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Analysis of student conceptual development using the Force Concept Inventory

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DATA BASE

- Force Concept Inventory (FCI): 30 single choice questions on concepts of kinematics, dynamics and forces.
  Version of 1995 [Hestenes et al., 1992].

TH Rosenheim (TH RO):

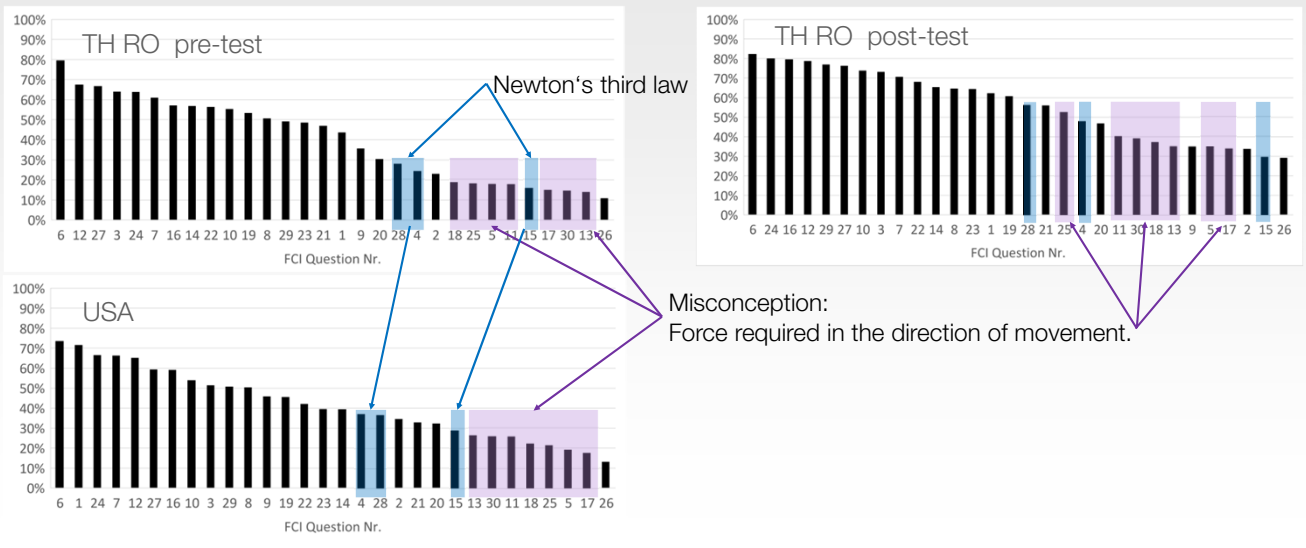
- 10 years: 2013/14 to 2022/23;
- 12 engineering programmes
- 4957 pre-test results from the start of the study programme
- 2618 post – test results

USA [Morris et al., 2012]:

- > 4500 student responses
- Universities: Harvard, Mississippi State, Rice

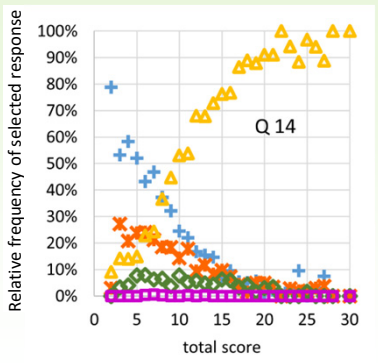
PARETO

Percentage of correct answers per question



ITEM RESPONSE CURVES

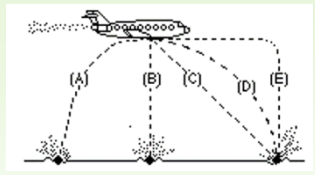
- One diagram for each of the 30 questions.
- Frequency of the correct answer as well as the four distractors of a question plotted as a function of the total score in the FCI (according to [Morris et al., 2006]).
- The frequency of the correct answer increases monotonically to 100 % for the maximum total score of 30.
- The graphs provide information about student conceptual development.
- Examples: question 14 (monotonically decreasing distractors) and question 17 (distractor with plateau or maximum).
- Most distractors address known misconceptions.



Question 14:

- Correct answer D (△) monotonically increasing
- Distractors monotonically decreasing
- → Proove of test quality:
  A higher total score corresponds to a higher probability of answering each question correctly.

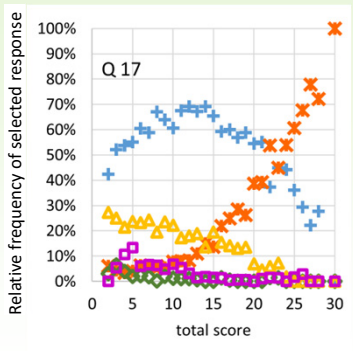
Distractor E (□) not effective.



A (+), B (*), C (◇), D (△), E (□)

Graphic for question 14

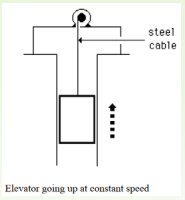
Question 14 asks for the trajectory of a ball that falls from an aeroplane and is seen by an observer standing on the ground.



Question 17:

- Distractor A (+) with plateau or maximum
- Indication of a misconception
- With increasing understanding (i.e. higher FCI total score), misconception initially increases!

Misconception A (+): a resulting force in the direction of movement is required.



Graphic for Question 17

The following applies to the forces on the elevator:

A (+) force by cable > force of gravity
B (*) force by cable = force of gravity
C (◇) force by cable < force of gravity
D (△) force by cable > downward force of gravity and air
E (□) None of the above.

DATA IN COMPARISON

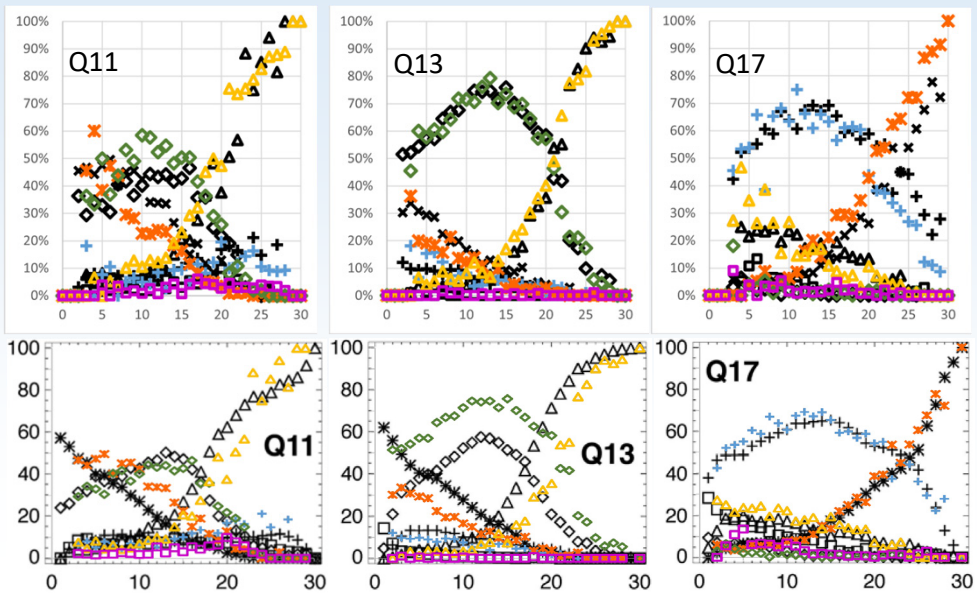
Item response curves for questions (Q) 11,13, 17 of the FCI.
A (+), B (*), C (◇), D (△), E (□)

TH Rosenheim data:
Pre-test in **black**
Post-test in colour

- Pre- and post-test data show similar pattern.
- Example Q11: normal force (*) understood prior to „no force in direction of motion"(◇)

USA in **black** [Morris et al., 2012]
TH RO pre-test in colour

- Data of the TH Rosenheim show a similar pattern as the data from the USA [Stanzel, 2023].



CONCLUSION

- Student conceptional development as function of FCI total score reproducibly shows a progression specific to each question.
- The FCI total score provides a reliable value for the distribution of all answer frequencies to all questions.

MEASURES

- Detailed feedback to teachers and students
- Further development of educational material

Further information at www.pro-aktjv.de

References:

[Hestenes et al, 1992] Hestenes, D., Wells, M. & Swackhamer, G. (1992). Force concept inventory. *The Physics Teacher*, *30*(3), 141-158. https://doi.org/10.1119/1.2343497

Graphs for questions 14 and 17 of the FCI: [Hestenes et al., 1992].

[Morris et al, 2006] Morris, G. A., Branum-Martin, L., Harshman, N., Baker, S. D., Mazur, E., Dutta, S., Mzoughi, T. & McCauley, V. (2006). Testing the test: Item response curves and test quality. *American Journal of Physics*, *74*(5), 449-453. https://doi.org/10.1119/1.2174053

[Morris et al, 2012] Morris, G. A., Harshman, N., Branum-Martin, L., Mazur, E., Mzoughi, T. & Baker, S. D. (2012). An item response curves analysis of the Force Concept Inventory. *American Journal of Physics*, *80*(9), 825-831. https://doi.org/10.1119/1.4731618

[Stanzel, 2023] Stanzel, S. „Analyse studentischer Fehlvorstellungen mittels des Force Concept Inventory: Item Response Curves im internationalen Vergleich", PhyDid B, Bd. 1, Nr. 1, Nov. 2023 https://ojs.dpg-physik.de/index.php/phydid-b/article/view/1339

HigHRoQ TH ROSENHEIM

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