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Using Video Games, Are a Help to Improve Student's Design Skills?

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Abstract

This paper describes an exploratory study aimed to determine whether having played video games influenced the modeling skills of engineering students. The study was carried out in one hundred and twenty engineering students, who were attending a course of Fundamentals of Physics for Engineers. The work was carried out in three phases. Firstly students were asked to draw a detailed model of a catapult suitable to launch a ball against a real object situated behind an obstacle. Secondly, participants had to complete a written test to assess their formal knowledge about parabolic shot, energy and momentum. Finally, a survey on previous experience with video-games related to catapults was conducted. Results showed that in general, students showed a good knowledge of the physics of catapults and had extensive experience in video-games, but only a few of the models (19.5%) were free from design errors. A Survey on previous experience playing video-games revealed that action and strategy are the most popular among students. These results showed that playing these types of video-games is ineffective in improving the design skills of students. We suggest that using other type of video games, such as, simulation ones should be studied.

1. Introduction

Modelling is a demanding task requiring skills and expertise not generally available for freshman engineering students. Due to this, in the first years some subjects, particularly Physics, have to be reoriented towards enhancing design skills acquisition. A teaching strategy widely used for this purpose is called Problem Based-Learning, in which students have to propose a solution to a given real-world challenge. It is reported that this type of instruction plays an important role in integrating science, technology and mathematical concepts. Another promising teaching strategy called Game Based Learning is emerging. Computer and video games have been shown to be extremely effective tools for learning, particularly due to their ability to create a "system" that players are allowed to test and experiment with [1]. We consider that combining both approaches could result in appropriate means which allows students to test their conceptions and experiment with their designs before choosing the optimal solution. Before developing such approach, it would be necessary to better understand the difficulties student face when designing solutions to a problem and how playing video-games affects students' modelling skills.

In this work we use a Problem Based Learning activity to investigate what effect has the previous experience of students with video games on their modeling skills

2.1 Modeling

Models are simplified representations of reality. The process of building these representations, called modelling, is an essential activity both in science and in engineering and it is known to be one of the most difficult skills to be learnt [2,3]. Generally speaking, science uses models in order to explain how the world works, whereas engineering models aim to predict or estimate the behaviour of a system. A model that allows one to know the output variables from the input variables but whose internal structure is not explicit is known as Black-box model (fig .1). These kinds of models are frequently used in engineering when only estimates of the output variable are sought. Such models, however, are not universally valid because they lack of a description of the phenomenon involved. Therefore, it is only possible introduce variations, adaptations or improvements through trial and error procedures [4].

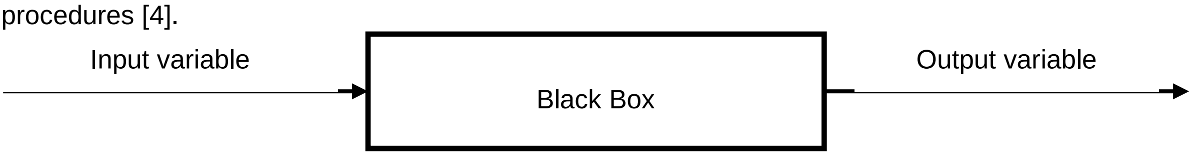


Figure.1 Black-Box Model

2.1 Catapults and video-games

Catapults are ancient military machines used to throw heavy projectiles against enemy targets. The energy required to launch the projectile is transferred by a hinged pole from a storage mechanism. Typically the three primary energy storage mechanisms are tension, torsion, and gravity. Students, in general, are familiar with these devices, not only because ballistics has been studied in most basic mechanical courses, but also because these weapons appeared in many interactive video-games that, currently, are popular among young people. As a consequence, these days many students have had the opportunity to interact in a virtual way with these ancient devices. Nevertheless, in most video-games catapults are modelled as Black-Boxes where players have learned to impact on the targets by trial and error procedures. Designing suitable catapults is a different task than playing with them. It requires the integration of physics concepts, mathematical calculation and geometrical constraints in order to break down the Black Box Model. So, modelling a catapult requires integrating two kinds of knowledge which are different in nature: on one hand the conceptual, mathematical or physicist knowledge that has been acquired through formal education and on the other the procedural knowledge that has been acquired by non-academic activities such as playing video games.

2.1 Physics of Catapults

According to [5] there are two main basic physics principles that any design of catapults must include:

P1: The kinetic energy of the projectile cannot be equal to, or greater than, the potential energy stored by the tension, torsion or gravitational storage mechanism.

P2: The projectile reaches the maximum range when the launch angle is equal to 45 º

Henceforth, at least the following relationship should be coherent with the above-mentioned principles:

R1: Relationship between Projectile mass m and counterweight mass M.

R2: Relationship between height of the pivotal centre a, and arms lengths b and c.

R3: Relationship between arm design and launch angle.

R4: Relationship between the sense of rotation of the catapult’s arm and the launching direction of the projectile.

3. The study

3.1 Purpose

The main aim of this study was to investigate how first-year engineering students incorporate their previous formal Physics knowledge with their, previously acquired, experiences playing video games when they draw a model.

3.2 Participants

The study was conducted in 120 engineering student enrolled in a course in Fundamentals of Physics, subdivided into 3 groups with 40 students in each class. All students had studied physics in high school. The study was conducted in the first sessions of the semester.

3.2 Procedures

The work was carried out in one hour session class. Firstly students were asked to draw up a detailed model of a catapult suitable to launch a ball against a real object situated behind an obstacle. Secondly, participants had to complete a written test to assess their formal knowledge about parabolic shot, energy and momentum. Finally, a survey on previous experience with video-games related catapults was conducted.

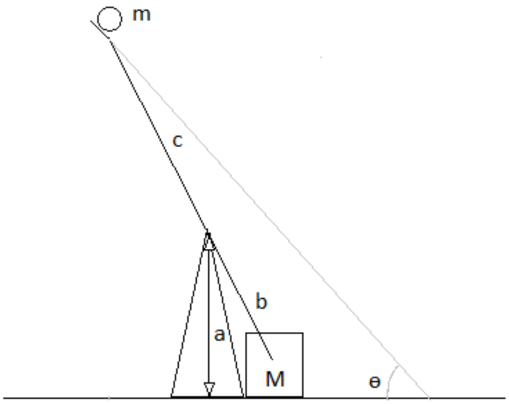


Figure. 2 Scheme of a catapult.

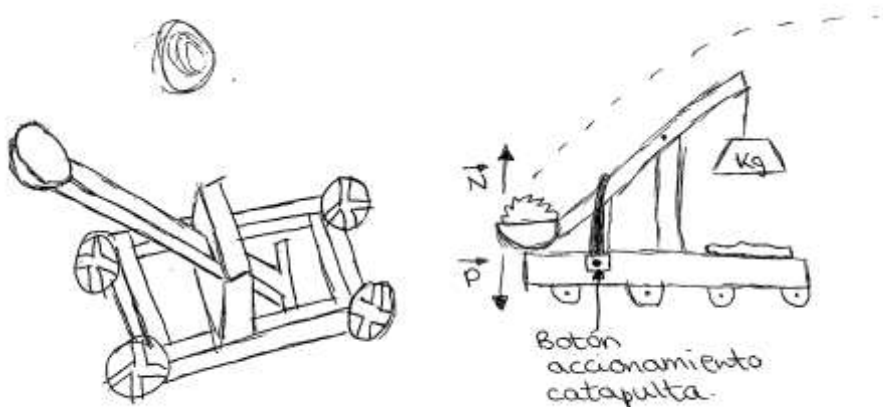
4. Results and discussion

Catapult designs drawn by students were analyzed as follows. First we determined whether they corresponded to a Black-Box model and how many of them had a correct input/output relationship. Figure 3 (a) shows a typical black model. This example faithfully reflects the external aspect of a medieval catapult throwing a projectile forward and upward, but does not provide any detail of how it works. Thus, it is only possible to check the R4 relationship, or, in other words, whether the design (input) and the launching direction of the projectile (output) are coherent. As we can see in table 2, thirty five per cent (35%) of designs can be considered as black-box models, and it is remarkable that a small, but significant, number of them were inconsistent with R4.

With regards to the non-black-box models (65%), only 30% of them were consistent with all the principles and relationships considered; the remaining 70% contained at least one incoherence type. Therefore only 19.5 % of the drawing could be considered physically consistent. As we can see in Table 1, most frequents failures concerned procedures for reaching the maximum range due to incoherencies with relationships R2 (60%) and R3 (18%), as well as with principle P2 (30%).

The results of the formal knowledge test are shown in table 2. It can be seen that the student has a good comprehension of the Physics involved in catapults, especially regarding the transmission of energy and the influence of the par-momentum on the design of the artefact. This fact is particularly noteworthy when compared to the poor results achieved in the drawing test. It seems to suggest that student have problems in integrating their formal knowledge into their way of thinking.

On the other hand, the survey on previous experience with video-games showed that students had significant experience on catapults acquired this way. Usually video-games are categorized into eight genres: action, adventure, fighting, puzzle, role-playing, simulation, sport and strategy [6]. Table 3 shows that a high percentage of students have played at least once with video games involving catapults, mainly action (52%), simulation (51%) and strategy (23%) games. But simulation games are not significant in terms of hours played.



(a) (b)

Figure 3. (a) Typical Black-Box model. (b) Non Black-Box model.

Model tipe		Coherent (%)	Incoherent	incoherence type (%)
Black Box	35%	93%	7%	R4 (7%)
No Black Box	65%	30%	70%	P1 (10%)
				P2 (30%)
				R1 (10%)
				R2 (60%)
				R3 (18 %)

Table. 1Analysis of the designs of catapults from the students.

Knowledge about:	Correct Responses (%)
P1 Kinetic energy versus potential energy	83
P2 Angle of 45	43
R1 Relation Projectile mass m and counterweight mass	86
R2 Height of the pivotal centre	75
R3 Arm design	57
R4 Launching Direction	98

Table 2 Percentage of students which answered correctly the different test about the design of catapults.

The most attractive games for the students are the strategy ones; resulting values of over 50% in all groups regardless of whether they succeeded or not with the design of a catapult. The action games are the next games which students have devoted more hours of action, with about 30% of students. In table 3 it seems that students who were able to design the better catapults prefer the action games than other students, but this difference may not be very significant.
When we examine the features of the most popular video-games used by the students (Table 4) we conclude that in general, catapults are shown in a more or less realistic shape, but in all cases are presented as black-box models. In these games student are able to control input parameters in order to reach the appropriate output, but they are unable to act on them. The results confirm what might have been expected, that is, that this kind of video-games can contribute to supply information about the physical appearance of these weapons, or to help players to acquire tactical skills. They do not, however, have any effect relating to the demanding exercise of modelling, whereby one is required to possess a deep understanding of the underlying physical principles and the technical constraint involved. Other types of commercial video-games which are potentially more effective for this purpose are simulation games, such as crayon physics. However, as we can see in fig 4, these games are practically neglected by the students. Further studies are required in order to determine whether simulation-based commercial video-games can be used as tools to improve students modelling skills, select the most appropriate and work out how to make them more attractive to students.

Type of played game	Percentage of Students	Hours playing with games			
		Designed catapults			
	%	Do not work	Black-Box	Work properly	installed backwards
Action	52	35,82	35,33	43,55	26,47
Adventure	3	0,00	0,00	1,97	0,00
Fighting	4	0,80	0,00	0,70	0,00
Puzzle	0	0	0	0	0
Role-playing	0	0	0	0	0
Simulation	51	1,62	0,76	0,64	1,96
Sport	0	0	0	0	0
Strategy	23	61,76	63,91	53,14	71,57

Table 3. Percentage of students who play different types of video-games, and percentage of hour dedicated to these types of video-games related with their capabilities of design a catapult correctly.

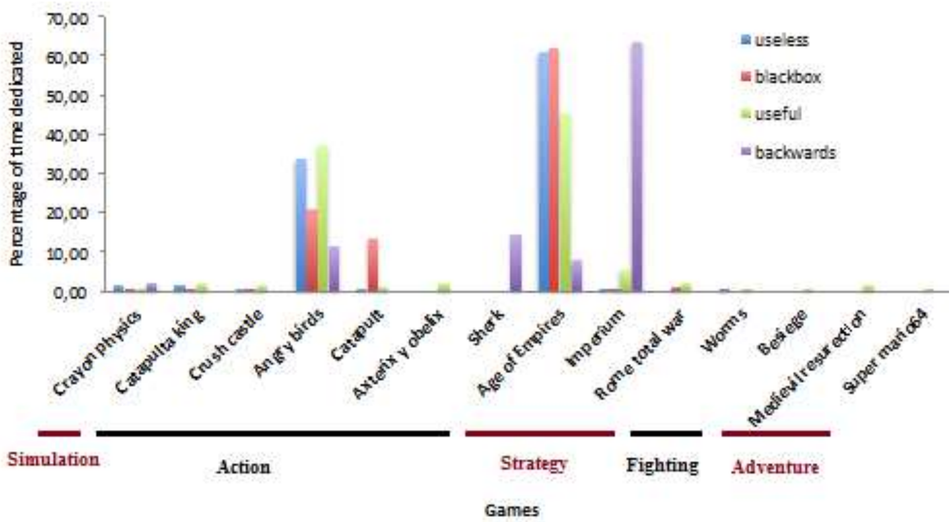


Fig. 4. Percentage of time dedicated to playing different games from those students who built catapults which do not work properly, which were inadequately explained, which work properly and which were installed backwards.

5. Conclusions

35% of the students drafted black-box modelled designs, while 45 % of the students designed a useless catapult, and only 19.5% of students were able to figure out a satisfactory design of a catapult.

Tests about physical operating principles showed that kinetic energy and momentum are well known but the relationship between launch angle and range is more difficult to understand.

A survey based on previous experience playing video-games revealed that action and strategy are the most popular games among students. These results showed that playing these types of video-games is ineffective in improving the design skills of the students. We propose further research into the effects on design skills of other types of video games, such as simulation-based games.

References

[1] Ross, AM, Fitzgerald, ME and D.H., R. (2014). Game-based Learning for Systems Engineering Concepts *Procedia Computer Science 28*, 430-440
[2] Justi, R. S., & Gilbert, J. K. (2002). Modelling, teachers' views on the nature of modelling, and implications for the education of modellers. *International Journal of Science Education*, *24*(4), 369-387. r.
[3] *Koponen, I. T. (2007). Models and modelling in physics education: A critical re-analysis of philosophical underpinnings and suggestions for revisions. Science & Education, 16(7-8), 751-773.*
[4] Şen, Z. (2014). *Philosophical, logical and scientific perspectives in engineering*. Heidelberg: Springer.
[5] Cano, R., Cearras M., y Díaz F. (2002) *Estudio de la Física de una Catapulta. http://www.fisicarecreativa.com/informes/infor_mecanica/catapulta_diaz2k2a.pdf*
[6] Cheng, M. T., Chen, J. H., Chu, S. J., & Chen, S. Y. (2015). The use of serious games in science education: a review of selected empirical research from 2002 to 2013. Journal of Computers in Education, 2(3), 353-375.