Problem-Based Learning
What, when, how?

Dr. Lisette Wijnia – May 26, 2017

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Today

- Problem-Based Learning
  - What is it?
  - Origin
  - Characteristics
- Empirical research on Problem-Based Learning

Definitions of PBL

- “The learning that results from the process of students working together toward the understanding or resolution of a problem” (Barrows & Tamblyn, 1980)

- “PBL = instructional method characterized by the use of problems as a context for students to learn problem-solving skills and acquire knowledge” (Albanese & Mitchell, 1993)

- “PBL = approach to structuring the curriculum which involves confronting students with problems from practice which provide a stimulus for learning” (Boud & Feletti, 1997)

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PBL = **Student**-Centred

- Student has central position in PBL

  → does not rely on information transmission, but active participation

- Stems from a constructivist view on learning:

  → focus on students' learning process

  → active knowledge construction instead of passive knowledge consumption

Example of a **Problem**

McCloskey (1980) asked students to indicate the trajectory a package that falls out of an airplane would follow. Most students gave the wrong answer, although they all had physics classes. Which option would you choose and why?

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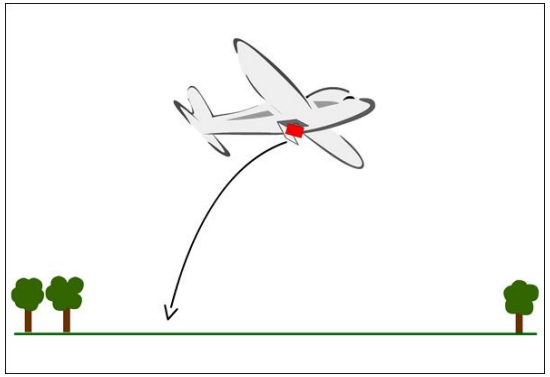

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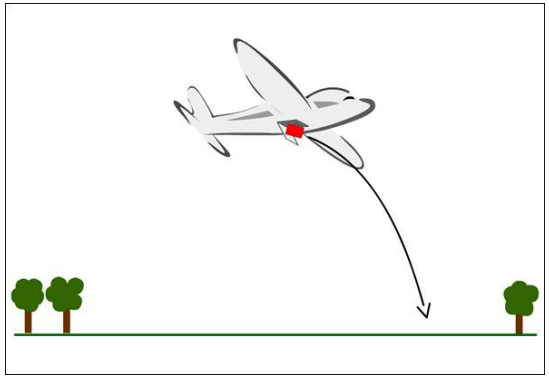

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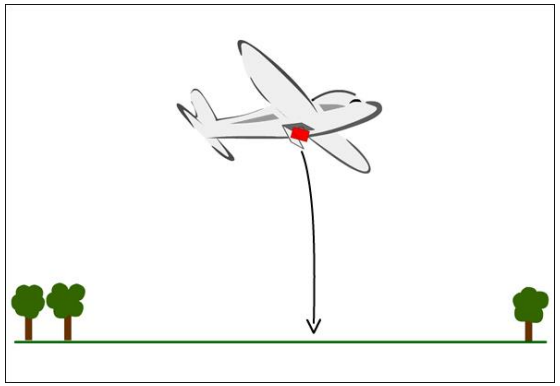


What Happens in PBL? → **Process**

- Together with fellow-students in a group meeting, led by a tutor
- Read the problem at-hand

  → 1. Difficult words / unfamiliar terms are clarified
- We ask ourselves: What is the problem?

  → 2. Define the problem
- We think of possible explanations for the problem

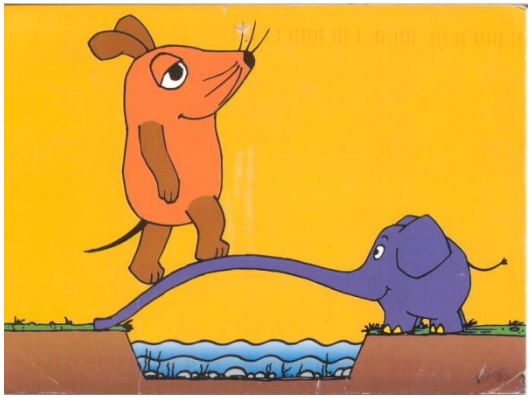
  → 3. Brainstorm
- We elaborate on these explanations

  → 4. Problem analysis
- We decide on the things we need to explore further

  → 5. Formulate learning goals
- We go to the library or to the electronic learning environment

  → 6. Self-study
- We share the findings with each other

  → 7. Reporting phase



Applied to Our Problem

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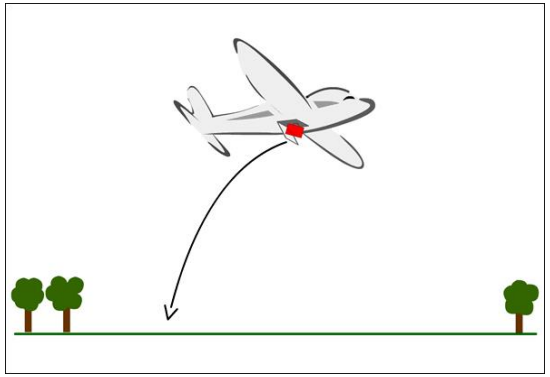

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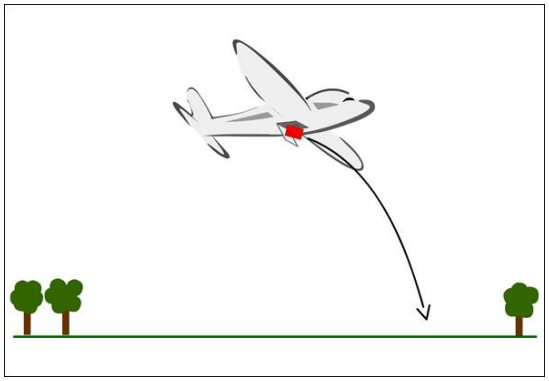

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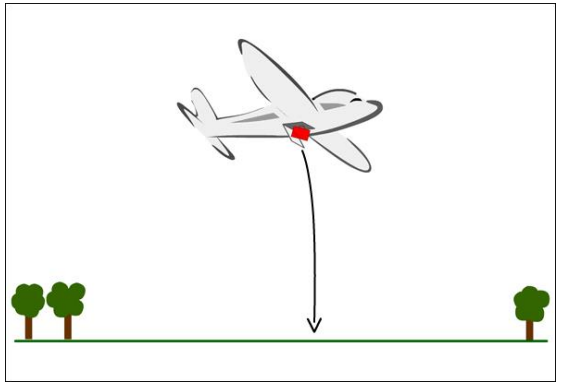
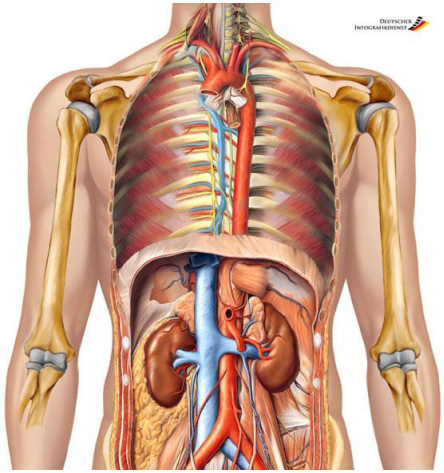


Possible learning issues that will direct students' self-study activities:

- What misconceptions do people have with respect to force and movement ?
- What are these misconceptions based on?
- Why are misconceptions so difficult to change, despite physics courses?

The Origin of PBL

- End '60s, McMaster University in Canada
- Professors noticed problem 1st-year medical students:
  → great difficulty with courses of anatomy, biochemistry, & physiology
  → relevance?



- Also problems with seniors
  → applying knowledge in internships
  → keeping up-to-date: knowledge expires
- Idea to use realistic medical problems in education

PBL Innovative?

- The idea to use “problems” or “cases” in education ≠ new
- New: Moment of presenting these problems
- In PBL: the problem is the **starting point**, before all other curriculum input (↔ case-based learning)
- By starting with the problem:

  → allow to *activate prior knowledge*

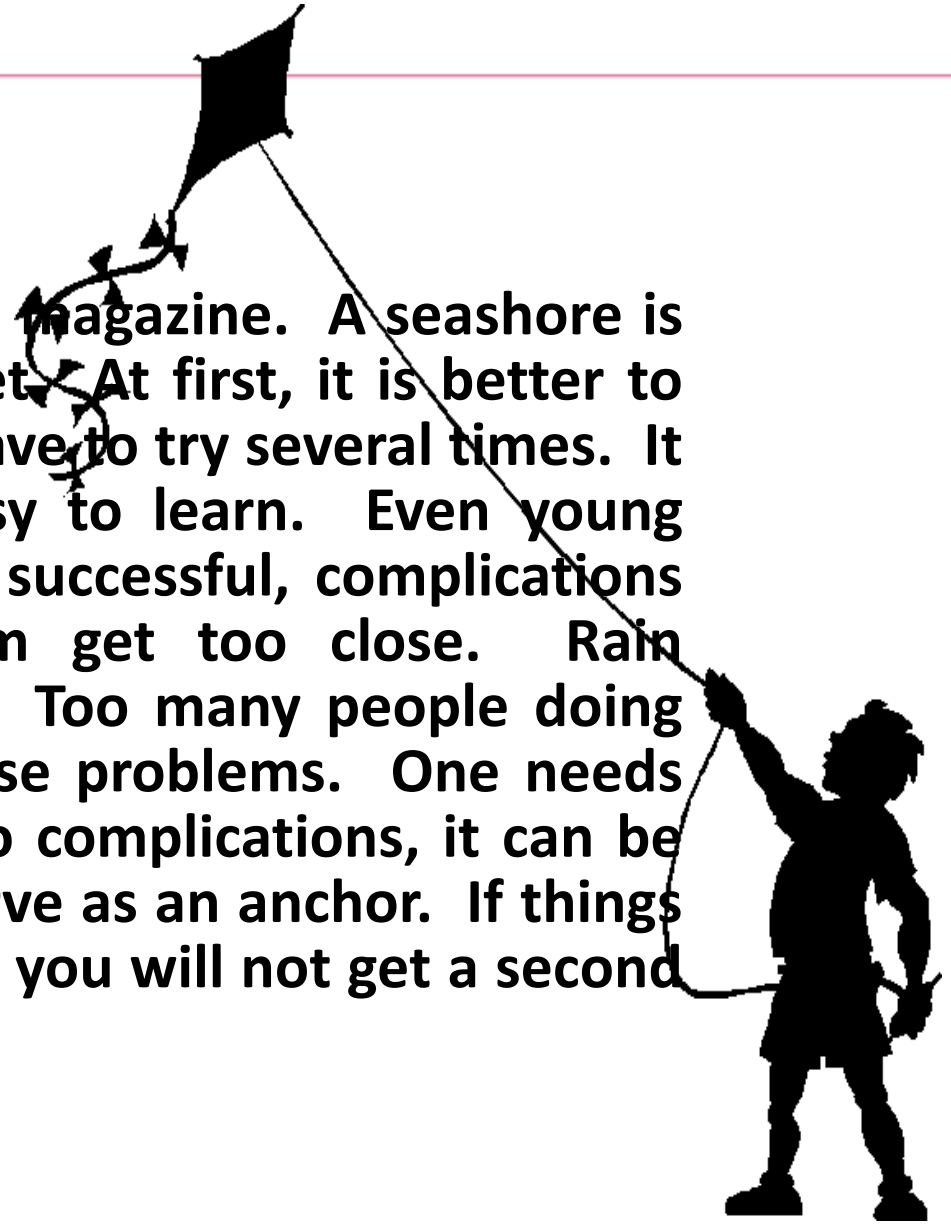
  → opportunity to discover *knowledge gaps*

  → put learning in a *meaningful context* from the start

An Example

A newspaper is better than a magazine. A seashore is a better place than the street. At first, it is better to run than to walk. You may have to try several times. It takes some skill but it's easy to learn. Even young children can enjoy it. Once successful, complications are minimal. Birds seldom get too close. Rain however, soaks in very fast. Too many people doing the same thing can also cause problems. One needs lots of room. If there are no complications, it can be very peaceful. A rock will serve as an anchor. If things break loose from it, however, you will not get a second chance.

Flying a Kite



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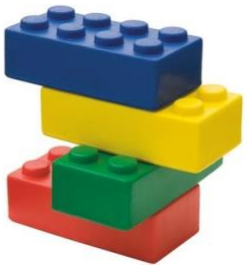
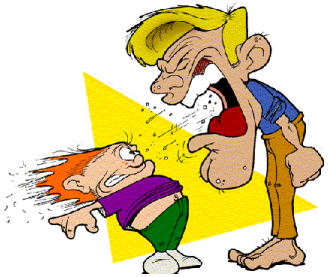
The Problem in PBL

- Embedded in a realistic context
  → e.g. future profession



- Builds on existing knowledge



- Elicits discussion
- Stimulates self-study

- Enhances the integration of knowledge
  → seeing the bigger picture

Integration of knowledge

- Learning = selecting, organizing & integrating information with prior knowledge
- RTLNBCZDFCNNBBCARD
- RTL NBC ZDF CNN BBC ARD

The Degraded Text

Marianne Vermeer is a university professor in educational psychol
In much of her own teaching, she uses chapters from academic b
and journal articles. She carefully selects those articles and gat
them in a "reader". The articles must be well-structured and sh
coherent writing style, because it is well-known that organi
coherent texts are easier to remember than disorganized, incohe
texts.
For her fourth-year elective course, "Memory - Capita Selecta",
Marianne composed such a reader. One of the articles in this reade
presenting a particularly interesting study. A popular theory about
human memory, studied before by her students, is clearly rejected
the results of this study. In the examination for the course, an oper
question is posed about this study. Students are required to relate
presented results to the human memory theory that is questioned,
and explain in their own words why the reported results are not in
agreement with this theory.

PBL is…

Other features of PBL I

- Teacher = "guide on the side" not "sage on the stage"
- Education in courses, 2 meetings/week:

  rythm, structure → micro-deadlining

- Organization of the educational activities around the students' learning process → focus on tutorial meetings, lectures are limited, sufficient time for self-study
- In-between tutorial groups, students work independently

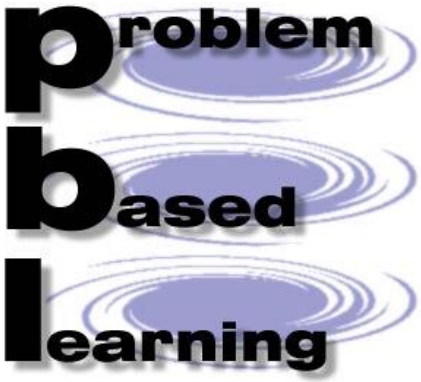
  → *self-directed learning* (plan, monitor, adjust)
- Not 1 handbook, but rich variety in learning resources

  → integrating different points of view

Other features of PBL II

- Periodical assessment → also formative: How am I doing?

- Besides knowledge acquisition,
  explicit attention for skills and attitudes
  → some skills automatically trained
  (e.g., collaboration & communication skills)



- Strong control on the quality of the educational activities
  (evaluation of the program by students)

PBL's Siblings

- **Project-based of project-centered learning**:

  - *more student-centered* than PBL, students can give own input

  - investigate an issue collaboratively, but also make an *end product* (e.g., website, presentation, report,...)

  - tutor facilitates, also consult multiple learning resources

- **Case-based learning**

  - students *prepare a case* at home (case is NOT starting point)

  - ask questions during the group meeting, tutor facilitates

- **Inquiry- or Enquiry-based learning**

  - often seen in science education, starting point = ? or situation

  - ask *teacher (= expert)* questions & formulate hypotheses (H's)

  - seek evidence for H's by gathering and processing data

  - evaluate conclusions in the group

Have the expectations been met?

Previous Research

- Many studies on experiences with (implementing) PBL, student satisfaction & perceptions
- Empirical evidence for effects of PBL on **knowledge retention** & **comprehension** = rather scarce
- Several studies, which in sum show that:

  → Traditional students better on immediate knowledge tests

  → PBL students seem to remember more over time (i.e., better long-term retention)

  → PBL students better on application of knowledge (in ≠ disciplines)

  → PBL students better on items in context (e.g., clinical cases)

But...

- PBL critics: quality of PBL effect studies = poor
  → Relying on self-report, focus on experiences with PBL, self-selection effect when studying existing curricula (i.e., no randomization), no control groups

- Some studies answered the call for more controlled experiments in PBL research
  → Capon & Kuhn (2004): within-subjects, PBL vs lecture/discussion. Results: after 6 weeks no ≠, after 12 weeks PBL better
  → Pease & Kuhn (2011): longer instruction periods + greater scope & complexity of concepts. Results: PBL better
  → Sendag & Odabasi (2009): online, teacher-led vs PBL, MC test, no ≠

A PBL Effect Study (Sofie Loyens)

- Experimental approach to test PBL effects
- 3 groups: PBL, lecture, self-study (control)
- All participants familiar with 3 formats
- Quantitative (free recall) & qualitative (comprehension) effects of PBL
  → type of assessment crucial (Gijbels et al., 2005; Walker & Leary, 2009)
- Tested immediately & after 1 week
  → time of assessment crucial in prior studies (Capon & Kuhn, 2004; Dochy et al., 2003)

Method

- **Participants:**
  - 66 first-year PBL Ψ students
  - Random assignment to PBL (*n*=21), lecture (*n*=24) or self-study (*n*= 21)

- **Materials:**
  - Study text about constructivism: definitions, historical overview, different types, common ground in different types, applications in educational practice (10 pages, 4629 words)
  - Constructivism = study topic in 1st year, not covered yet
  - Test: free recall + comprehension (9 MC questions + 1 open-ended)

Design

PBL-group (*n* = 21)	Lecture-group (*n* = 24)	Self-study group (*n* = 21)
* Participants received an ill-structured problem about constructivist learning + had a 15 min pre-discussion of this problem with 10 fellow-participants * Self-study of text about constructivist learning (30 min) * Group discussion of text about constructivist learning (30 min)	*Participants received a lecture about constructivist learning consisting of all information of the self-study text about constructivist learning, presented on 50 PowerPoint slides that students received at the beginning of the lecture (75 min) *Students were allowed to make notes	* Participants had to study the text about constructivist learning individually (75 min)

Results

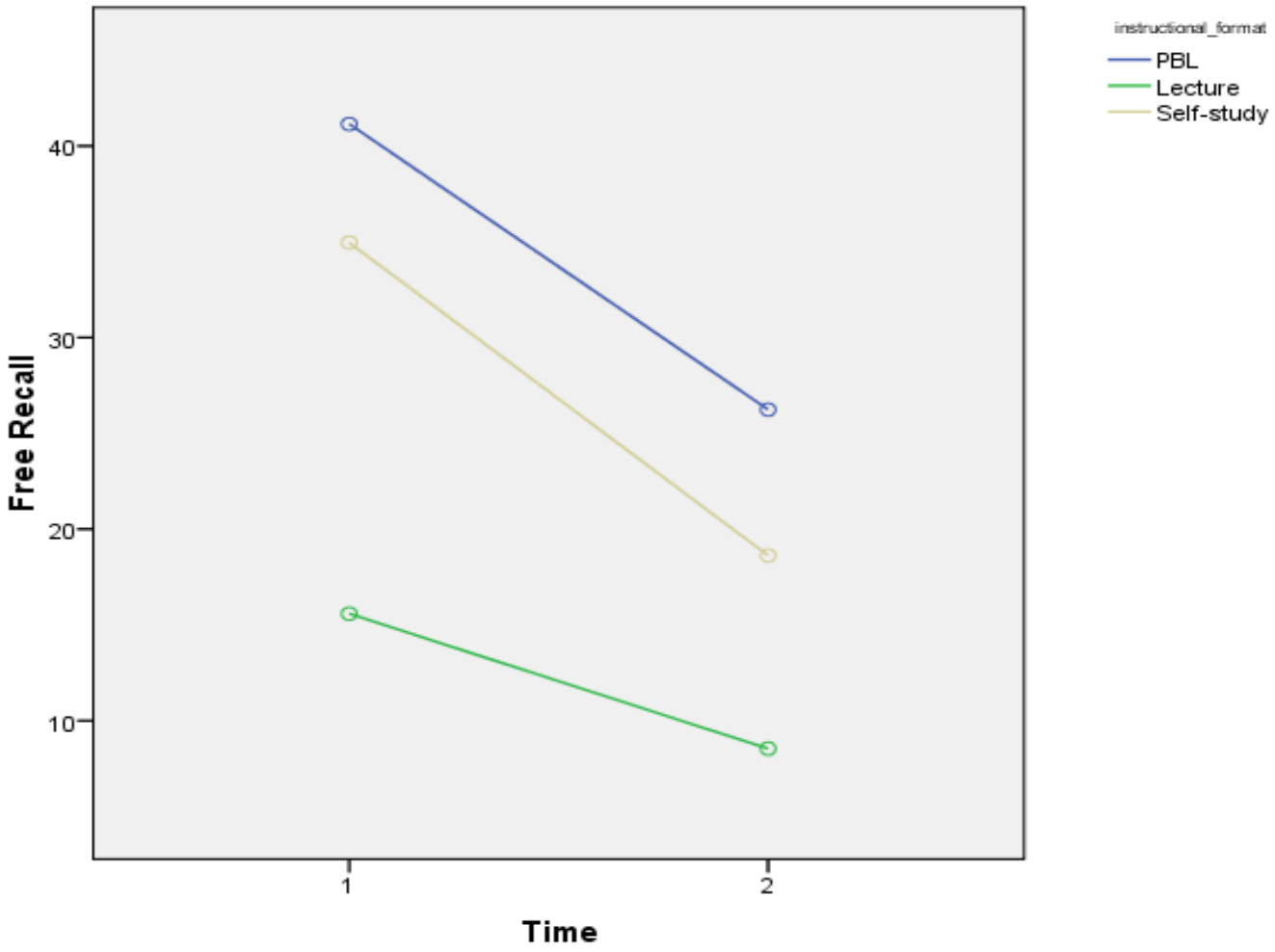
- 2 RM ANOVA's: instructional format (PBL, lecture, self-study) as BS factor + time (immediate & after 1 week) as WS factor

- Sign main effect of time (scores ↓ over time) for
  - free recall [$F(1,63) = 127.48$, $p < .01$, partial $\eta^2 = .67$]
  - comprehension [$F(1,63) = 11.62$, $p < .05$, partial $\eta^2 = .16$]

- Sign main effect of instructional format for
  - free recall [$F(2,63) = 23.31$, $p < .01$, partial $\eta^2 = .43$]
  - comprehension [$F(2,63) = 11.42$, $p < .01$, partial $\eta^2 = .27$]

- Sign interaction effects for
  - free recall [$F(2,63) = 6.82$, $p < .05$, partial $\eta^2 = .18$]
  - comprehension [$F(2,63) = 6.10$, $p < .05$, partial $\eta^2 = .16$]

Free recall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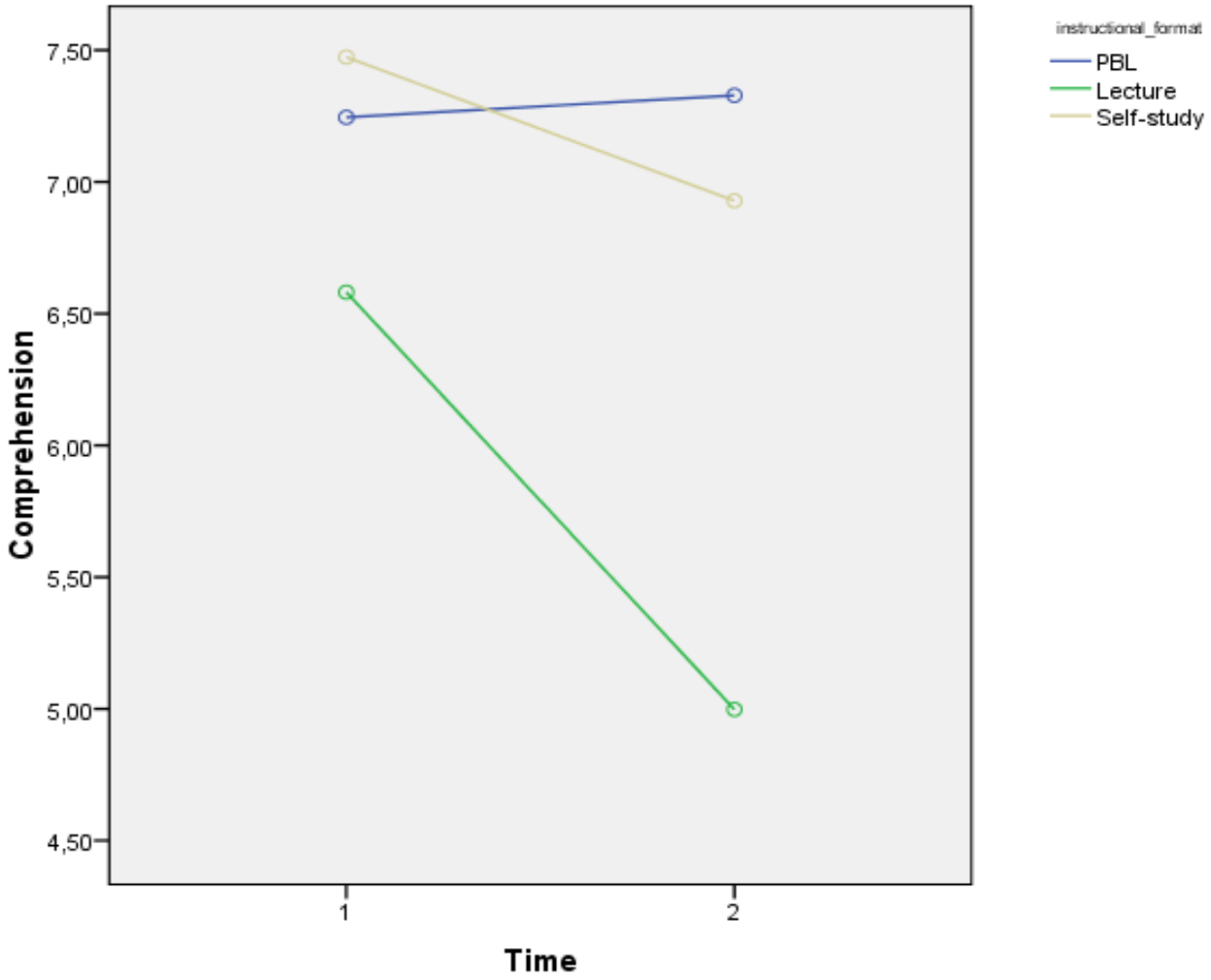
PBL
Lecture
Self-study
Free Recall
40
30
20
10
1
2
Time

Comprehension



What do these results imply?

- Beneficial effects of PBL (both quantitative & qualitative) compared to receiving a lecture

- In line with previous research: trend to better retention over time (only qualitatively)

- Better organization of acquired knowledge?
  $\rightarrow$ effect not found for pure recall of information

- However, no ≠ between PBL & self-study $\rightarrow$ evidence for negative "effects" of lectures

But...MY lectures are the best!

- **Time available for self-study**: only predictor of study duration and % graduates (Schmidt, van der Molen, te Winkel, & Wijnen, 2009)

  → Numbers of lectures negatively correlated with students' self-study time and % graduates & positively with study duration

  → "Students learn more by being taught less"

But...PBL is expensive!

- Indeed, you need separate rooms, tutors, ... & effects on knowledge are not unequivocal

- Comparisons between curricula not always fair because of lower drop-out rates
  → more students graduate in PBL,
  not only the most excellent students
  (Schmidt, van der Molen, te Winkel, & Wijnen, 2009)

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- Comparison lecture-based, PBL & mixed in 1 year
  → PBL students earned more study credits (EC)
  (Severiens & Schmidt, 2009)

But...PBL is expensive!

- **Graduation rates**

  → 8% more graduates in student-centered curricula

  → it took students on average 5 months less time to graduate in student-centered curricula

  (Schmidt, Cohen-Schotanus, & Arends, 2009)

- Less drop-out & students graduating faster also **outside the Netherlands**

  (Burch et al., 2007; Iputo & Kwizera, 2005)

- Criticisms about costs of PBL strange, since faster graduation & less drop-out → **monetary gains**

But...group learning is inefficient!

- **Collaboration** stimulates discussion and task involvement (Visschers-Pleijers et al., 2006; Van Blankenstein et al., 2011)

  → Analysis of verbal interactions during a tutorial group: 80% of interaction were focused on learning

  most interactions: *cumulative reasoning:* making statements, argumentations & judgments

  → Explanations during tutorial groups: + effects for long-term retention of knowledge

- **Students' professional behavior** (preparation & active participation) during tutorial groups predicted study success (.66)

  → mediated the influence of self-study time on performance

  (Loyens, Rikers, & Schmidt, 2007)

But...SDL is too much to ask!

- Students cannot handle self-directed learning (SDL)

  → SDL will lead to knowledge gaps

  → "They just need to study my book"

- SDL ≠ unguided learning!

- Incorporated in PBL through: formulating their own learning goals, searching information, making a time schedule, monitoring progress

  → WITH guidance of tutor, appropriate training for literature searches, built-in micro-deadlining

- SDL = important, also after graduation, since knowledge has an expiration date: PBL students better able to stay up-to-date with scientific literature (Shin, Haynes, & Johnston, 1993)

But...students get lost in literature!

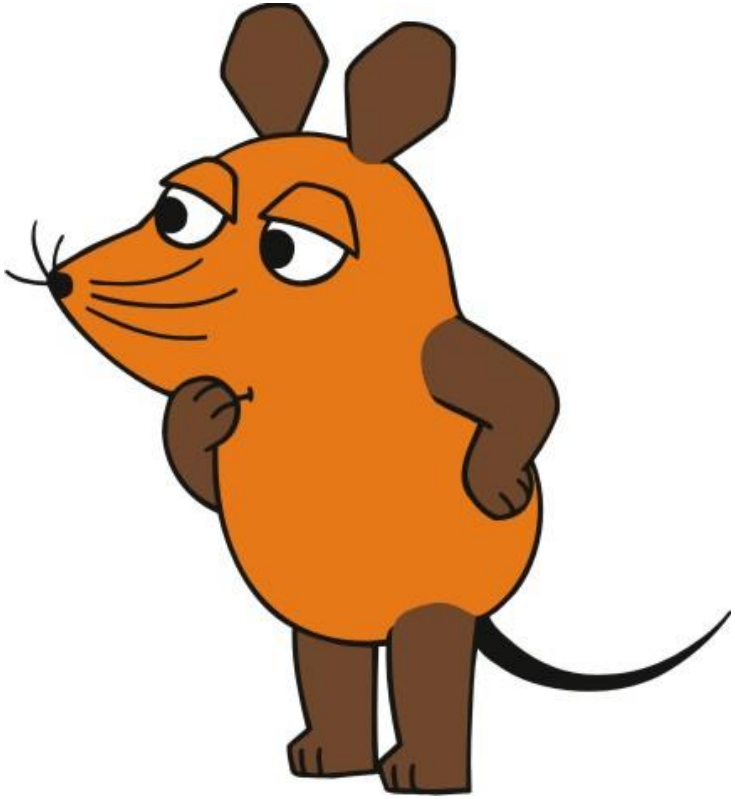
- In first year: restrict the amount of resources (give a list to choose from)
- Choice in resources is more motivating and equallty effective for learning when compared to mandatory resources (Wijnia et al., 2015)
- Courses with more literature resources (hence more freedom of choice): higher grades & trend towards more self-study time (te Winkel et al., 2006)
- PBL students use literature resources more actively & visit library more frequently & longer when compared to “traditinal learning” (Marshall et al., 1993)
- PBL students become more efficient in looking for literature (Williams et al., 1995)

But...students just study for tests!

- By organization of educational activities (micro-deadlining), regular study is a must
- Focus on long-term retention to avoid cramming
- Assessment should be in line with the learning environment & leave room for individual readings
- Limit re-sit exams: the more re-sits, the more procrastination

Thank you!

Tell me, and I will forget.
Show me, and I may remember.
Involve me, and I will understand.



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