Are naïve models of causality interfering with learning in physics classroom?

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Inhelder & Piaget's study on movement conservation (1955)

The principle of inertia states that a ball launched by a spring on a flat surface will keep a rectilinear steady movement, if no obstacle breaks down or deviates the move.

But actually it is impossible to observe any rectilinear steady movement (because of friction, etc.). Still, Piaget tries to see if children nevertheless can master the concept of conservation of movement.

- Children are provided with various balls, a spring launcher, a flat surface.
- Piaget interviews children and challenges their answers with counter-arguments: "Will each ball go as far? Where do you expect each ball to stop? Why?"

Results

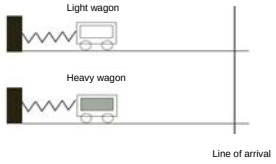
Children usually reach a conservative level at 14-15 years old

Our study in a high school classroom – 1st phase

Inspired by Piaget & Inhelder's study we deviced a written questionnaire for 17 years old students with the following question (among others):

"Two immobile wagons of unequal mass are push by two identical launchers (=equally deformed springs).

When we release the springs, which wagon reaches the arrival line first?"



Results

17 years old students usually do not reach conservation

Comparison between Inhelder & Piaget's subjects and our subjects

Stages	Main issues in the answers (Inhelder & Piaget)	Main issues in the answers (Our study)	% of students (n=20)
Stage I (5-6 y. old)	Incoherent answers / No rule determining the movement	No such answer	0%
Stage IIA (7-8 y. old)	"The weight is the cause of movement" (the ball's own force)	The weight causes movement: "this wagon goes faster, because it is heavier"	15%
	"Light balls are more easily launched and hence go further	"A heavy ball accelerates more, but a light ball is launched faster"	10%
	Contradiction between the two statements above is not solved	Students do not solve the contradiction neither do they answer which wagon is first	
Stage IIB (9-10 y. old)	First indication of a reversal point of view on the problem:	Movement needs a constant force to sustain it but students focus on the ball's	
	from causes of movement to causes of slowdown.	resistance to the spring and it's consumption of the driving force (the launcher)	
	"The weight is an indirect cause that stops the ball"	"More weight needs more force to be moved, thus the light wagon goes faster"	50%
Stage IIIA (13 y. old)	No mention of sustaining cause of movement anymore	Inversion of the problem: the first wagon to arrive is the less to be slowed down	
	Answers focus on some factors slowing down the ball	"The friction slows down the heavy wagon more than the light one"	15%
Stage IIIB (14 y. old)	Thanks to hypothetical reasoning it becomes clear that without	No such answer	0%
	any force slowing down the ball, the movement continues forever		other answers 10%

Comments

Why do we notice this difference of achievement between children's answers in Inhelder & Piaget's study and in our subjects' answers ?

Hypotheses:

1. **The effect of the adult-child social interaction:** we make the hypothesis that Inhelder & Piaget's conversation during the interview and the argumentative moves enhance the level of answers. The adult requires from the child to foster a cognitive development of the subjects in the spot (cf. Perret-Clermont 1980, Schwarz et al. 2008).

→ To test this hypothesis we have designed an interactive activity using Digalo[1] in the classroom environment in order to see if students perform better on our questionnaire item in this setting.

2. **The effect of experimental inquiry:** Inhelder & Piaget's subjects were given real objects to play with. They were thinking hands on and had the opportunity to confront their points of view with the feed back of reality.

→ This dimension is missing in our written questionnaire. To evaluate it, we have designed an experimental activity, in the classroom environment, providing two cars, a spring launcher and a timer.

In the face of unforeseen feedbacks from the objects, subjects have to elaborate further their understanding of movement: "On a horizontal point the weight reduce the velocity, why? -…the weight is exerted on the table, not in the void"

Conclusions

Adolescents have resistant naïve models of causality (i.e."more weight, more movement"). But carefully planned pedagogical situations, designed to foster social interaction, argumentation and direct confrontation with facts can lead students into a reconsideration of their prejudice.

1 Digalo is a software for the acquisition of argumentative competencies which has been developed within the European Union (5th Framework) Project DUNES. For a full description of the use of this tool, see Muller Mirza, Tartas, Perret-Clermont, de Pietro (2007).

Our study – 2nd phase

The teacher requires from groups of 3-4 students to answer the questions via a shared argumentative map (Digalo software).

Example of a map:

Findings

Amomg the 4 groups of this Digalo map, 2 started the map with a stage II level, and 2 challenged this point of view with answers at stage III. One of the two groups starting at stage II finally agrees with stage III answers, giving the light wagon as the first to reach the arrival line.

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