IPN
Leibniz Institute for Science and Mathematics Education

What students learn from hands-on experimental tasks

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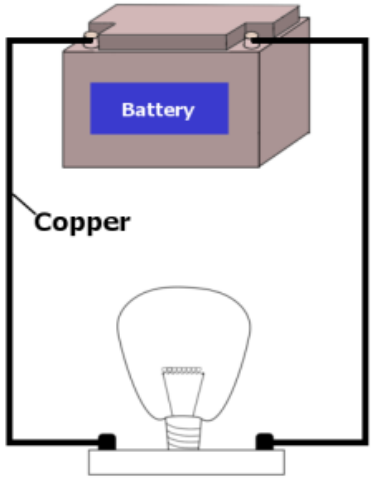
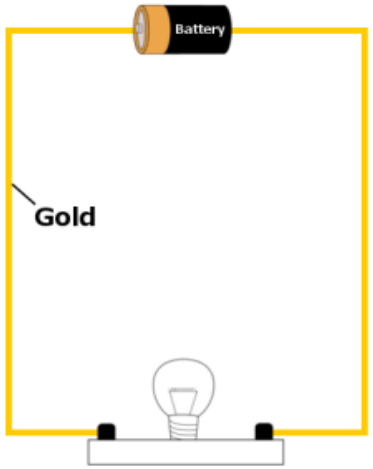
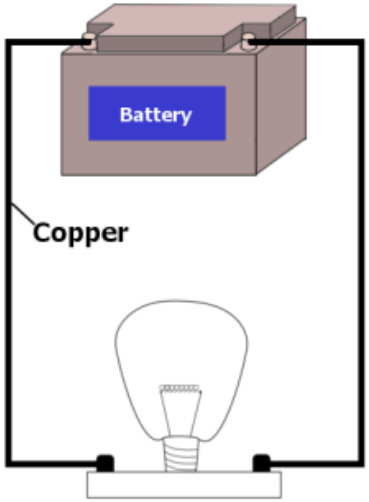
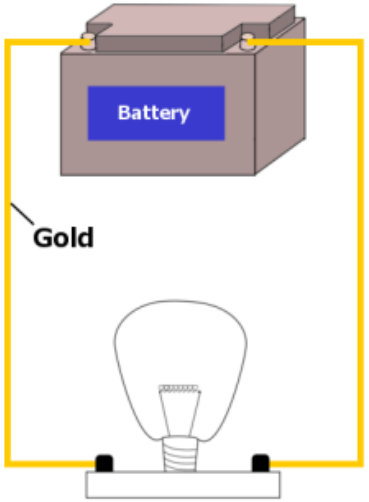
Control-of-Variables-Strategy









Control-of-Variables-Strategy

Teaching CVS – Results of a Meta-Analyses:

Instruction Methods	g
Cognitive conflict	0.80_a
No cognitive conflict	0.53_b
Hands-on training	0.59
No hands-on training	0.74
Test Instruments	
Multiple-choice	0.52_a
Open response	0.65
Hands-on tests	0.74_b
Virtual tests	0.42_a

(Schwichow et al, 2015)

Hands-on activities in science classes

➔Hands-on activities are often utilized in science classes …

(Börlin, 2012; Tesch, 2005)

➔because they are assumed to support:

- Content knowledge acquisition
- Learning of scientific practices
- Understanding of the nature-of-science
- Motivation and interest in science

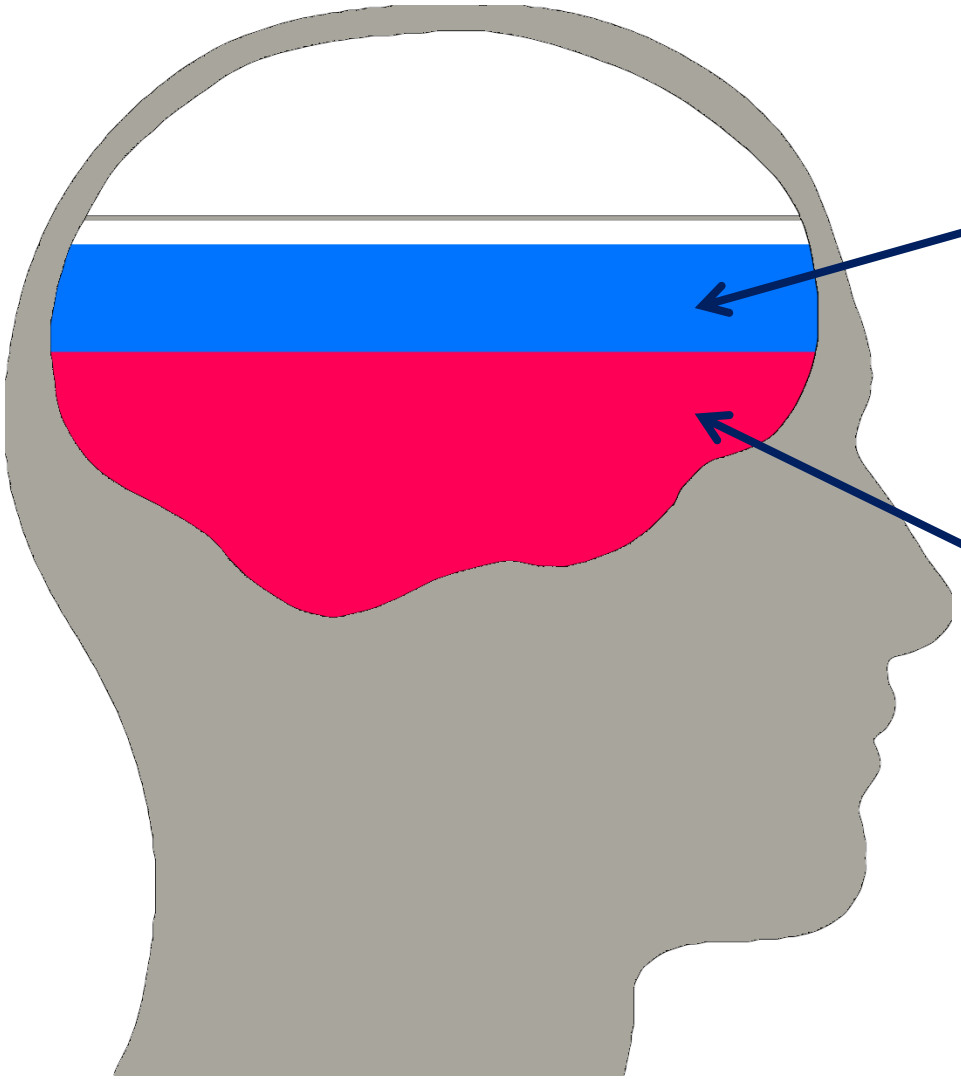
(Haury, et al, 1994; Millar, 2004)

➔ They might have a negative impact on learning CVS?

(Schwichow et al, 2015)

Hands-on activities in science classes

Cognitive load theory (Sweller, 1988; 1994)



Extrinsic CL
- Measure
- Take nots
- Technical problems
- Ect.

Intrinsic CL
- Design
- Identify
- Interpret
- Understand

Design

Sample: 161 8th graders

Training condition	Pre-	Introduction	In-between-	Training	Posttest
Hands-on (n = 82)	▪ MC-CVS ▪ Content knowledge ▪ Cognitive abilities ▪ Reading abilities	Cognitive conflict	▪ MC-CVS	Hands-on	▪ MC-CVS ▪ Hands-on CVS: *1) Elec.magnets* *2) Light bulb* ▪ Poster CVS: *1) Magnets* *2) Memory* ▪ Content knowledge
Paper-and pencil (n= 79)				Paper-and-pencil	
	First unit (90 min)		Second unit (135 min)		

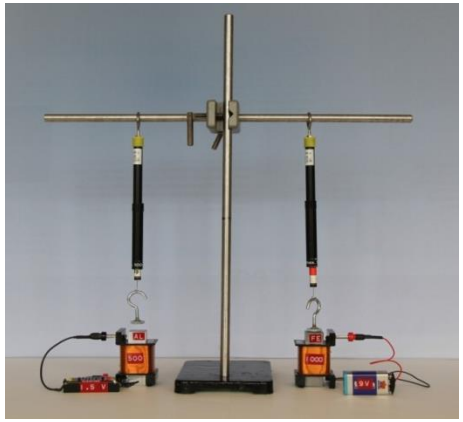
Materials

Hands-on

Physik Elektrizitätslehre	Kraft eines Elektromagneten	Code:

Aufgabe 1:
Lea und Marian wollen herausfinden, ob die anziehende Kraft eines Elektromagneten davon abhängt, wie oft der Draht um den Kern gewickelt ist. Sie haben dazu das vor euch aufgebaute Experiment geplant.

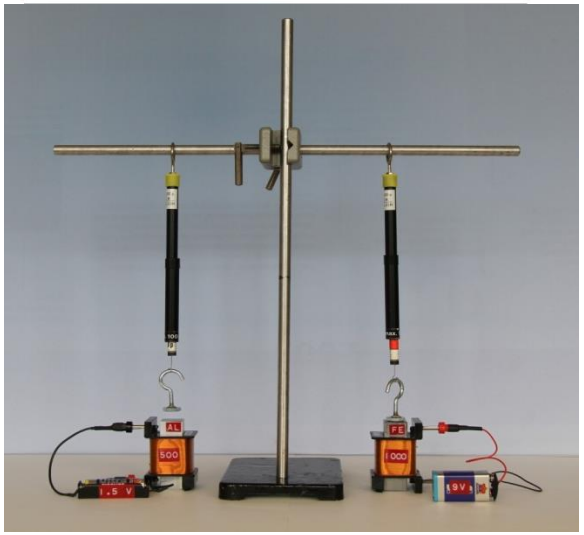
Schaut euch das Experiment bitte in ruhe an und verändert es zuerst einmal nicht. Leider ist ihr Experiment nicht aussagekräftig. Schreibt bitte auf was die Probleme dieses Experiments sind.



Paper-and-pencil

Physik Elektrizitätslehre	Kraft eines Elektromagneten	Code:

Aufgabe 1:
Lea und Marian wollen herausfinden, ob die anziehende Kraft eines Elektromagneten davon abhängt, wie oft der Draht um den Kern gewickelt ist. Sie haben dazu folgendes Experiment geplant:



Schaut euch das Experiment bitte genau an. Leider ist ihr Experiment nicht aussagekräftig. Schreibt bitte auf was die Probleme dieses Experiments sind.

Test Instruments

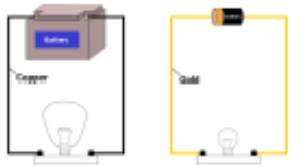
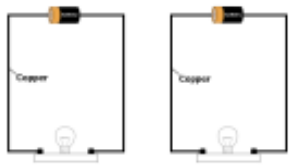
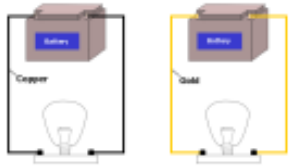
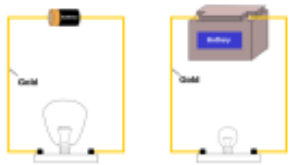
CVS MC test

Wires	ID-LS-1

Peter wants to find out whether the material of a wire has an impact on its resistance.

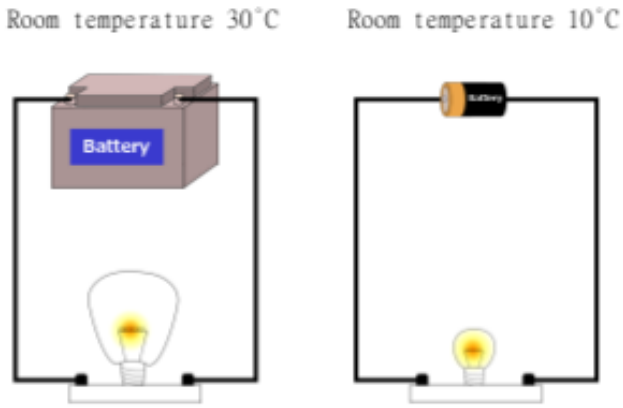
He assumes that the bulb will shine brighter when he uses gold instead of copper to connect it with a battery.

Which of the following experiments would be a good experiment to test his assumption?

☐	
☐	
✖	
☐	

Bright light	UN-LS-2

Toni did the following experiment:



What does his experiment show?

☐	The material of the wire has an impact on the brightness of the bulb.
☐	The room temperature has an impact on the brightness of the bulb.
☐	The wire's material and the room temperature have an impact on the brightness of the bulb.
✖	The experiment does not allow any valid conclusion.

(Schwichow, Christoph, Boon, & Härtig, 2015)

Test Instruments

CVS Hands-on test

Elektromagnet 1

	Uhrzeit
Beginn	:
Ende	:

Verschiedene Ströme

Tina möchte die Stärke eines Elektromagneten variieren.

Vermutung:

Tina vermutet, dass das magnetische Feld eines Elektromagneten stärker ist, je größer der Strom ist, der durch ihn fließt.

Überprüfe bitte durch Experimentieren, ob Tinas Vermutung richtig ist. Du kannst dazu alle Gegenstände nutzen, die du in der Kiste „Elektromagnet" findest. Du musst aber nicht alle Materialien nutzen!

Bedenke, dass in einem guten Experiment immer zwei Aufbauten miteinander verglichen werden müssen.

Beobachtung:

Was hast du herausgefunden?

☐	Tinas Vermutung ist falsch.
☐	Tinas Vermutung ist richtig.

Wie sicher bist du dir, dass das, was du herausgefunden hast, richtig ist?

o sehr unsicher o unsicher o sicher o sehr sicher

Denk noch einmal über deine Experimente nach. Warum kannst du ganz sicher sein, dass du etwas über den Einfluss der Farbe auf die Erwärmung herausgefunden hast?

Test Instruments

CVS Poster test

Poster B

Does the amount of iron have an impact on the force of a magnet?

Hypotheses

I think the more iron is in a bucket the stronger the bucket will be attracted by the magnet. I think that because I know that iron is attracted by magnets.

Material

3 Different buckets
Iron & wood shavings
1 Scale
1 Force meter
1 Magnet

Procedure:

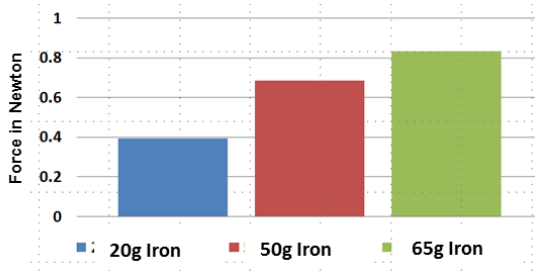
1. I filled 20g, 50g and 65g iron shavings in the three buckets..
2. Than I added 20g wood shavings to each bucket .
3. I put a magnet directly under the force meter.
4. I hang the three different bucket at the force meter.
5. I draw a figure of my results.

Conclusion

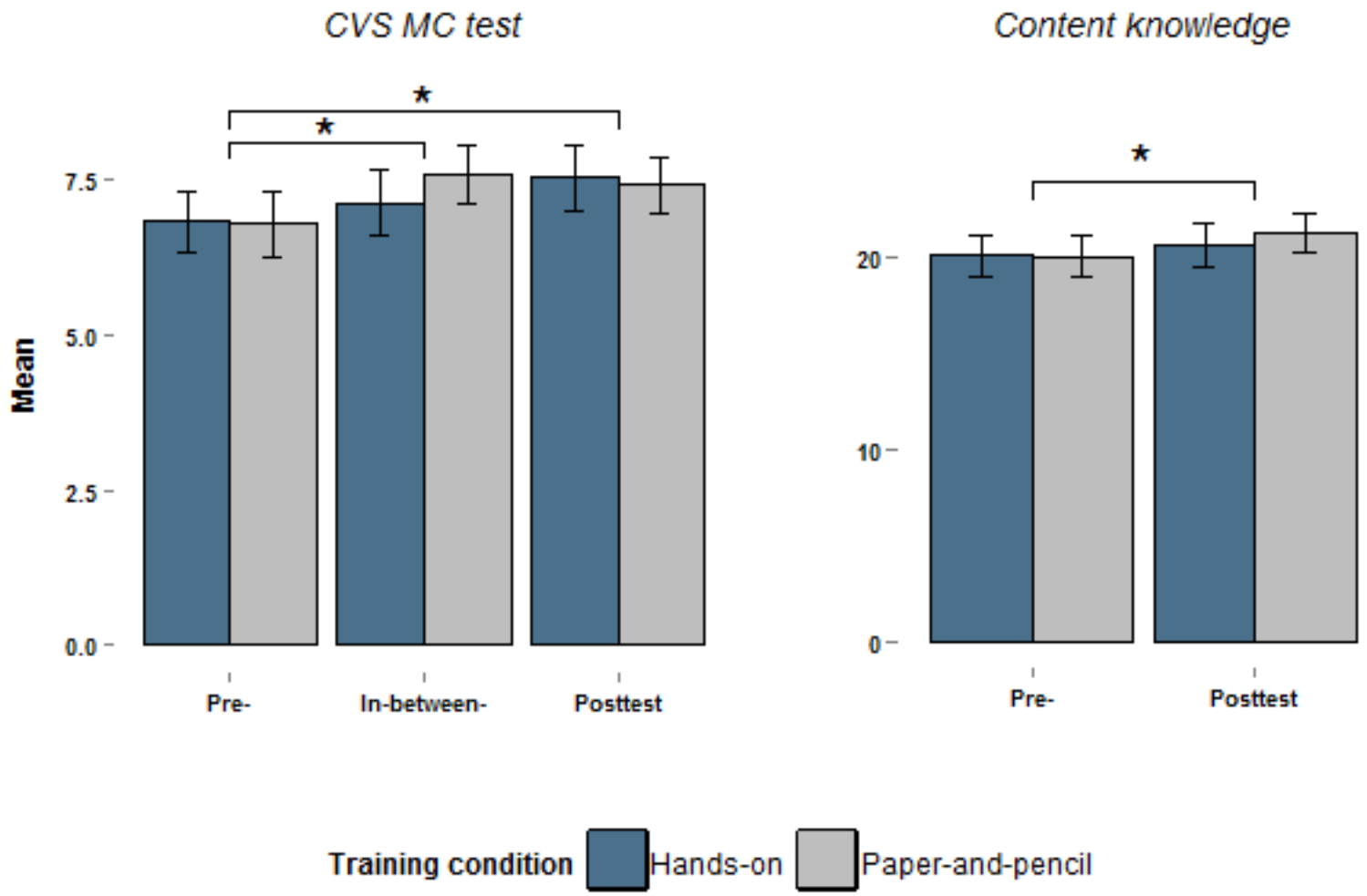
The bucket with the fewest iron attracted the strongest.

Equipment

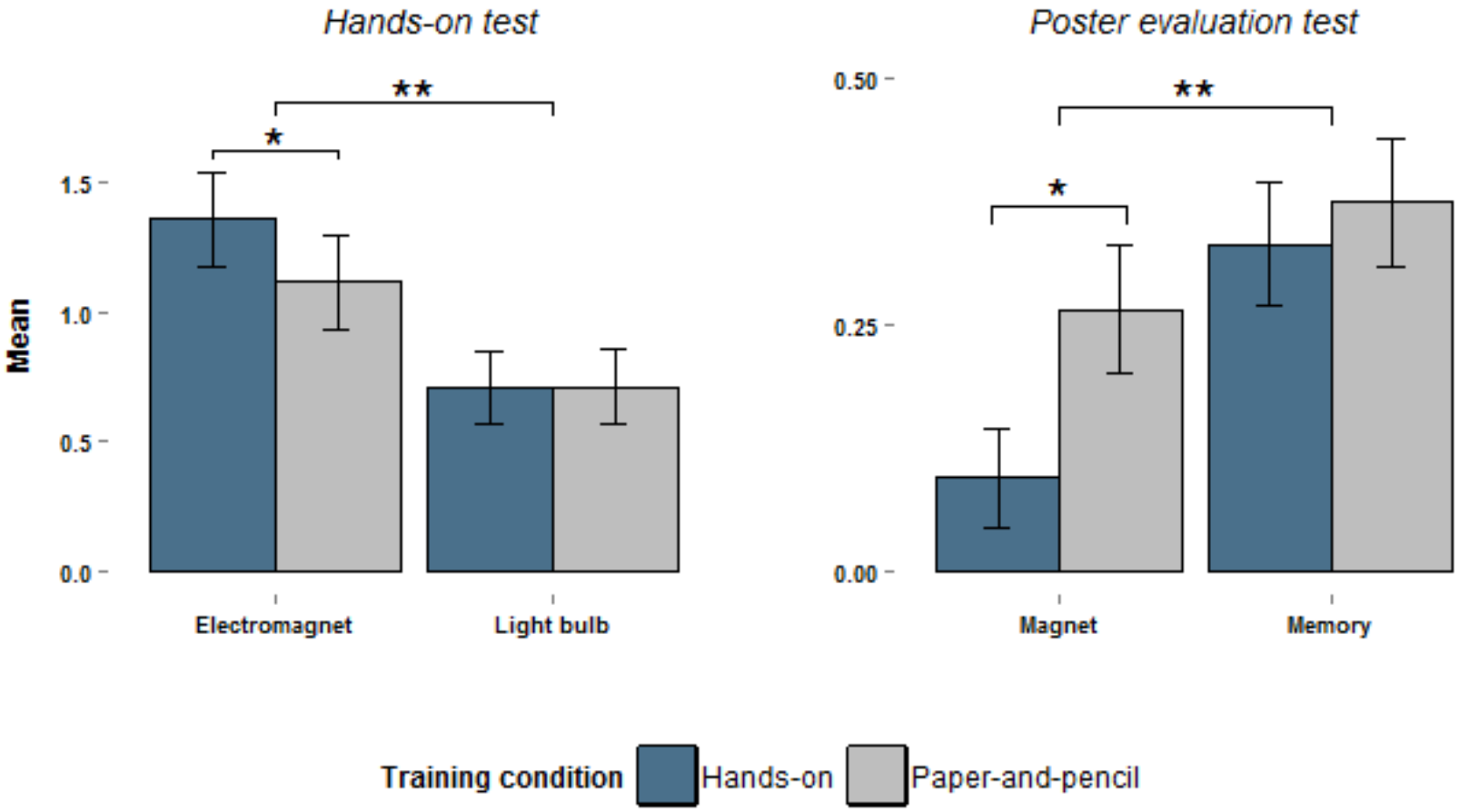
Results:



Results


CVS MC test
Content knowledge
Mean
7.5
5.0
2.5
0.0
20
10
0
*
*
*
Pre-
In-between-
Posttest
Pre-
Posttest
Training condition
Hands-on
Paper-and-pencil

Results


Hands-on test
Poster evaluation test
Mean
1.5
1.0
0.5
0.0
0.50
0.25
0.00
★
★★
Electromagnet
Light bulb
Magnet
Memory
Training condition
Hands-on
Paper-and-pencil

Discussion

What students learn from hands-on activities?

Nothing unique?!

→Comparing hands-on to virtual training tasks

(Klahr, Triona & Williams, 2007; Triona & Klahr, 2003)

Discussion

1)Theoretical implication

➔Hands-on task are neither beneficial nor obstructive

➔CVS is an non-manual skill

➔Cognitive manipulation of variables is important

2) Implication for science education:

➔Hands-on as well as paper-and-pencil support learning of CVS

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Thank You!

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Materials

Training Condition	Task 1 Coils		Task 2 Core Material		Task 3 Current	
Hands-on	Note that the presented expt. is confounded	Plan/ sketch a better expt.	Plan /sketch plus run expt.	Interpret the expt.	Plan/ sketch plus run expt.	Interpret the expt.
Paper-and-pencil	Note that the presented expt. is confounded	Plan/ sketch a better expt.	Plan/ sketch expt. only	Interpret a photo of an expt.	Plan/ sketch expt. only	Interpret a photo of an expt.

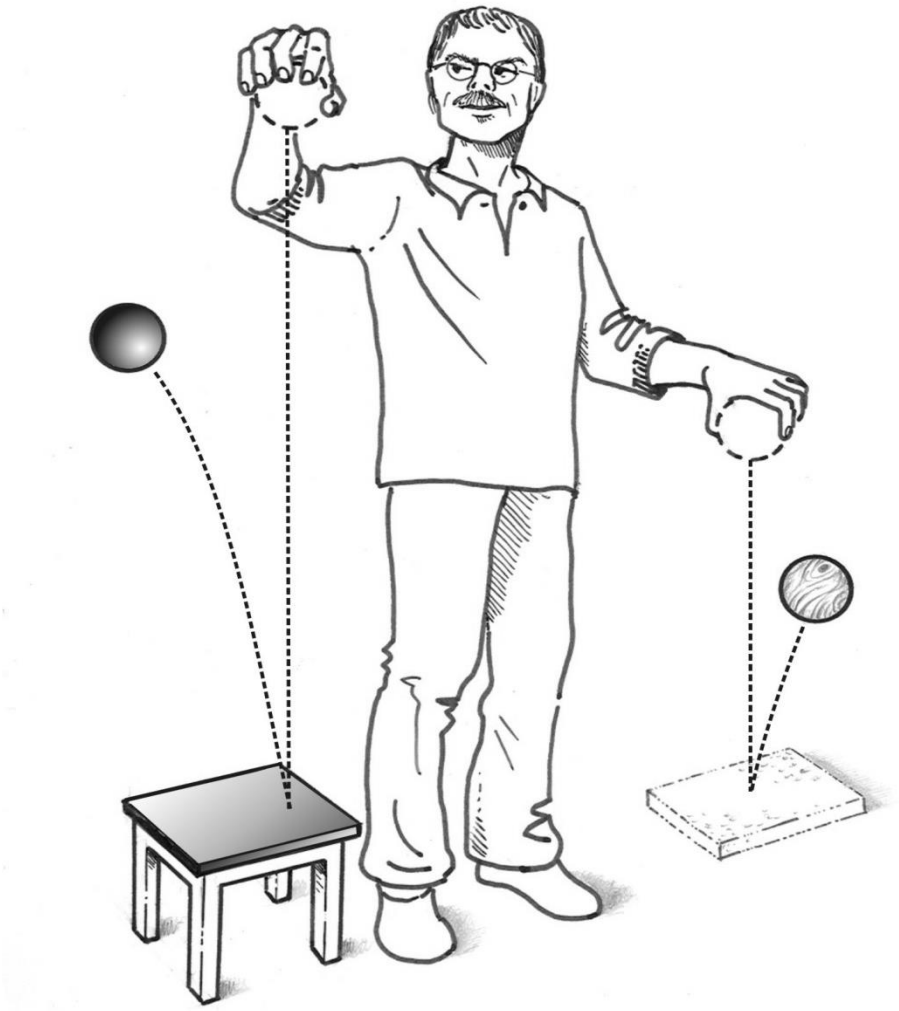
Materials

Comparison of hands-on and paper-and-pencil materials

	Hands-on	Paper-and-pencil
Content	identical	
Tasks	identical	
Number of Tasks	identical	
Source of Information	Experiment	Photo
Number of solved tasks	different	
Required content knowledge	Circuits + CVS	CVS
Manual skills	Setup of the circuits & manipulation of Variables	No
Quality of the information	Depend on experiments	Default by Photos

Materials

Cognitive Conflict



Lawson & Wollmann (1976)

Materials

Experiments

Paper-and-pencil

Lillie's hypotheses: The force of an electromagnet depends on the current.

Please run an experiment to prove Lillie's hypotheses. Take notes of all your results and your experimental set-up.

Our results:

Lilly and David did the following experiment:

What did you found-out about Lillie's hypotheses?

What did Lilly an David found out?

	Lillie's hypotheses is correct. The force of an electromagnet depends on the current..
	Lillie's hypotheses is wrong. The force of an electromagnet does not depend on the current..

Test Instruments

CVS Poster test

Poster A

Who has the better memory? Girls or boys?

Hypotheses

I think girls have a better memory than boys because girls pay more attention to details than boys.

Sampel

- 19 girls (8th graders)
- 17 boys (6th graders)

Procedure:

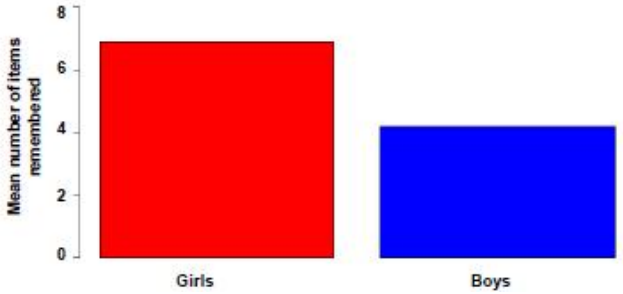
1. I showed the boys and girls 8 items to remember an read out their names loud.
2. The participants should writhe down the name of each item on a piece of paper. They had 20 sec. for each item.
3. Than I toke the notes and poster away.
4. Next the participants wrote down the names of each item they remember.
5. I counted the correct names and draw a graph.

Conclusion

Girls have a better memory than boys.

Items

Results:



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