. Evaluation of personal experience with different versions of the game leads to understanding different game strategies and ways of solving problems and cognition.

V.   COMPUTERS' SUPPORT TO LERNING BALANCING

Computers can be very useful in enhancement above described real educational game Duel on a labile salver:

- Playing with labile salver can be completed with experiencing players' own body balancing on a dynamic platform supplemented with computer monitoring of centre of mass.

Figure 3.   Human body balancing on a dynamic platform

- New point of view can be obtained by observing the recording of the process development slowed down and focused on chosen area [3,4], especially observing the touch-area between the base and the salver in the critical phase before overbearing.

Figure 4.   Observation of the critical phase

- Entirely new experience can be obtained by playing virtual games focused on balancing.

VI.   MECHANIC BALANCING IN VIRTUAL GAMES

There are many free on-line games that are focused on building structures. Many of them don't respect physical principles, but they can develop perception and response time (e.g. Build the tower [5]). The task is to build the highest tower by releasing the block hanging on the crane. It is not possible to build wider base in this game, only put blocks at each other. It is not necessary to build the tower upright, blocks can be sticking to a certain extent (single block only a little, but it is possible to build a "stairs" with centre of mass that is not over the base).

Another type of games is focused on realistic mechanical balancing on a lever (e.g. Equinimity [6] or BalanceFury [7]) or on building a balanced construction under certain conditions (e.g. .Perfect balance game [8]).

The game Equanimity [6] is visually very similar to Duel on a labile salver. The task is to balance the seesaw through determining the position from which the body is dropped. Bodies occur randomly in predefined shapes and colors. If three or more bodies of the same color touch each other, they disappear. Although this disappearing is not equivalent to any real situation, it makes the game more dynamic. By customizing the setting, the player can change several parameters: the density of the bodies (one of 4 values), friction between the body and the seesaw, type of bounce, number of bodies' shapes $(1 - 3)$ and number of colors $(1 - 6)$. In this way the player can easy change the sensitivity of the system

and simulate different physical conditions, even unusual (small friction, lots bounces) or unrealistic (none friction and silly bounces). The score respond to number of disappearing, but the player can change the task for himself and try to build the highest "tower", or to put on the seesaw as many bodies as possible.
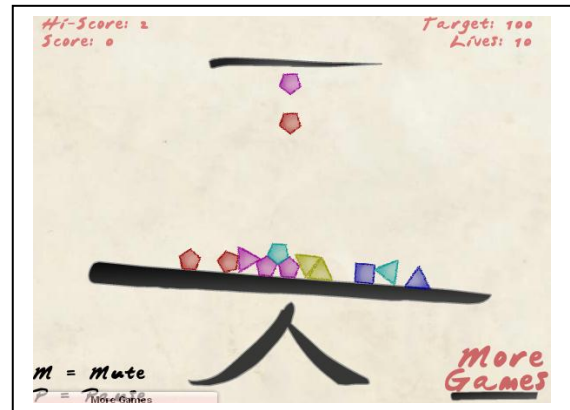

Figure 5.   Computer game Equinimity

The task in Perfect balance game [8] is to build a balanced structure using all bodies (blocks similar to tetris and circles) defined in certain level. The difficulty increases in each level.

The balanced structure is already built in the game "Falling red star" [9], where the task is to remove the blocks in such manner that the red star will fall from the top of the structure to the base, but not down from the base. The complexity of the structure increases in each level.

VII.   CHALLENGES

The research realized by European Schoolnet focused on using digital games in schools [10] showed that:

- teachers use digital games more often than it was supposed,

- digital games are mostly used in teaching languages, history and geography, less in science,

- teachers prepare the using of a game very carefully,

- teachers are convinced that digital game are motivating and improve self-confidence,

- teachers are not sure whether digital games improve critical thinking and support building of knowledge and skills directly related with taught subject.

Research focused on using games in school-education in Slovakia [11] showed that 40% of physics teachers do not know any game suitable for physics education.

Using of games in education should be broadly supported. Some of their advantages (motivation, individual tempo, obviation the fear of failure, positive relation to education) are

already proven; others (improvement of knowledge construction and subject skills development) should be further investigated. Teachers need help – proved games, methodically elaborated experiences, and suggestions to guiding of learning process.

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