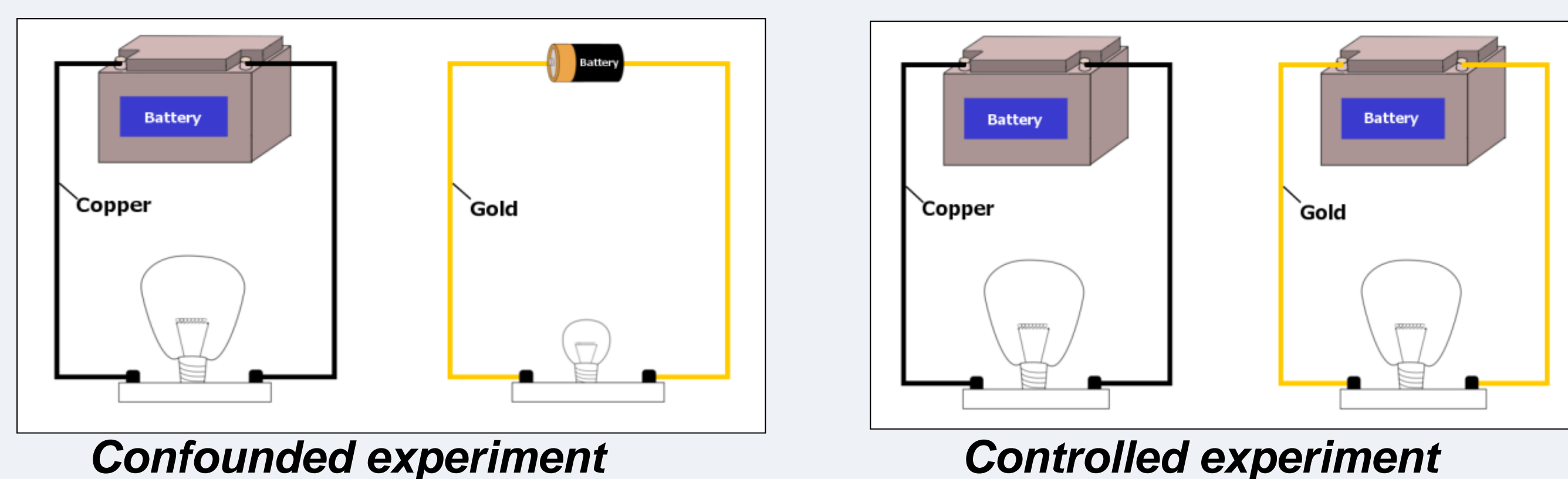


Martin Schwichow & Simon Christoph



CVS in Science and Science Education:

- Important science process skill
- Prominent object of science standards and curricula
- Necessary for learning through inquiry
- Linked educational goals such as inquiry skills and argumentation

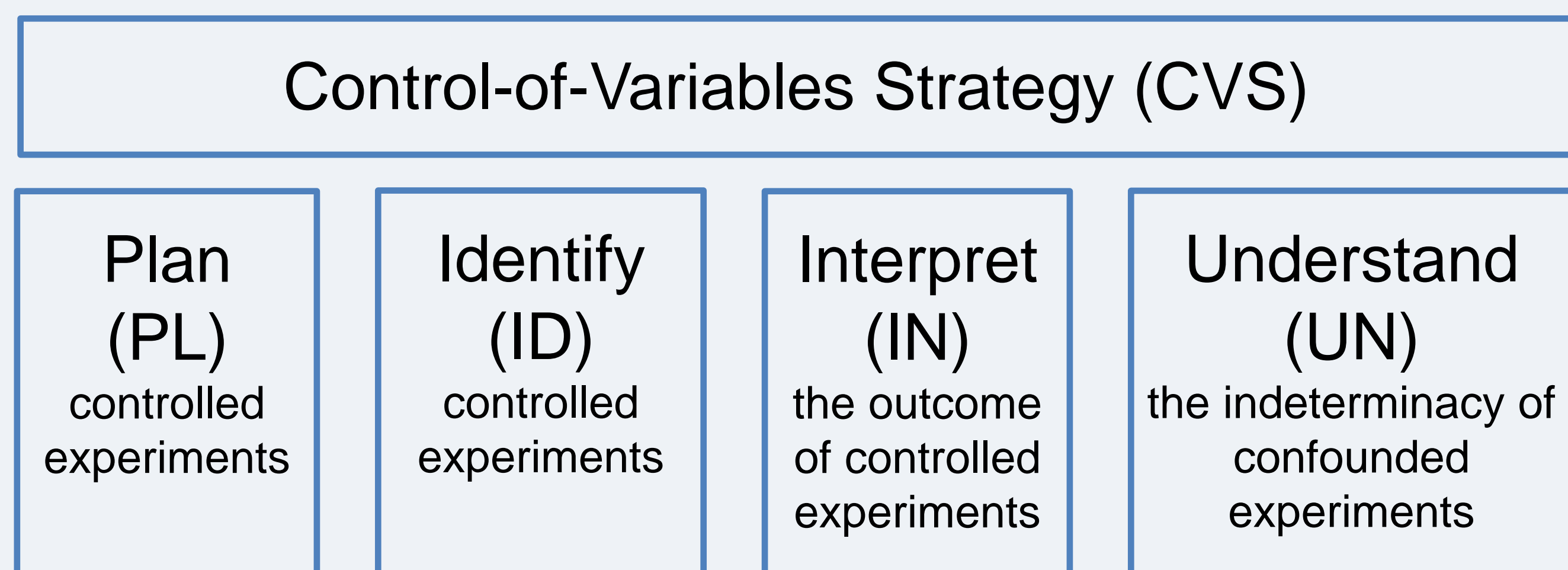


Figure 1: Four facets of the control-of-variables strategy (Chen & Klahr, 1999).

Impact of CVS facets on item difficulty (Schwichow et al., submitted)

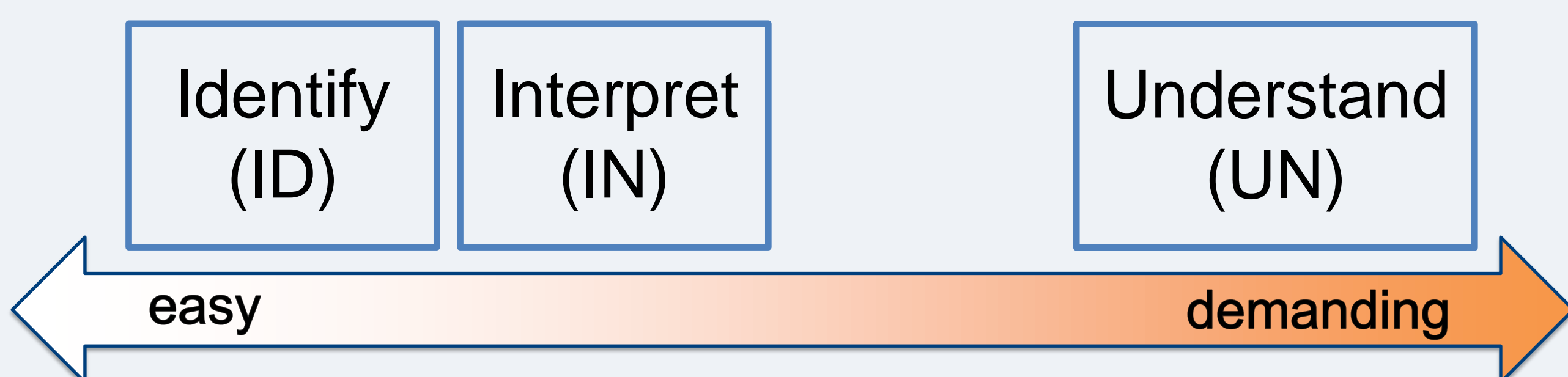


Figure 2: Results of an investigative study with 386 8th graders.

Research questions

- (1) How do students' skills with regard to the four facets of the CVS develop over time?
- (2) Do students' CVS skills depend on their content knowledge?
- (3) Does the item content have an impact on the item difficulty?

Methods

Sample

- Cross-sectional study with 1294 students (52% female) from four Gymnasiums in Schleswig-Holstein, Germany

Table 1: Sample Descriptive Statistics.

Grade	5	6	7	8	9	10	11	12	13	Total
Mean age (SD)	10.45 (0.56)	11.40 (0.56)	12.36 (0.63)	13.40 (0.55)	14.45 (0.63)	15.51 (0.69)	16.78 (0.69)	17.17 (0.78)	18.50 (0.81)	13.78 (2.45)
Number	178	168	154	211	173	173	60	107	70	1294

Test Instruments

- 1) CVS online test (48 items) in the context of heat & temperature and electricity & electromagnetism.

- 2) Physic content knowledge test (31 items) covering heat & temperature and electricity & electromagnetism.

Data Analyses

- Rasch analysis: Transforming row data into a linear logit scale (Boone, Staver, & Yale, 2014).
- Exclusion of misfitting items (MNSQ infit 0.8-1.2) → CVS 45 items (3 excluded), content knowledge 31 items (no excluded)
- Creation of Wright Map and data analyses with ANOVA and linear regression

Results

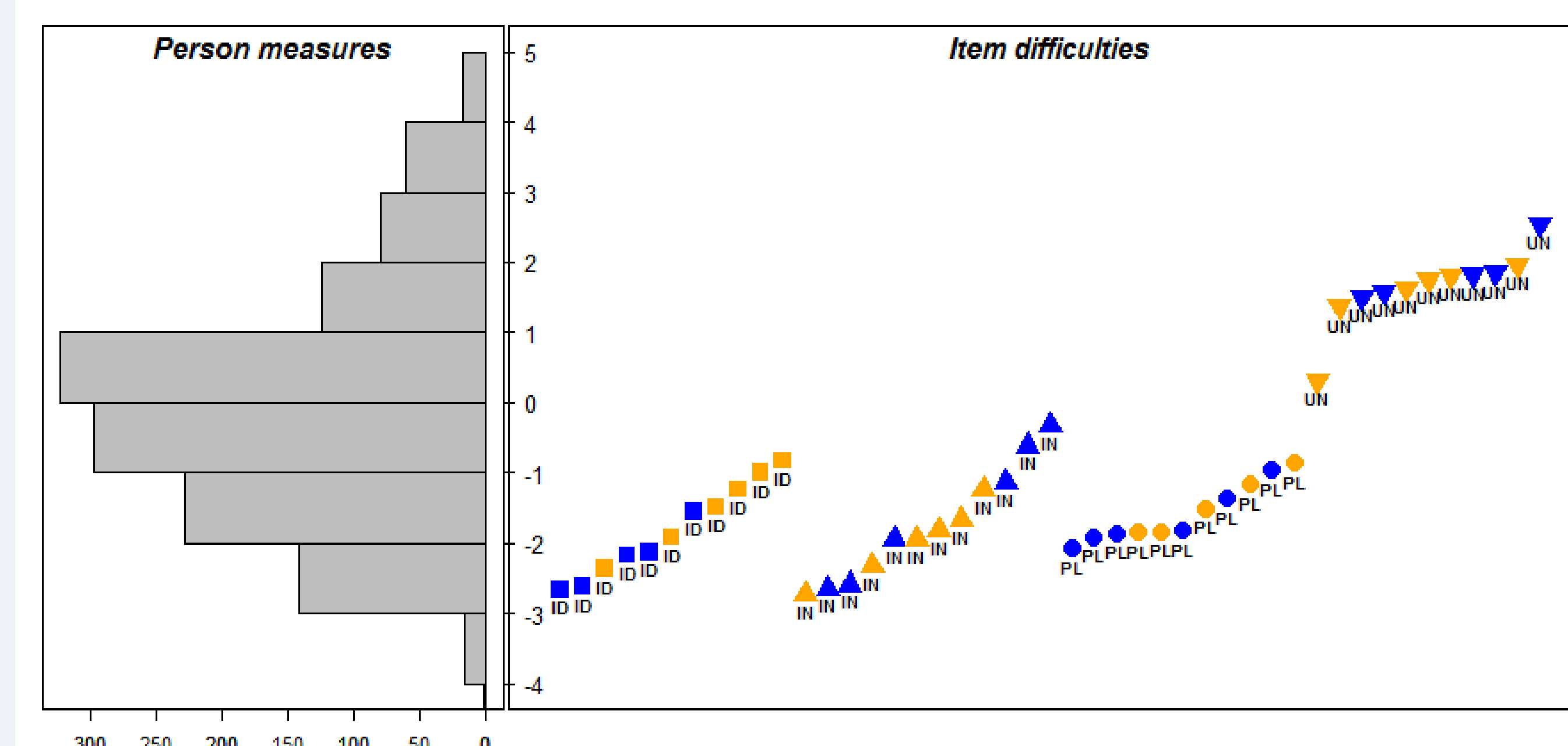


Figure 3: Wright Map of person measures and item difficulties

Table 2: Linear Model

	Beta	F-Value	P
Grade	0.42	277.75	***
Content knowl.	0.34	691.47	***
Grade*Content knowl.	0.00	0.04	0.84

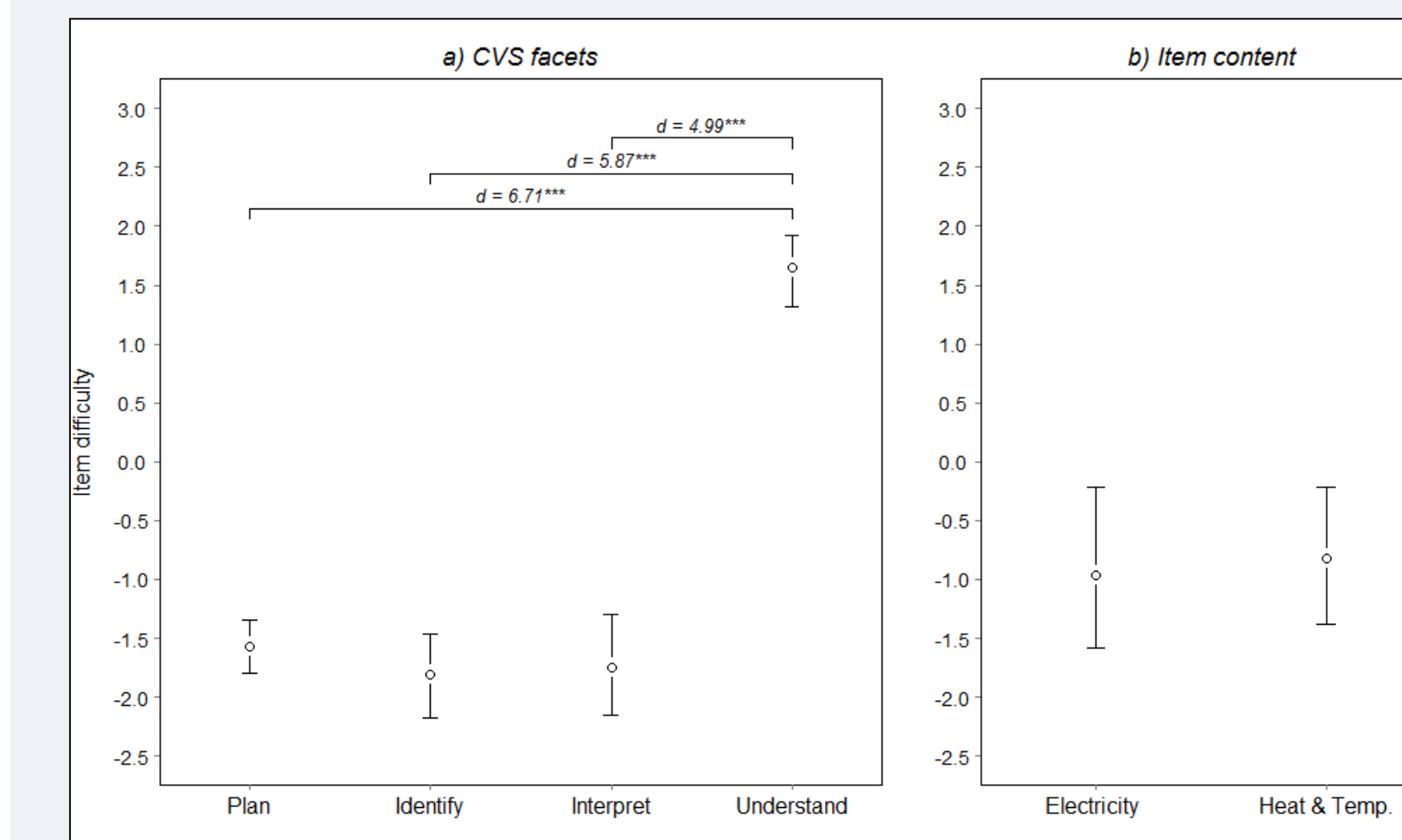


Figure 4: Mean item difficulties and SE (in logits) for

a) Plan (PL), identify (ID), interpret (IN) & understand (UN) items.

b) Items with content from heat & temperature and electricity & electromagnetism

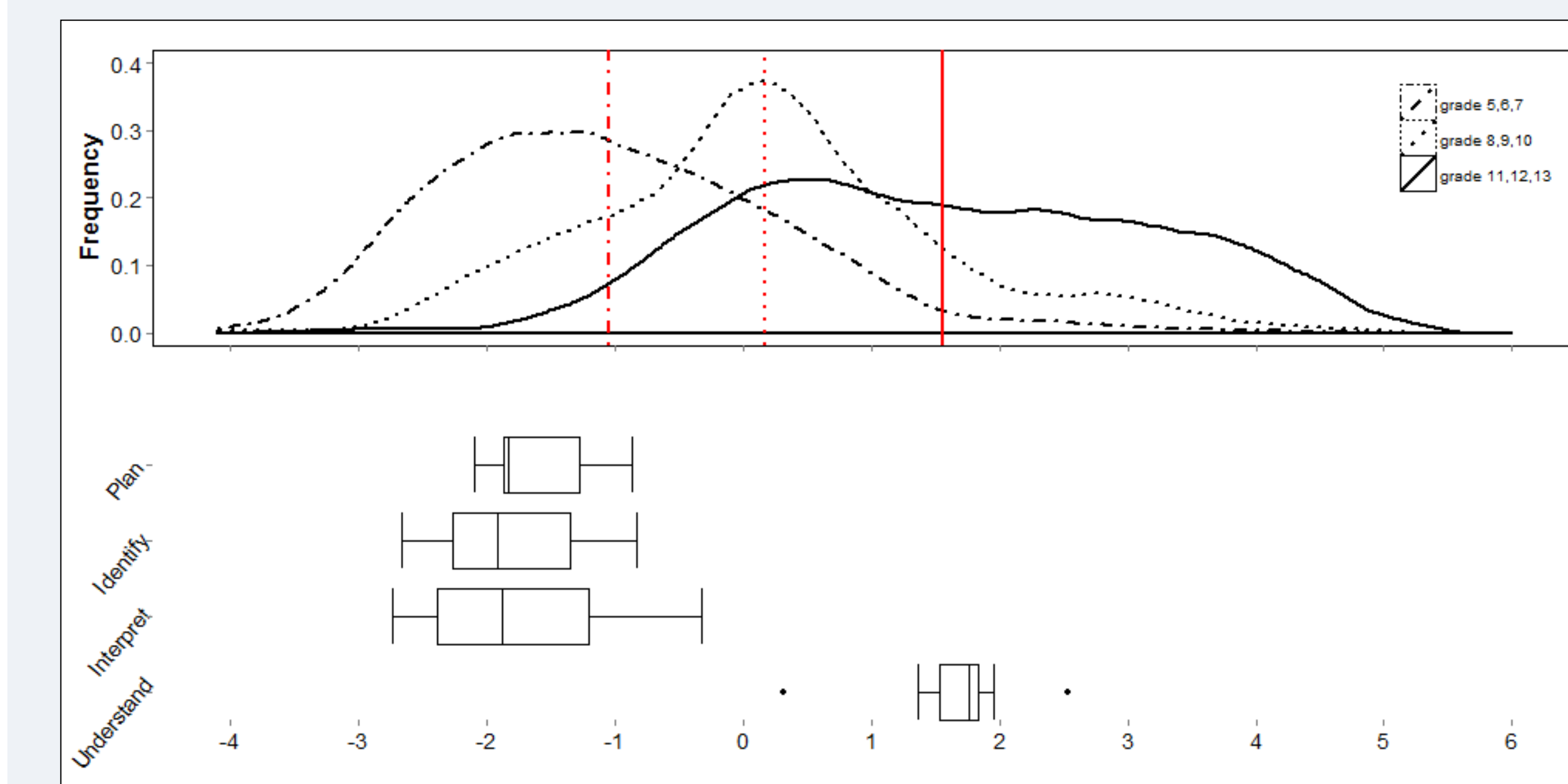


Figure 5: Person ability by grade compared to items difficulty (in logits) by CVS facets.

Discussion

- Development of students skills with regard to the four CVS facets

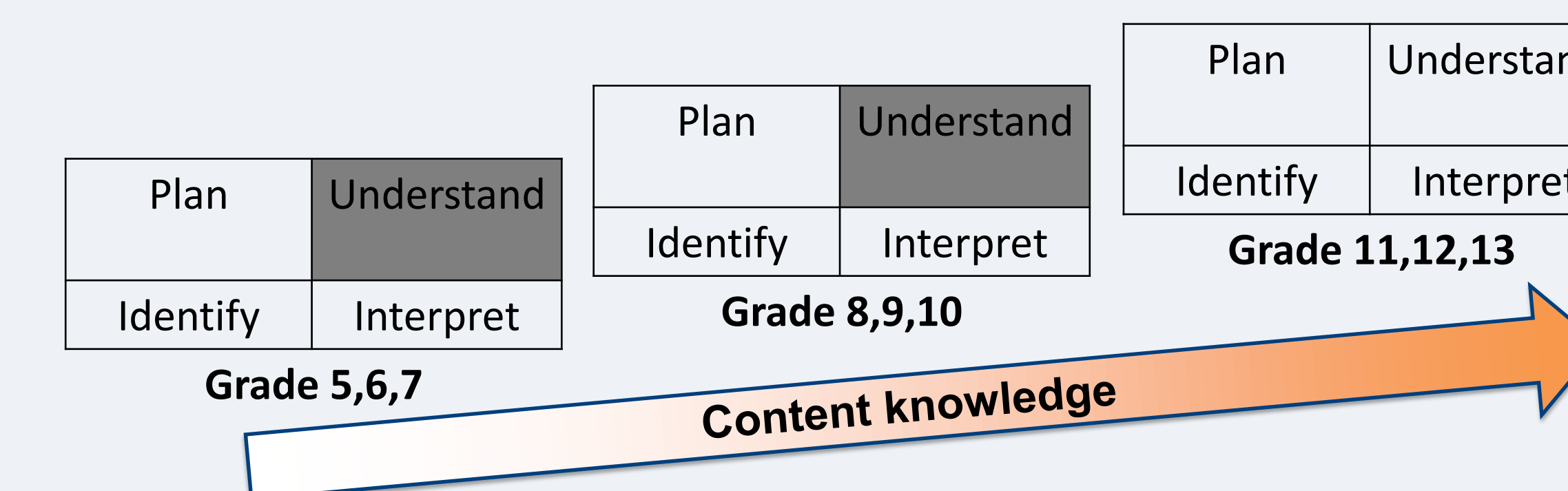


Figure 6: Summary of findings.

- Variance in students' CVS skills increases with age
- CVS skills and content knowledge co-develop but relationship is unclear
- Content knowledge cannot explain increase in CVS skills → Content knowledge is necessary but not sufficient for CVS
- Item difficulty depends on CVS facets and not on item content

Implications

- Only testing all CVS facets provide a complete picture of students CVS skills
- Science education should focus more on the understand (UN) facet as it is important for inquiry and scientific literacy
- Why some students achieve the understand (UN) facet is an open question

