

Informal Teaching of Special Theory of Relativity

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Textbook

“Introduction to the Theory of Relativity”

<https://is.muni.cz/elportal/>



Obr. 19: Relativistická abeace světla – náčrt pro odvození

Stačí jeho výsledky přepočítat podle Lorentzovy transformace (11) a dostaneme:

$$y' = -\frac{1}{\sin \alpha \sqrt{1 - \frac{v^2}{c^2}}} \left[(V \cos \alpha - u) t' + \left(\cos \alpha - \frac{uV}{c^2} \right) x' \right]$$

Protože tento vztah by měl být formálně stejný jako předchozí, lze jejich porovnání získat vztahy pro souvislost mezi úhly α a α' a mezi rychlostmi u a u'

$$\text{tg } \alpha' = \frac{\sin \alpha \sqrt{1 - \frac{v^2}{c^2}}}{\cos \alpha - \frac{uV}{c^2}} \quad (28)$$

Vztahy pro změnu velikosti a směru rychlosti šíření vlnění při přechodu k jiné vztažné soustavě

free online

Flash animations - multimedia supplement

Titulní strana

Obsah

Rejstřík

Strana 68

Zpět

Celá obrázka

Návrat

Konec

že čas, kterou pecivál uvidí na poutnickových hodinách po jeho návratu, bude

$$t_B = \left(\frac{L_A}{V} + \frac{L_A}{c} \right) \sqrt{\frac{1 - \frac{v^2}{c^2}}{1 + \frac{v^2}{c^2}}} + \left(\frac{L_A}{V} - \frac{L_A}{c} \right) \sqrt{\frac{1 + \frac{v^2}{c^2}}{1 - \frac{v^2}{c^2}}}$$

Protože však $t_A = 2 \frac{L_A}{V}$, výpočet dává

$$t_B = \sqrt{1 - \frac{v^2}{c^2}} t_A$$

jak jsme očekávali.

Poutník pozoruje rudý i modrý posuv po stejnou dobu. Před začátkem i na konci obratu (který probíhá po zanedbatelně krátkou dobu), je pro něho v důsledku kontrakce délky Země vzdálena o $L_B = L_A \sqrt{1 - \frac{v^2}{c^2}}$. Po návratu na Zemi tedy uvidí na peciválových hodinách čas

$$t_A = \frac{L_B}{V} \left(\sqrt{\frac{1 - \frac{v^2}{c^2}}{1 + \frac{v^2}{c^2}}} + \sqrt{\frac{1 + \frac{v^2}{c^2}}{1 - \frac{v^2}{c^2}}} \right)$$

Protože však $t_B = 2 \frac{L_A}{V}$, dostáváme znovu týž vztah mezi časy pecivála a poutníka.

V literatuře se často mluví o *paradoxu dvojčat* v souvislosti s představou kosmického letu s návratem, po němž se cestující dvojče bude věkem lišit od dvojčete, jež zůstalo „doma“, tj. v klidu vůči soustavě, která je prakticky inerciální. Zde bývá vznášena otázka, zda i biologický čas životních pochodů se nutně řídí vzorcem (25). Je nepochybné, že biologické procesy probíhají v souladu s principy speciální teorie relativity – všechna data s nimi spojená musí podléhat dilataci času. ~~Biologické~~ ~~časové~~ ~~procesy~~ ~~závisí~~ ~~na~~ ~~relativistickém~~ ~~časovém~~ ~~roztažení~~ ~~vlivu~~ ~~kosmického~~ ~~letu~~ ~~na~~ ~~lidský~~ ~~organismus~~ ~~však~~ ~~biologické~~ ~~procesy~~ ~~trvá~~ ~~uvážiti~~ ~~faktory~~, jimiž se situace kosmonauta nuluje k podobě situace pozemské (stavu beztlaku či přetížení, úroveň záření apod.) a které mohou mít vliv na biologické pochody.



Help to understand

- ✓ Motion Is Relative
- ✓ Simultaneity
- ✓ Spacetime
- ✓ Addition of Velocities
- ✓ Time Dilatation
- ✓ Length Contraction
- ✓ Postulates of the STR

Portal

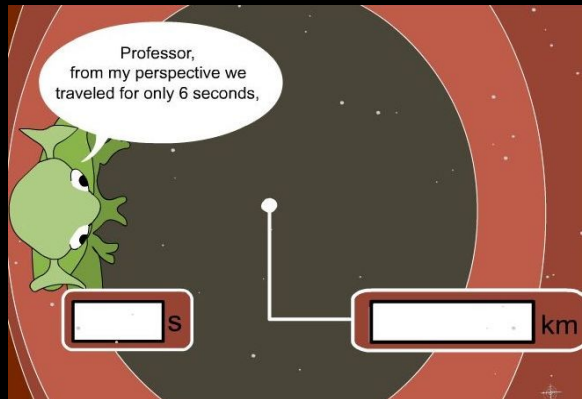
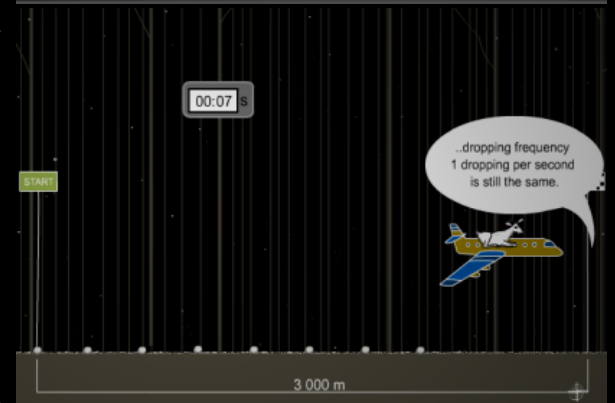
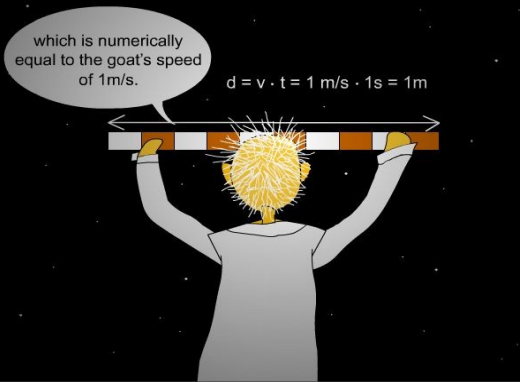
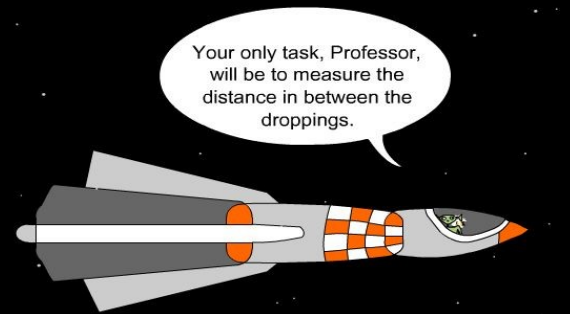
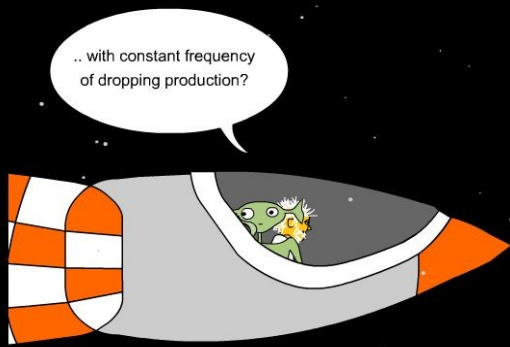
<http://www.ped.muni.cz/wphy/>

Animation Overview

The main characters Alien and Professor - guides through STR ideas. The story begins meeting an Alien and Professor.

Alien traveling at high speed rocket informs Professor of his observations. Step by step they formulate the basic postulates of STR in their communication.





trailer



The Case Study method



Main aims of the study:

- to examine how the observation of animations affects student's approach to perform their solution of quiz tasks .
- to identify incomplete „knowledge“ in areas that may prevent from misunderstandings in STR concepts.
- to find out if the learning process is enhanced by funny animations.
- to evaluate student's skills for understanding STR

Study Design 2013

Participants - university students (future teachers of physics).
They solved a set of 15 tasks – in sufficient time.

2 groups:

AA students were shown an animation before their work.

NA no animation before their work (tasks in advance).

Interview for each student about his practice was audio recorded. Records were transcribed.

After the analysis of full records - the categorization into indicators emerged.

The outputs are charts and brief descriptions of detected remarkable answers.

Observed symptoms and selected indicators:

- careful reading
- initial acceptance of the task (without any intervention)
- clarity in explanation
- ability to reformulate task by own words
- adequacy of graphic representation
- use knowledge of STR
- transfer of knowledge and skills from other disciplines
- value judgment - a solution based on reasoning
- limitation of own approach (feedback)
- creativity
- success in task solution
- ability to maintain attention



Example of Quiz Tasks:

Is the nonsimultaneity of hearing thunder after seeing lightning similar to relativistic nonsimultaneity?

Petard A is 300 m from you, petard B is 600m from you in the same direction, You see both explode at the same time.

Define event A to be „petard A explodes“ and event B to be „petard B explodes“. Does event A occur before, after or at the same time as event B ?

Event A occurs at spacetime coordinates (300m, 2 μ s).

Event B occurs at spacetime coordinates (1200m, 6 μ s).

Could A possibly be the cause of B ?

Event C occurs at spacetime coordinates (2400m, 8 μ s).

Could A possibly be the cause of C ?

Two lines meet at a point O (angle vertex) is beyond the drawing surface.

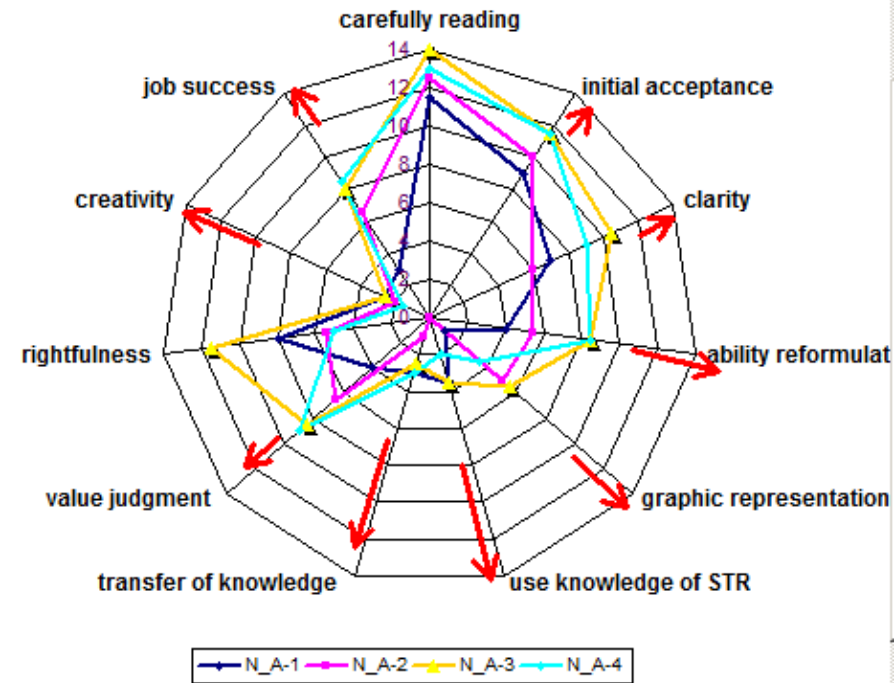
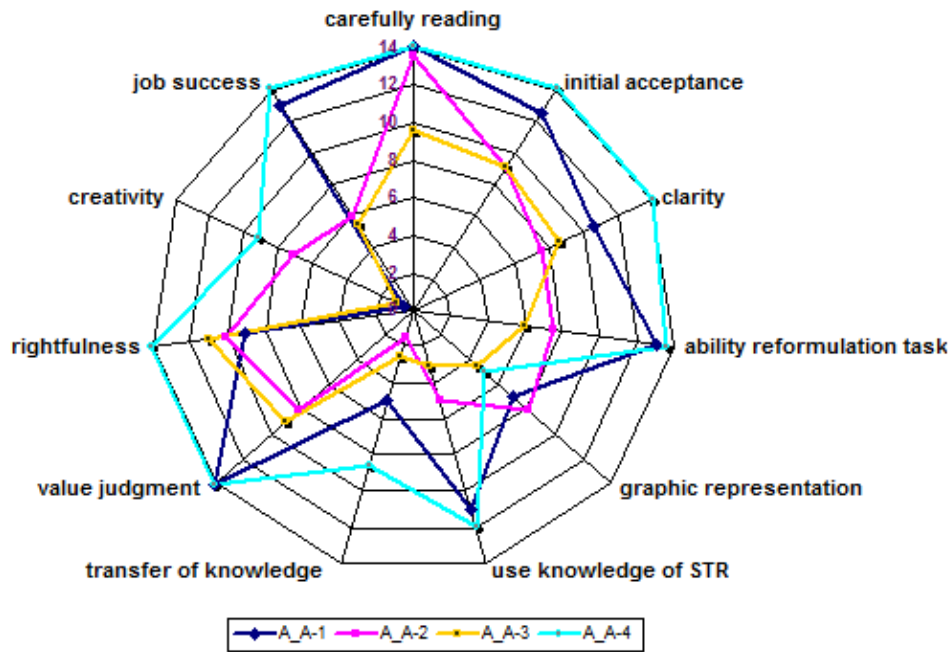
Thus O is the inaccessible point. Bisects the angle between lines.



Research Questions:

- What indicators are changed after students observation of cartoon animation?
- Is there a relationship between graphical and geometrical competence and ability to solve the set of tasks?
- Does the student's ability to clearly formulate their own approach affect the result of test?

Results



The influence of animations is significant in the majority of items....

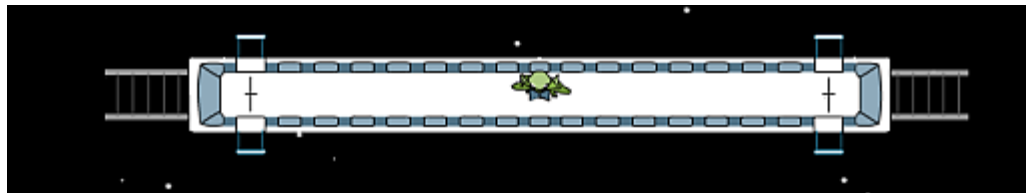


Conclusion

Many students seem to face difficulties in dealing with relativity of motion, in using frames of reference and in using postulate about light speed.

The students who were undertaken STR animations have obtained several benefits in their learning approach.

We can conclude that viewing animation is certainly not a wasting time in the classroom.



Thank you for your time ...

