A summary of a research article by Mirko Marusic & Josip Slisko, using the Lawson Classroom Test of Scientific Reasoning (CTSR).

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Mirko Marusic & Josip Slisko (2012): Influence of Three Different Methods of Teaching Physics on the Gain in Students' Development of Reasoning, *International Journal of Science Education*, **34**:2, 301-326.
Weblink: dx.doi.org/10.1080/09500693.2011.582522 (Very expensive to download.)

The authors used the free-response version of the Lawson Classroom Test of Scientific Reasoning (CTSR) to gauge **the relative effectiveness of three different pedagogies on increasing physics students' level of scientific thinking**. This research was done with 8 complete physics classes of high school seniors (ages 17–18) in Croatia.

Three different pedagogies were used, separately in different classes. The 3 pedagogies were:

* Experimenting and Discussion (ED group: 85 seniors in 3 classes).
* Traditional lecture (TM group: 62 seniors in the next year, for logistical reasons).
* Reading, Presenting, and Questioning (RPQ group: 91 seniors in 3 classes)

(Jane's note: The ED pedagogy is similar to Modeling Instruction.)

All three groups (i.e., 8 physics classes with 3 different pedagogies) were taught by the same teacher (Mirko Marusic). He was allowed one 45-minute 'free topic' session each week for 16 weeks (12 sessions for treating the chosen topics and 4 sessions for pre- and post-assessments). The topics were chosen by researchers.

(Note: these 16 "free topic" sessions were in addition to the obligatory physics syllabus in Croatia. Students in all 8 physics classes were taught the same way in the rest of the course. In Croatia, high school students have physics every year, along with biology and chemistry.)

Lawson's Classroom Test of Scientific Reasoning (CTSR - 1995 free response version) was given as pre-test and post-test. The total score on the CTSR is 12. This classification is given by Lawson (1995):

0–4 points — empirical-inductive level (concrete-operational thinkers);
5–8 points — transitional level (transitional thinkers);
9–12 points—hypothetical-deductive level (formal-operational thinkers)

RESULTS: CTSR mean scores of students were:

group	# students	pre-test	post-test	gain (# points)
ED	85	5.36	7.27	1.9
TM	62	5.29	5.63	0.3
RPQ	91	5.84	6.84	1.0

The ED group had large gains in other ways, too; much larger than the other groups. I quote:
** 62% of students considered physics to be helpful in logical thinking before the teaching intervention, while after the intervention 94% of them shared that attitude.*
** A positive shift towards the statement 'physics contributes to creative thinking' was achieved, and it went from 36% (pre) to 73% (post).*
** Prior to the teaching intervention, 15% of students considered physics to be their favorite subject, while after the project the percentage increased to 52%.*

Students in the ED group who started out as CONCRETE thinkers had the largest gains.

THE 3 PEDAGOGIES, in detail:

Experimenting and Discussion (ED):
ED pedagogy was applied to a group of three physics classes (85 students) for some classical physics topics. Some sequential tasks that promote **active learning** are:
(1) Predict–Observe–Explain (White & Gunstone; Lillian McDermott's group at Univ of WA);
(2) **Observe–Explain–Predict–Test** (Alan Van Heuvelen & Eugenia Etkina: ISLE & PUM).
Formulate and revise explanatory and predictive models; this resembles authentic scientific inquiry.
Of the 12 45-minute sessions, 4 each focused on force & motion, pressure, and heat.

I quote: "*Students who were not participative in regular physics classes often showed a great improvement in active-learning sessions. Another point that can be made about commonly non-participative students is that given a chance to voice their difficulties, as is the case in this type of learning, they can resolve their problems but are also thanked later by bright students who admit to not understanding it either, but are reluctant to admit it."*

Traditional Methods (TM): This group of 62 students were given **traditional lectures** by the teacher, on topics in the obligatory physics syllabus, during the weekly "free topic" 45-minute sessions. They had a textbook.

Reading, Presenting, and Questioning (RPQ):
The RPQ method was designed within the framework of three student-centered pedagogies that emphasize **collaborative learning: problem-based learning [PBL], process-oriented guided inquiry learning [POGIL], and peer-led team learning.** RPQ pedagogy was applied to a group of three physics classes (91 students) by introducing topics related to recent scientific discoveries in physics. Students in each class formed 3 teams and did the following:
(1) read popular articles suggested by the teacher - researchers;
(2) read online resources;
(3) presented their learning results to the class in PowerPoint format;
(4) questioned about unclear elements of reading and peer-presented materials.

The two topics were particle physics (Large Hadron Collider (LHC) at CERN) and cosmology (inflation, dark matter, dark energy ... Wilkinson Microwave Anisotropic Probe of NASA, which produced the Standard Model of Cosmology). One team presented on particle physics, one on cosmology, and one critiqued the presentations, recorded & posed student questions, and conducted a class debate. Students started out puzzled by this way of learning, but became interested, yet noted difficulties in "the highly specialized language of scientific articles and a vast amount of new information that requires the support of stronger mathematical skills."