A study of spatial reasoning skills in Carpenters' training ... and more!
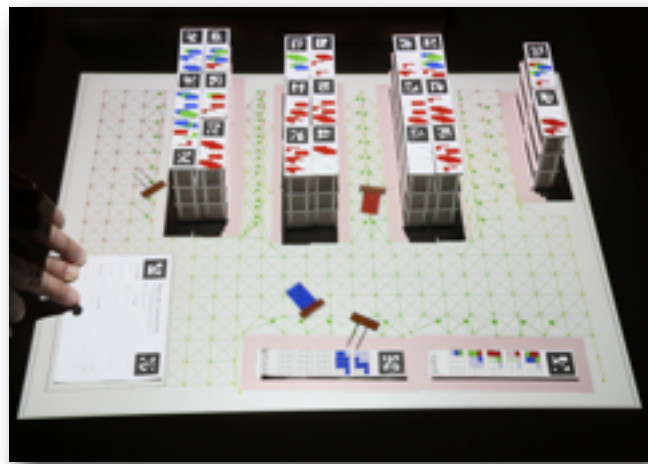
Sébastien Cuendet, Christoph Arn,
Patrick Jermann, Pierre Dillenbourg

EPFL
ÉCOLE POLYTECHNIQUE
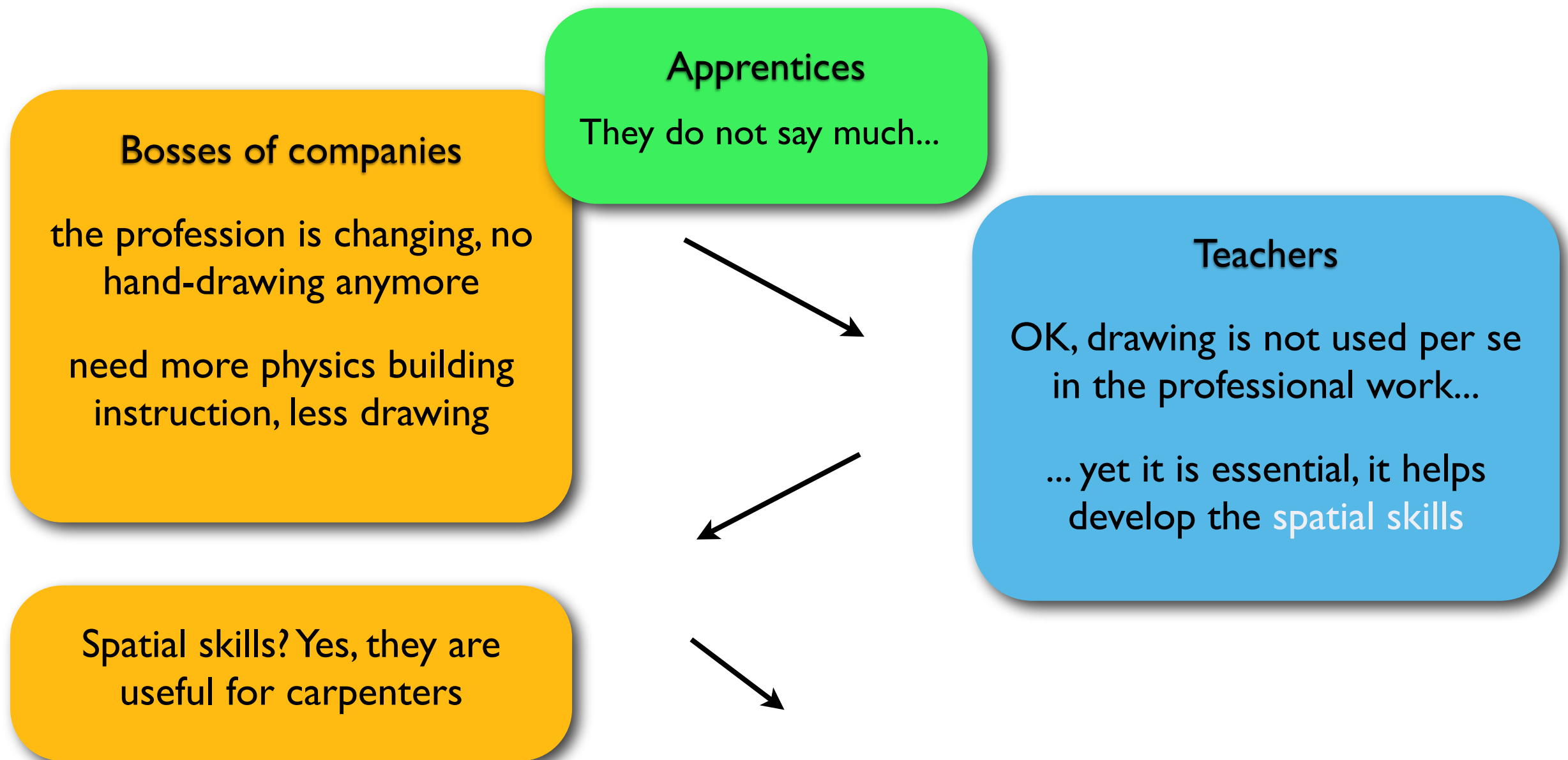FÉDÉRALE DE LAUSANNE

March 23rd 2011

Context

- Logistics environment is great to teach logistics; can we replicate this success with another profession?

- Criteria to choose profession:
  - Different from logistics
  - Many apprentices
  - Motivated teachers and practitioners
- Carpenters fit those criteria

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Field observations

Bosses of companies

the profession is changing, no hand-drawing anymore

need more physics building instruction, less drawing

Apprentices

They do not say much...

Teachers

OK, drawing is not used per se in the professional work...

... yet it is essential, it helps develop the spatial skills

Spatial skills? Yes, they are useful for carpenters

(1) can one train spatial skills?

(2) if so, is drawing an appropriate training mean?

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Spatial skills

- Very widely studied subject since the 1920s in the context of educational technology

- 3 main findings of interest to us:

    - spatial skills are trainable

    - well-developed spatial skills help for some school subjects and professions

    - men are better than women

- No data on carpenter apprentices' spatial skills ⇨ gather our own by testing their spatial skills
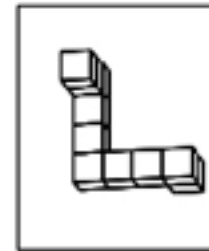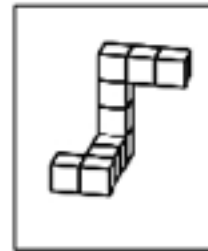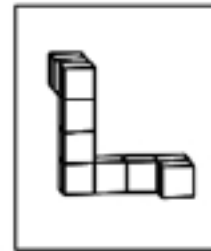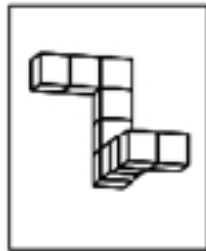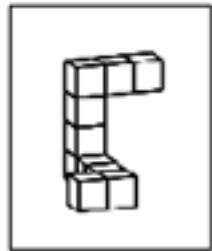
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Purpose of study

(1) Are carpenters's spatial skills better than the other populations'?

(2) Do carpenters's spatial skills improve during their apprenticeship?

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Test settings

- 3 populations: carpenters, logisticians, HS students
  - 726 subjects (440 carp., 153 HS, 133 log.)
  - 628 male subjects
  - 4 years: 0, 1, 2, 3 (only carpenters for year 3)
- Score: z-score average ((x - mean) / stddev)
- 50 questions split in 3 parts:
  - Mental rotation
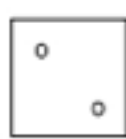 - Paper folding
  - Orthographic projections

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Question types

Mental rotation (24 questions)

Vue de face   Vue de côté

Vue de plan
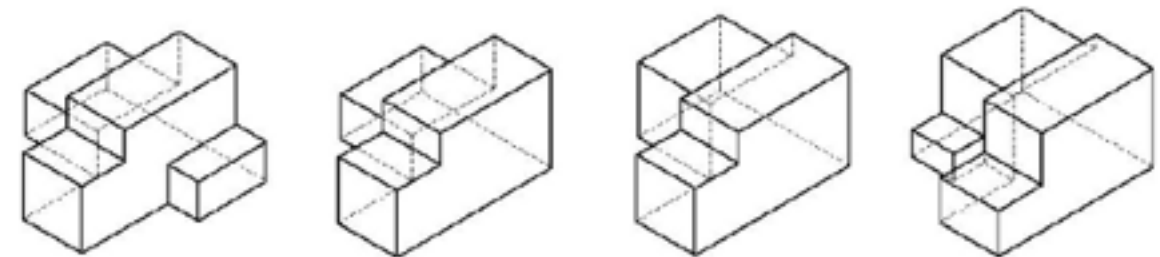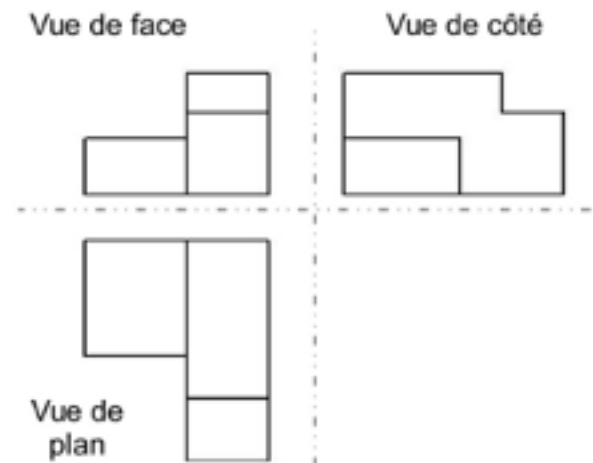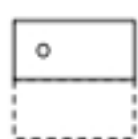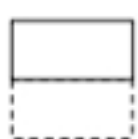
Orthographic projections (6 questions)

Paper folding (20 questions)
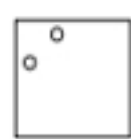
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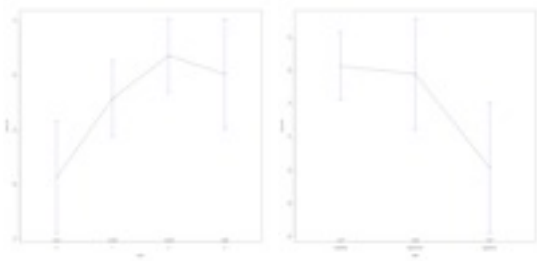
Type comparison

- Better than logisticians

- As good as high school students

- General school level of carpenters is closer to logisticians than high school

⇨ their spatial skills are indeed well developed

z-sco

| n=439 | n=74 | n=115 |
| carpenters | HS students | logisticians |

z-sco

year 0   year 1   year 2

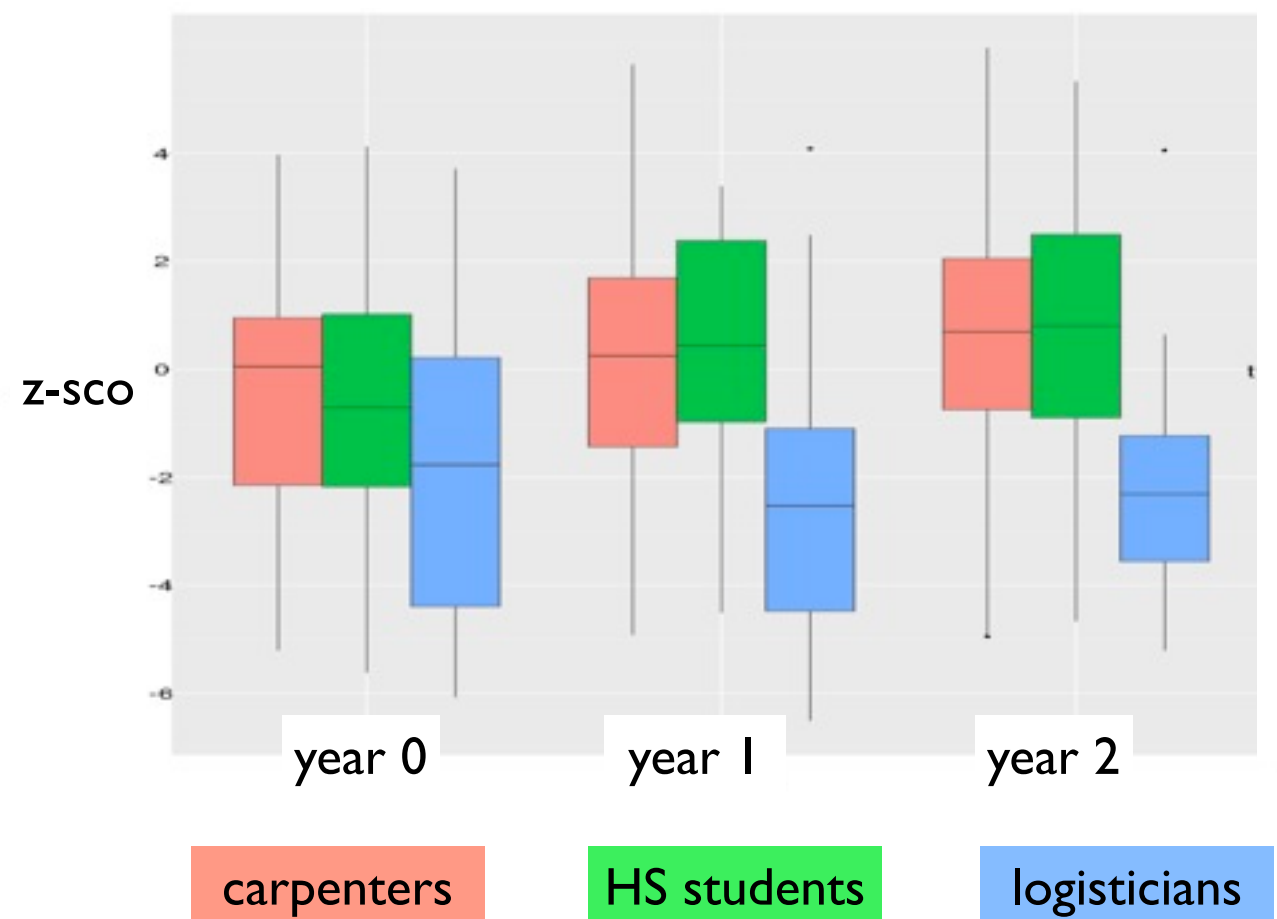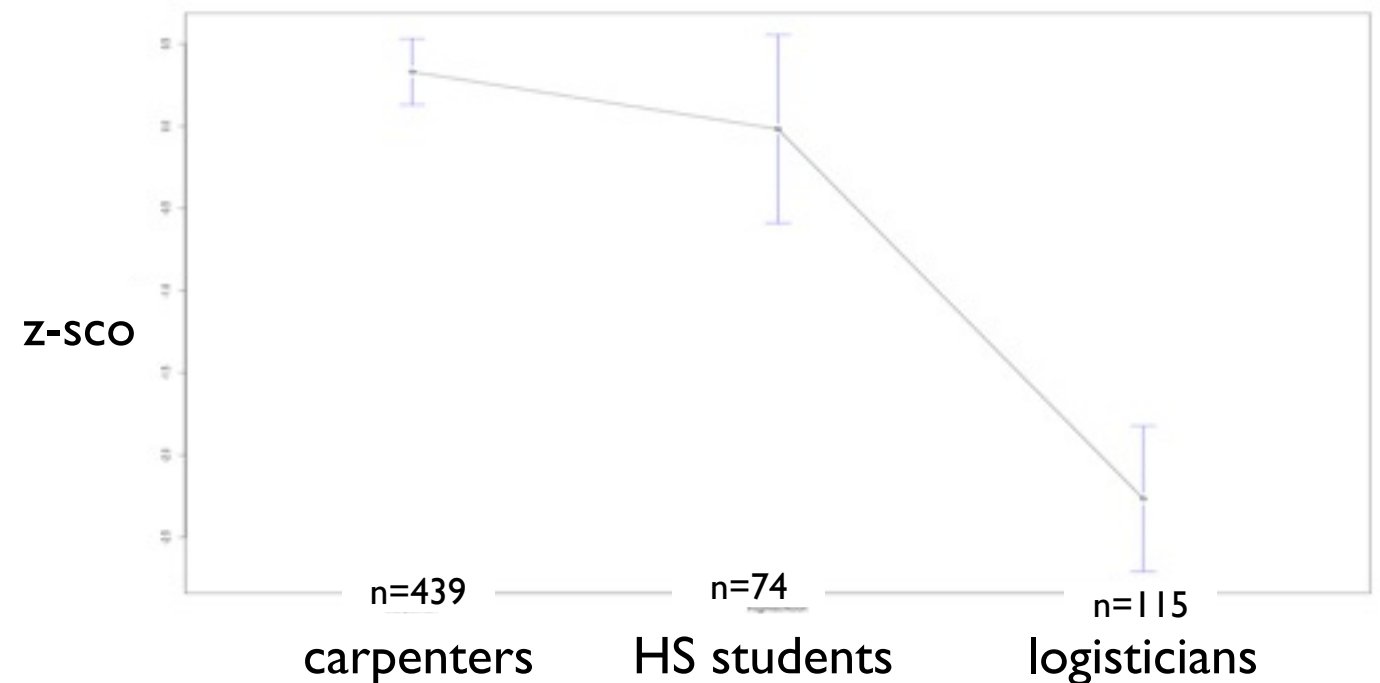carpenters   HS students   logisticians

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Year comparison
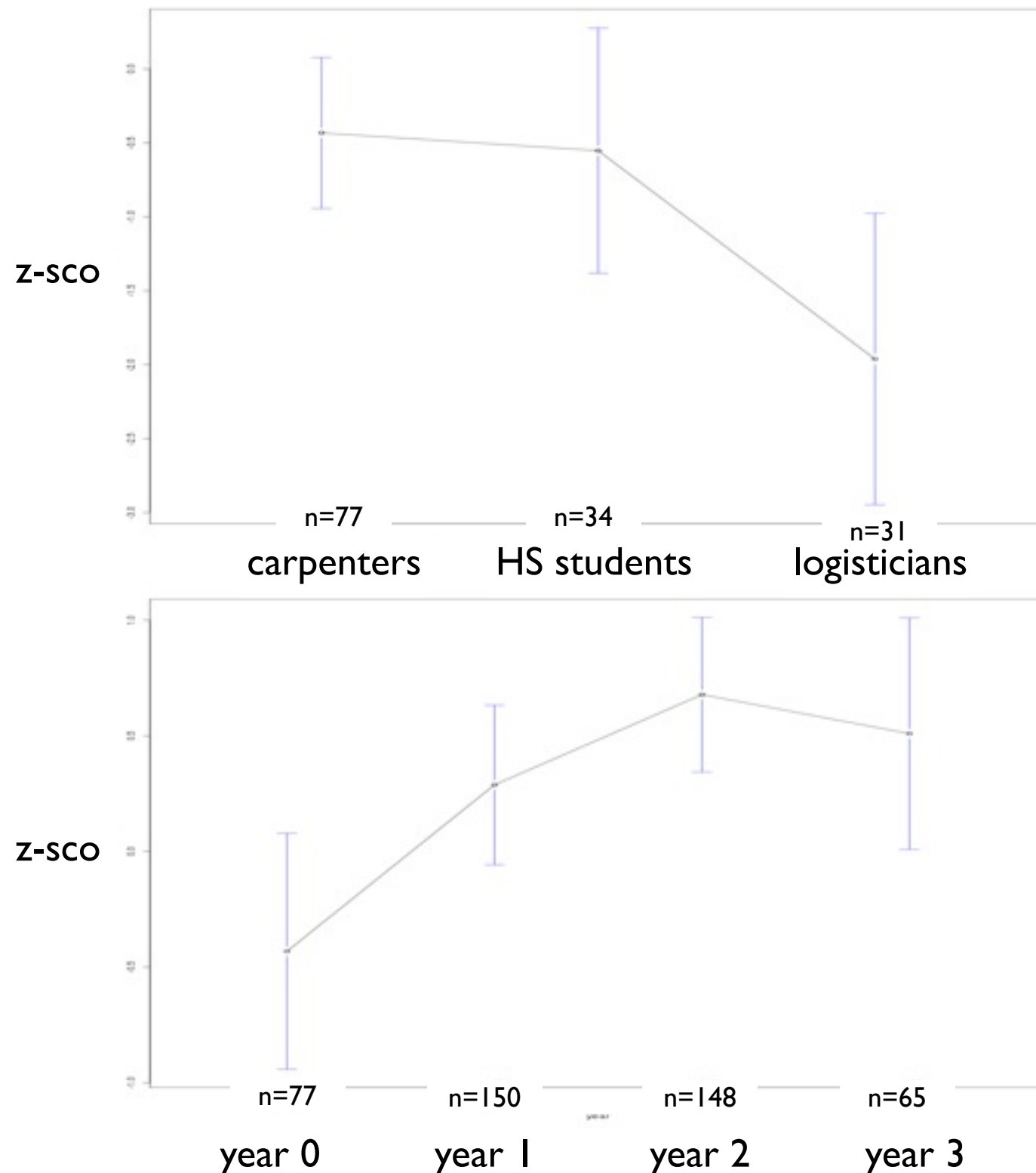
- No year effect
- Two explanations:
  - carpenters are slightly better before they start
  - ceiling effect of the drawing after one year

Intermediary conclusion

- Agreement among practitioners and teachers that spatial skills (SS) are key for carpenters

- Study confirmed that carpenter apprentices have above average SS

  - self-selection (already better before the apprenticeship)

  - SS also improve during their training

- Divergence between practitioners and teachers on how to teach those SS

- Idea: create an environment that would help develop SS by complementing drawing

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September 2010

The goals of the learning tool

Time gain for a greater exploration

Force the apprentices to focus on the cognitively hard things ⇨ increased learning efficiency

Make the 2D-3D transition more intuitive

Be complementary to drawing (same tools, mixed activities)

Make a stronger link between geometry and the profession

How it works

- Tinkerlamp
- 3D tagged blocks
- 3 orthogonal views
- 3D view of the model
- Control via tagged cards

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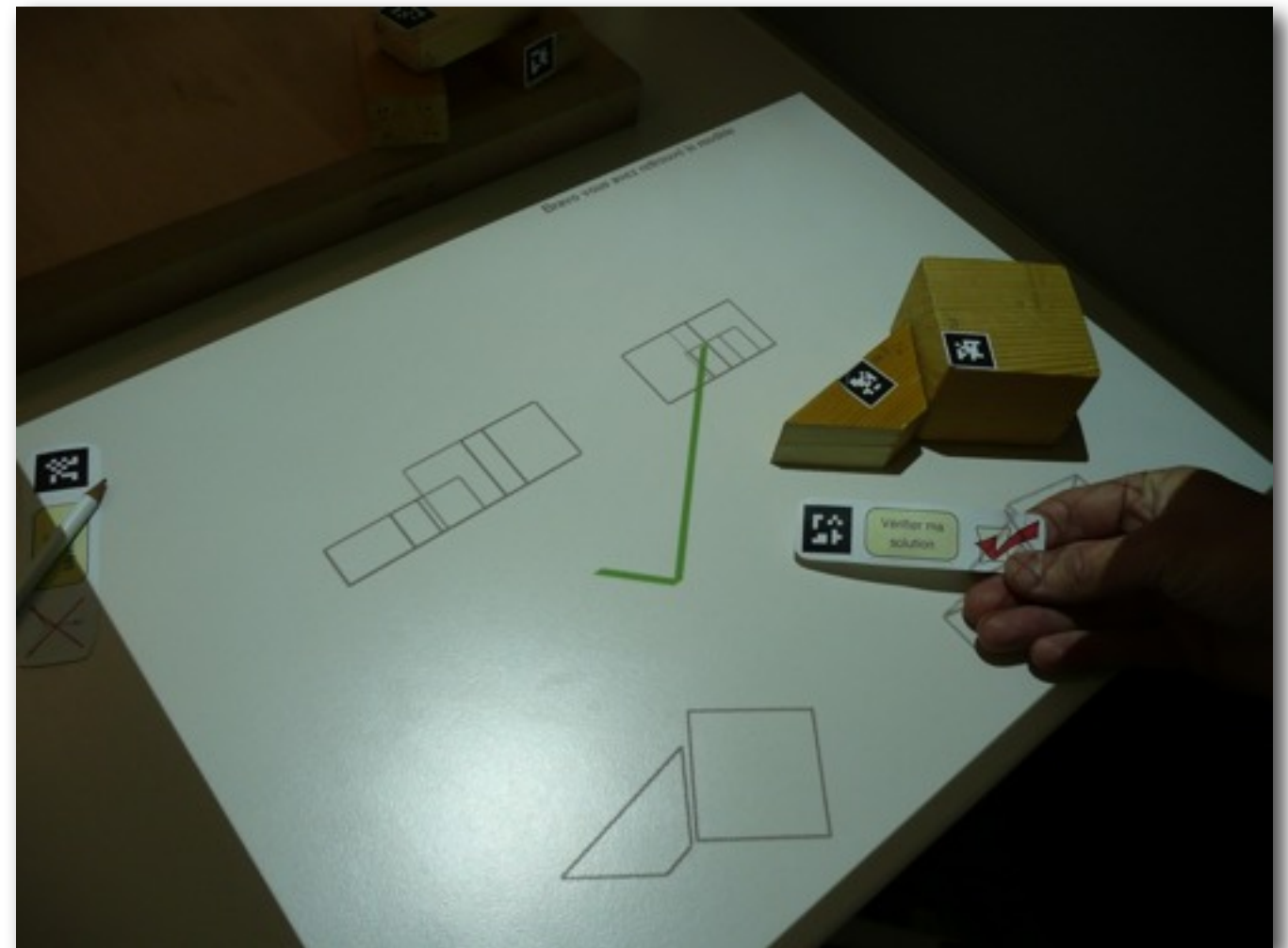
Activities

- Learning activities are built within the Tinkerlamp

- Examples of activities so far:
  1. Model matching
  2. Finding edges selected on the 3D model on each of the 3 projections
  3. Finding the true length of a surface
  4. Detail drawing (épure) of an edge

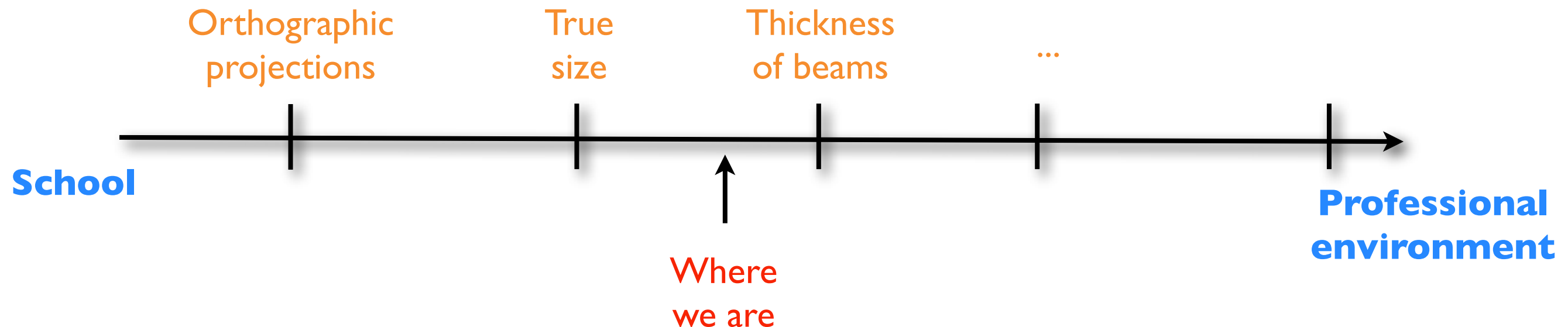Wednesday, March 23, 2011

In the classroom

- 3 levels of interaction:
  - individual
  - group
  - classroom

- Orchestration:
  - done by the teacher
  - organized thanks to the cards and their thoughtful distribution

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Tests / Feedback so far

- Two visits to a school, one more next week
    - took apprentices by group of 1 or 2 sequentially and made them do some of the learning activities
- Teachers are enthusiastic… but still need to be convinced to use it for "real teaching"
- Practitioners are thrilled, they see other domains of application (statics, physics building, …)
- First test in a real classroom environment: end of May 2011

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Conclusions

- Identified a need to familiarize intuitively carpenters with 3D geometry

- Developed a tool to respond to this need

School ———— Orthographic projections ———— True size ———— Thickness of beams ———— ... ———— **Professional environment**

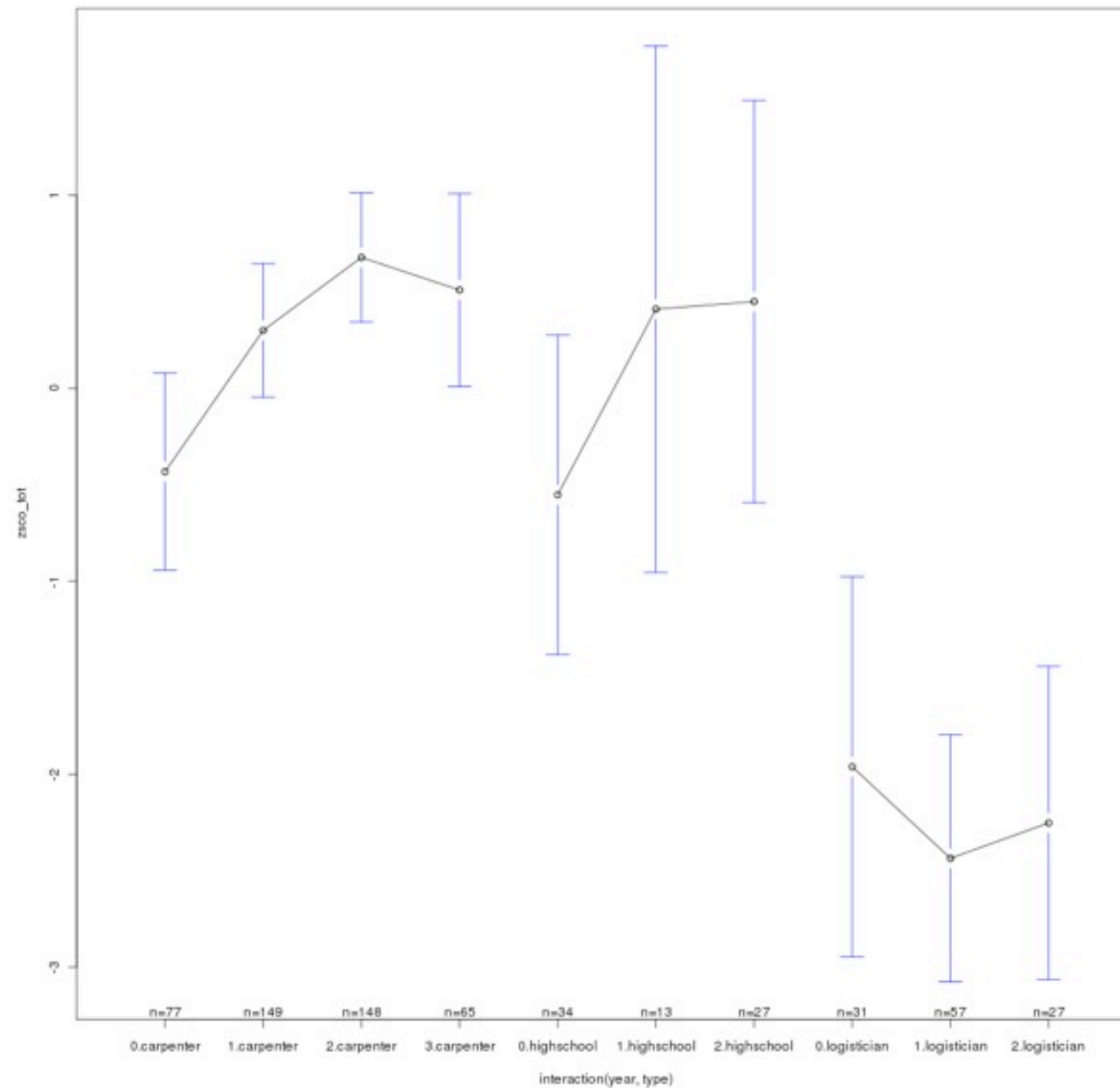Where we are

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Next steps

- Studies in classroom

- Develop missing technical features:

    - depth detection

    - more integration drawing

- Develop more activities

- Integration with CAD (Cadwork, SEMA, ...)

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Thank you for your attention

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Summary of results

Where do apprentices come from?

	VSB	VSG	VSO	Sample
Employés de commerce	11.6%	76.8%	11.6%	69
Logisticiens	2.0%	20.4%	77.6%	49
Menuisiers	5.6%	22.2%	72.2%	36