

SISC

Science In  
Social Context  
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# SCIENCE FOR LIFE!

- **development of a multi-concept instrument to study the impact of socio-scientific issues on students' learning and interest.**

**Mikael Winberg and Britt Lindahl**

# Socio-Scientific Issues (SSI)

The relative absence of right answers, a high degree of autonomy, and 'real world' connection are characteristic of socio-scientific issues that have been suggested to influence the quality of students experiences during learning science (Osborne et al, 2003)

SSI - Good for everyone?

# Possible counter-indications

If there is a mismatch between pupils' beliefs about their own role in learning and the requirements of the situation, they might become de-motivated or frustrated. (Windschitl and Andre 1998; Domin 1999)

Low self-efficacy pupils might perceive challenges and autonomy as threats to self-worth and thus display avoidance behaviours and negative emotions. (Seifert, 2004)

If students are unfamiliar with the work form, it might impose high levels of extrinsic cognitive load on students working memory. (Sweller, van Merriënboer, & Paas, 1998)

Low task value, e.g., indicated by not regarding science as important, might make pupils less inclined to use scientific arguments during SSI, hence learning less science.

# Aims

Aims:

To develop and evaluate an instrument that simultaneously considers the multivariate characteristics of the student, the situation, and learning outcomes.

To examine which personal and/or situational characteristics are the most important to describe variation in pupils' affective/ motivational and cognitive

# The instrument

- Two questionnaires; one distributed before the SSI-work, and one immediately after.
- Items were taken from extant questionnaires ROSE – Attitudes towards school, science in society and school POLLEN ([www.pollen-europa.net](http://www.pollen-europa.net))
  - New items were constructed, based on research on motivation, epistemological

# Before

- **Attitudes toward school and science.**
  - I like school
  - Science and technology can help poor people
- **Beliefs about, and attitudes towards, different ways to learn.**
  - Intelligent pupils do not need to work hard
  - Learning science is about memorizing facts
  - I like to discuss [science] during science class
- **Self efficacy.**
  - I am good at geography
  - I know when I am right
- **Ordinary work forms in science class.**
  - In science class, we have discussions
  - In science class, the teacher talks most of the time

# After

- **Work forms during SSI (what were the actual circumstances?)**
  - I could influence the way the work was conducted
  - We were allowed to formulate our own questions
  - During the work, I occasionally encountered information that did not match my prior knowledge about this [phenomenon]
  - My [class] mates did their share of the work
  - The work was about a current issue
  - We discussed a lot
- **Affective and motivational outcomes**
  - I worked concentratedly with the task
  - What we achieved/learned was important for me.
  - The work was boring
- **Cognitive outcomes**
  - I have learned new facts

# Procedure

Swedish 7-9 grade pupils (N=1488), 809 pupils answered both questionnaires and met the limits for maximum amount of missing data

The data set was cleaned

- Searching for max/min deviations, logical errors, and patterned data indicating spurious answers.

Outliers were detected by Hotellings (95% level) and distance to model (DmodX).

- Outliers were deleted and a new model was calculated, which did not differ from the original one.
- Due to this, and since it is difficult to judge when outlier answers are “wrong”, outliers were included in the subsequent models.

# Procedure (cont.)

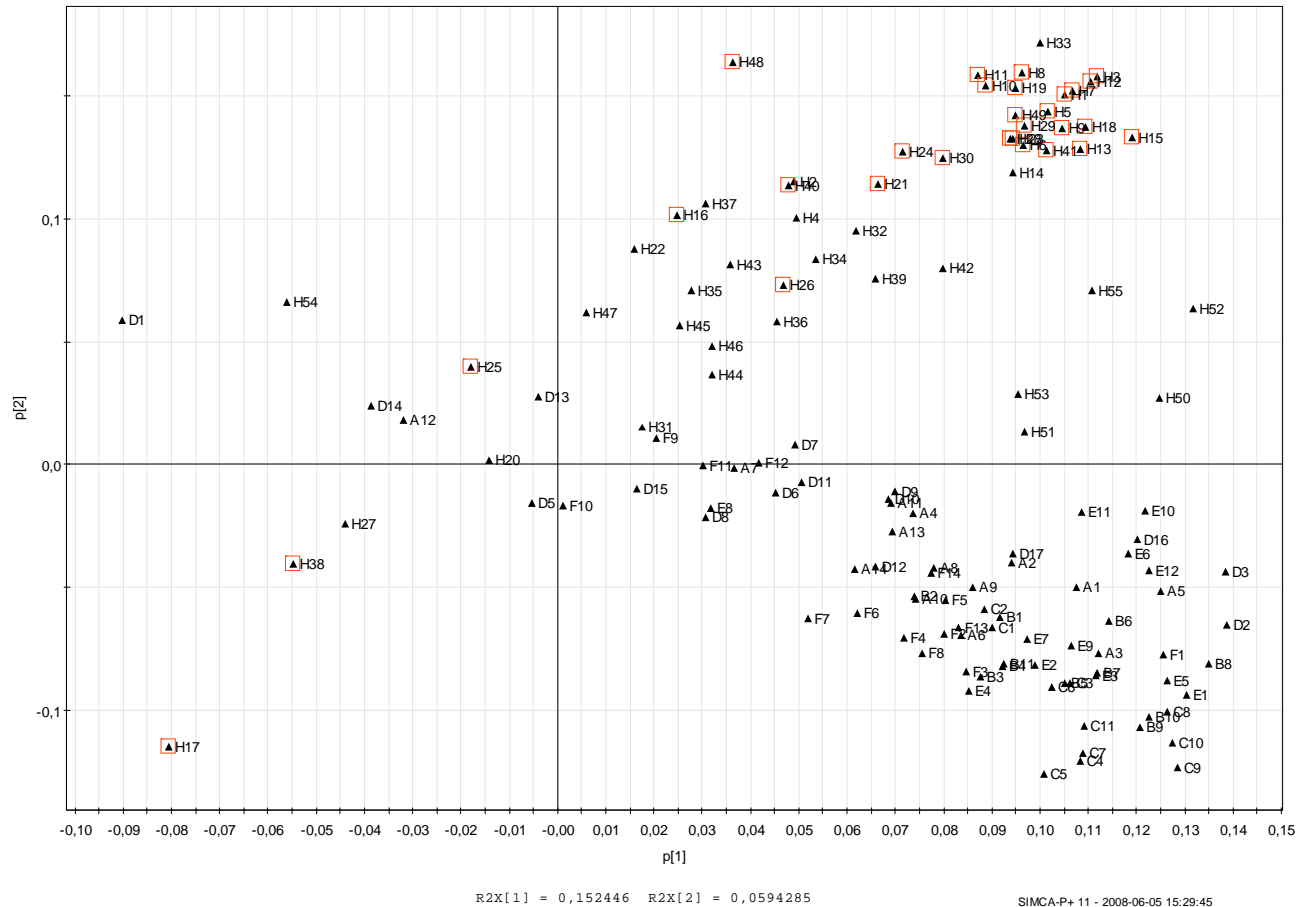
Pupils' responses to questionnaire items were subjected to Principal Component Analysis (PCA) [\(figure 1\)](#)

To increase interpretability, questionnaire items were categorized according to researchers assumptions and PCA analysis was performed on each item-category to assess dimensionality. [\(table 1\)](#)

Once intelligible item-categories had been established, they were complemented by the outcome variables and PLS\* **base models** were

\* Projection to latent structures by means of least squares

# Relations between questionnaire 1 and 2 items (showing only 2 out of 6 components)



# Categorization of questionnaire items

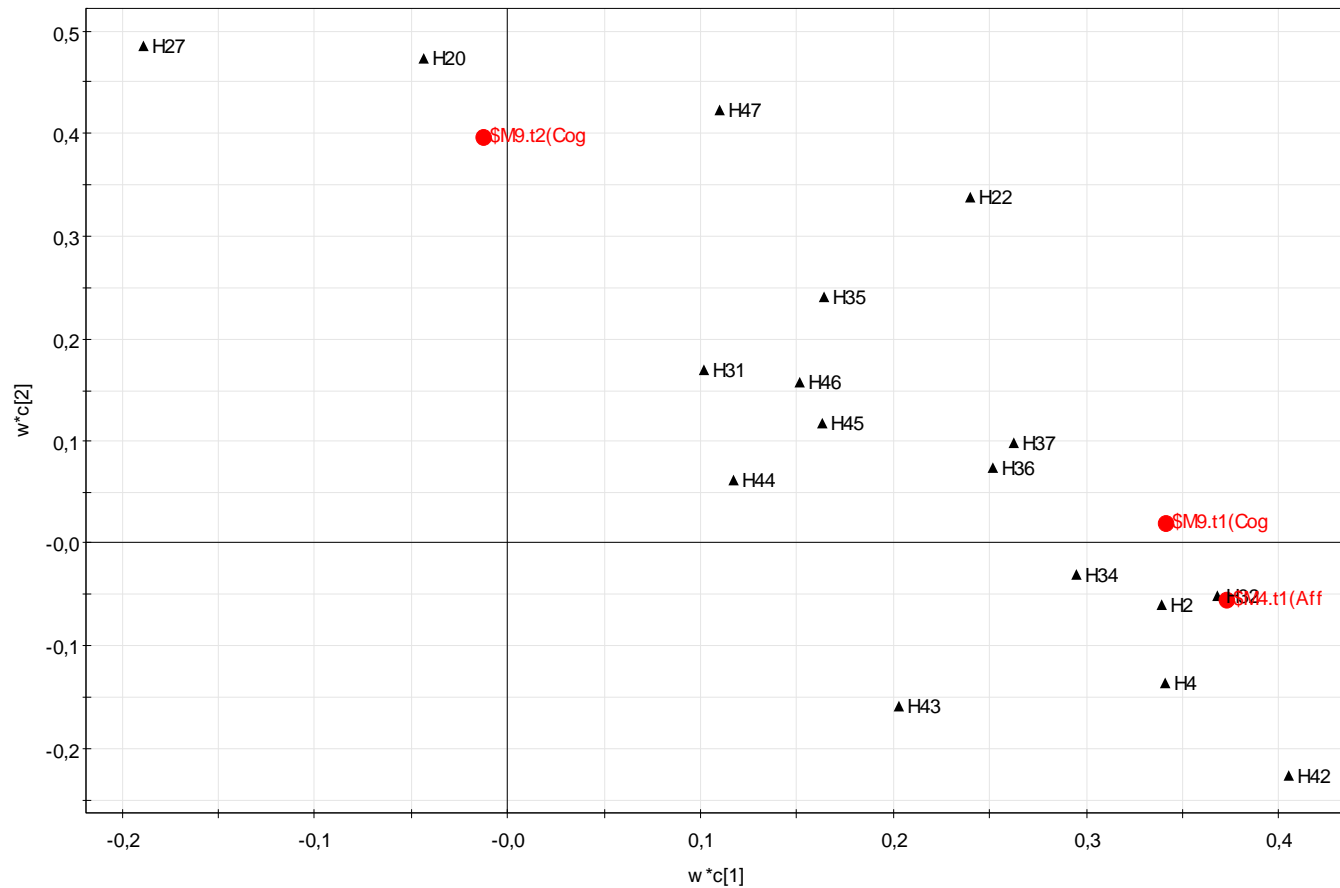
	Categories	Items	Comp.	R <sup>2</sup> (%)	Q <sup>2</sup> (%)
1	Attitudes and goals (P)	40	3	39	28
2	Beliefs about learning (P)	20	1	23	15
3	Self-efficacy / locus of control (P)	14	2	55	38
4	Ordinary work forms (P)	7	2 <sup>a</sup>	46	-6
5	Work forms during SSI-work (S)	17	3 <sup>a</sup>	37	0.02
6	Affective outcomes (O)	18	1	35	27
7	Cognitive outcomes (O)	11	2 <sup>b</sup>	44	13

<sup>a</sup> All components were forced (no one found significant according to cross validation rules)

<sup>b</sup> One additional component was forced

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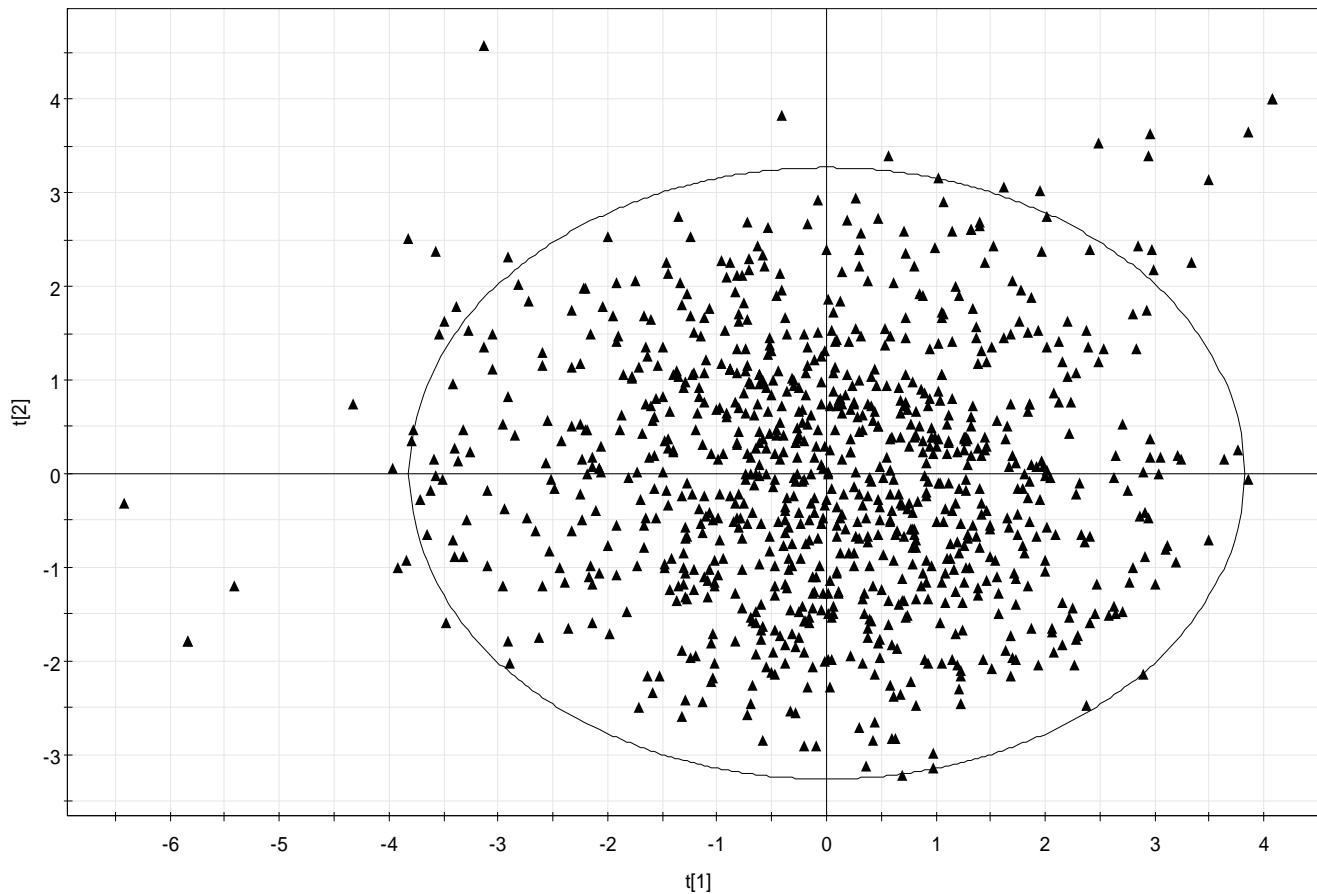
# SSI Work Forms vs Outcomes



R2X[1] = 0,149921 R2X[2] = 0,108977

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# Students in SSI base-model



R2X[1] = 0,149921

R2X[2] = 0,108977

Ellipse: Hotelling T2 (0,95)

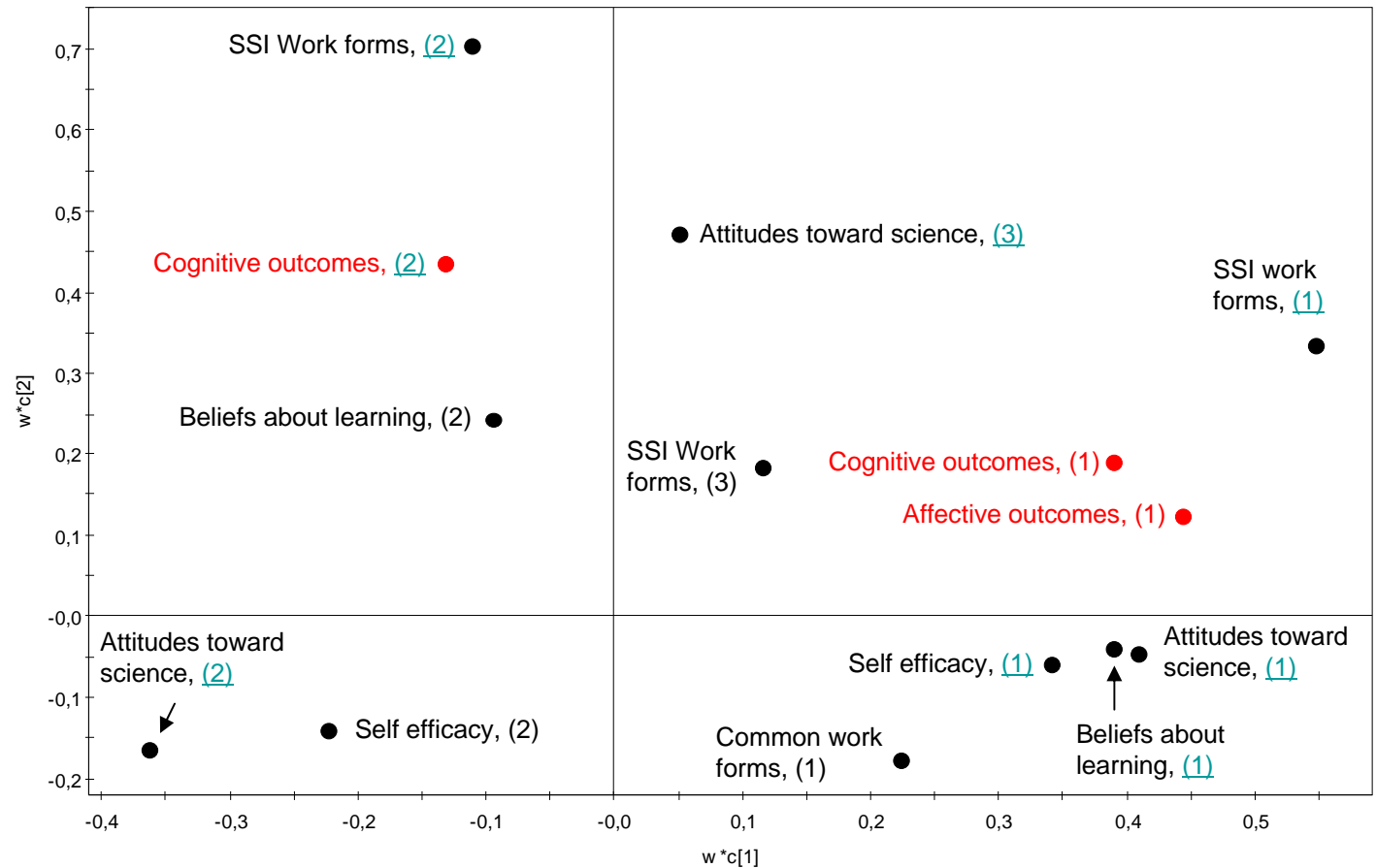
# Base - and top (PLS) model performance

Category	Comp.	R <sup>2</sup> X	R <sup>2</sup> Y	Q <sup>2</sup>
1 Attitudes and Goals	3	33	24	19
2 Beliefs about learning and knowledge	1	29	12	10
3 Self-efficacy / locus of control	2	49	12	10
4 Ordinary work forms in science class	1	28	4	3
5 Work forms during SSI-work	2	34	32	30
Top model				
<hr/>				
Components from category 1-5 vs. outcomes	3	48	44	42

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# Top-model

P1 ( $R^2_Y$  29%), P2 ( $R^2_Y$  11,5%), P3 only describes 3 % of variation in Y



$R^2X[1] = 0,23262$   $R^2X[2] = 0,129284$

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# Preliminary conclusions

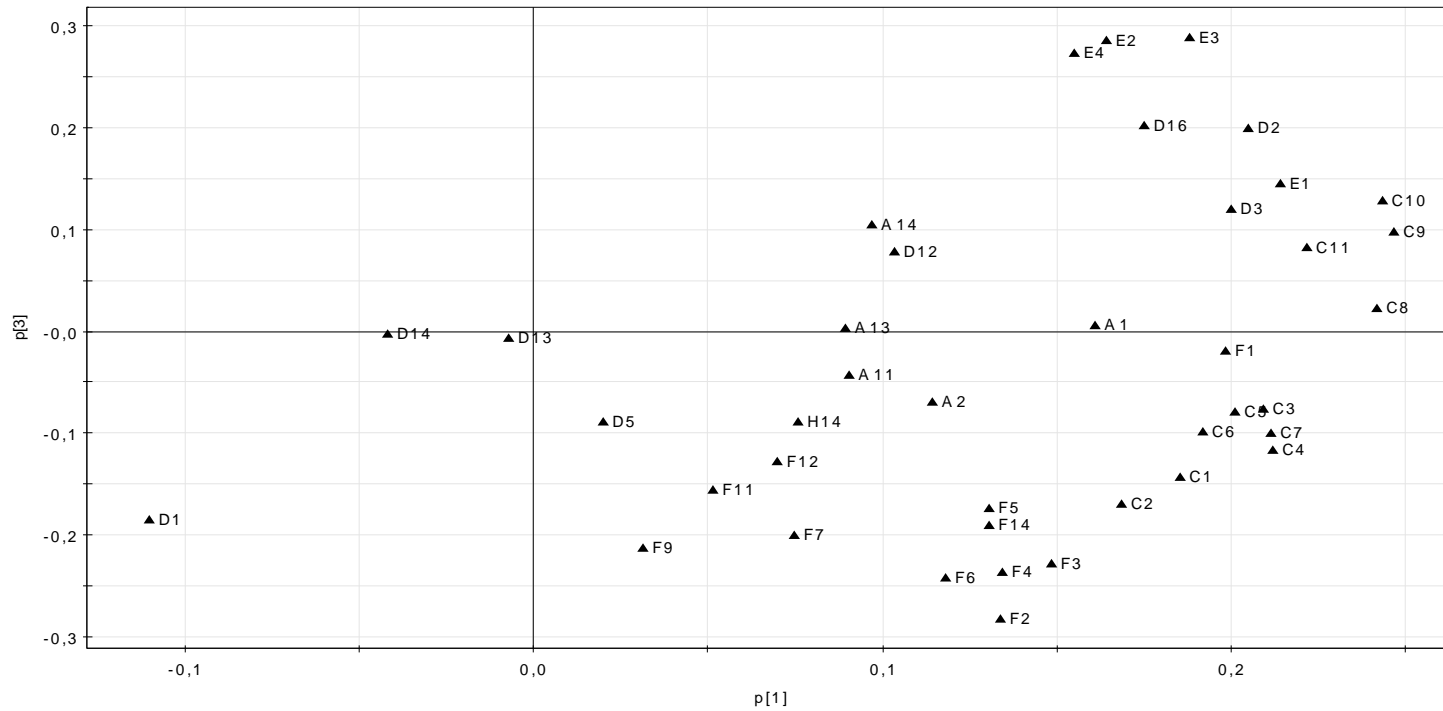
The Multi-aspect model is better at explaining outcomes, as defined here, than the one-aspect-at-a-time models.

Work forms, i.e., issues are up to date, frequent discussions, equally shared workload, and autonomy are most important to explain positive affective and cognitive outcomes. Encountering/realizing cognitive conflict is also positive for these pupils.

A perception that school science is relevant, in line with what the pupil wants to learn, and that science has an important role in society is also related to positive outcomes. It is *possible* that these attitudes moderates the effects of cognitive conflict (which is a significant factor for both positive and negative outcomes)

Pupils achievement goals seem important for predicting these types of outcomes. Unfortunately, only one item measured this.

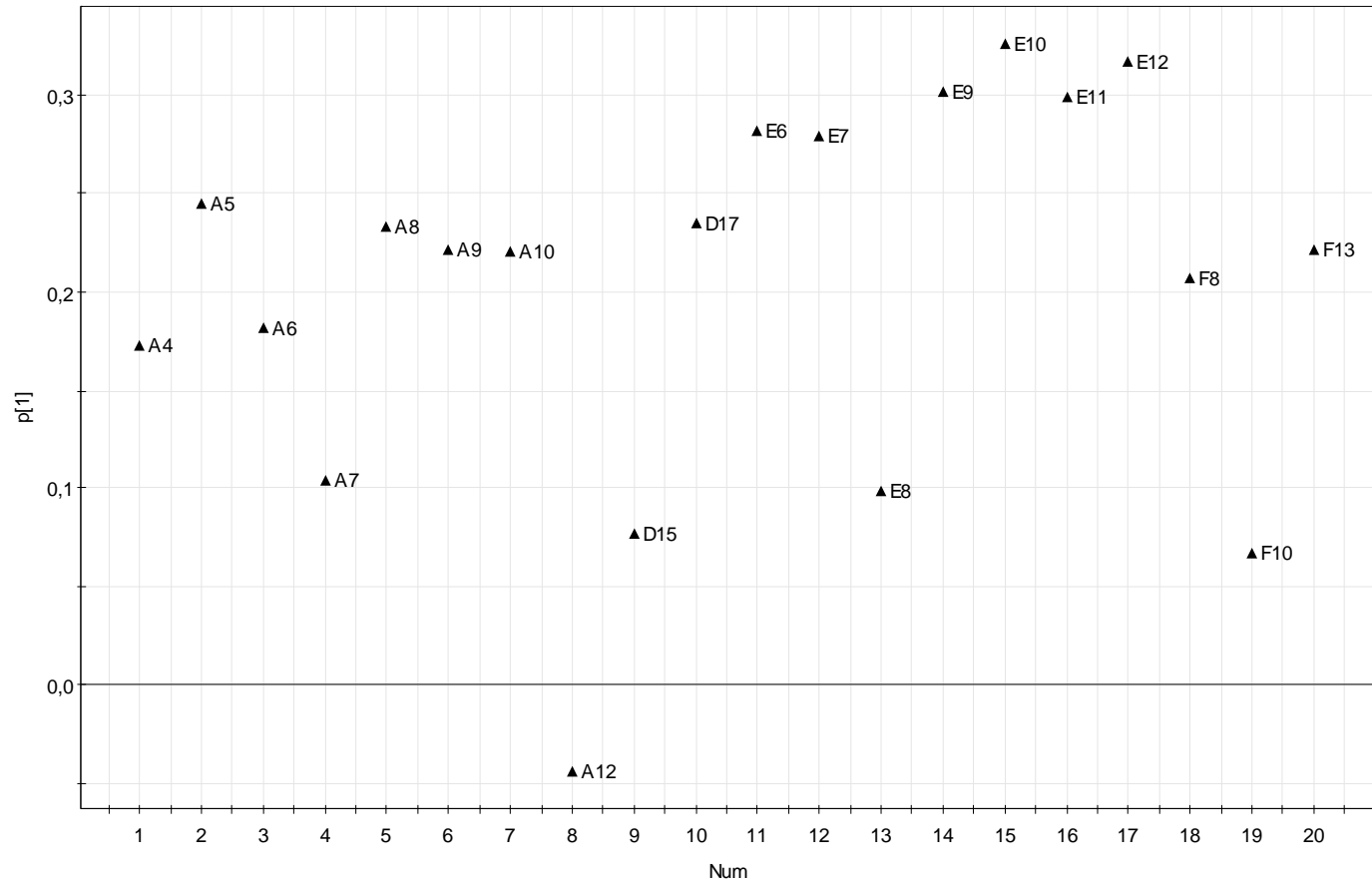
# Attitudes and goals



R2X[1] = 0,245948 R2X[3] = 0,0623071

SIMCA-P+ 11 - 2008-06-04 13:52:11

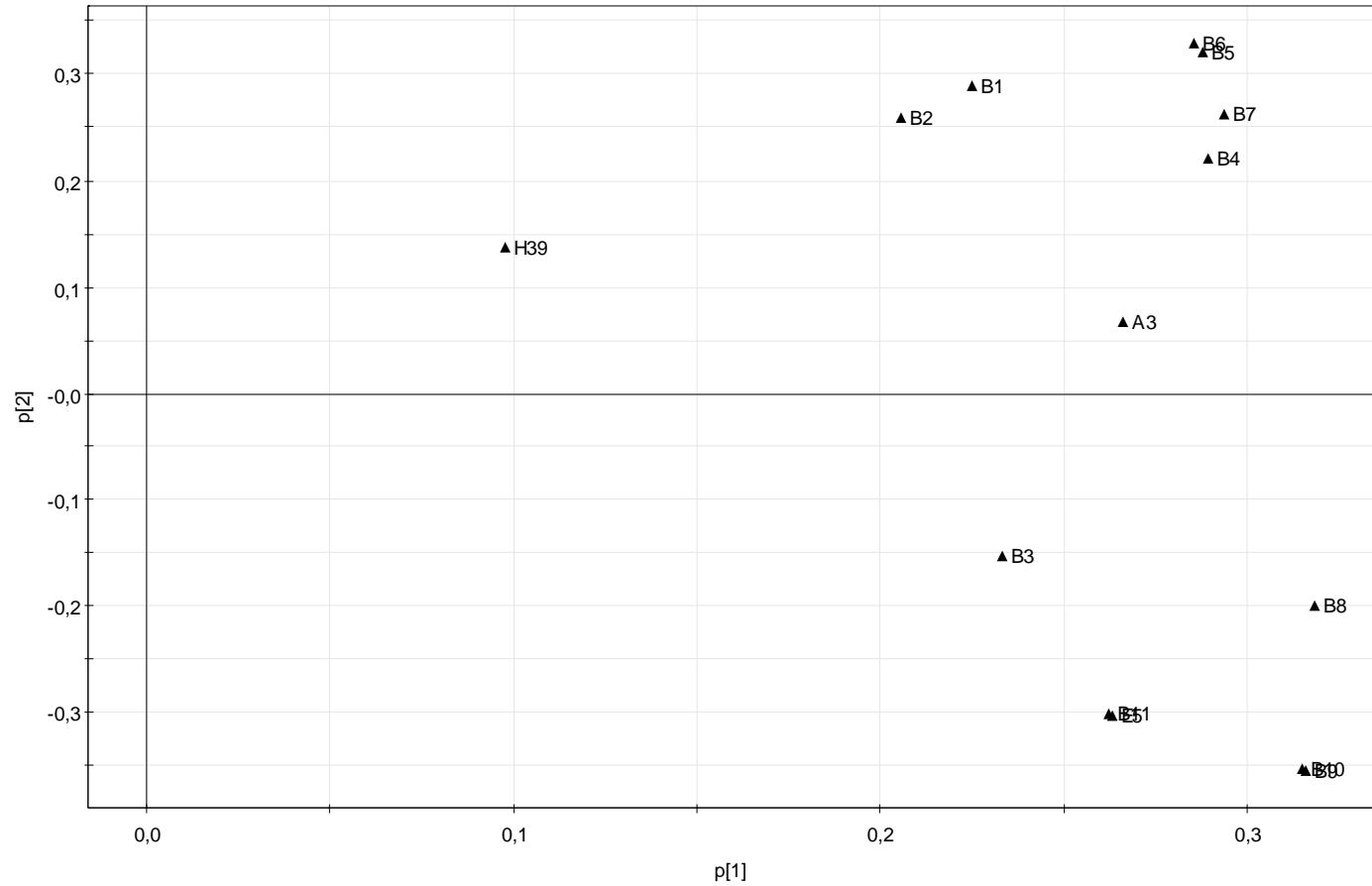
# Beliefs and attitudes about learning



R2X[1] = 0,232127

SIMCA-P+ 11 - 2008-06-04 14:20:14

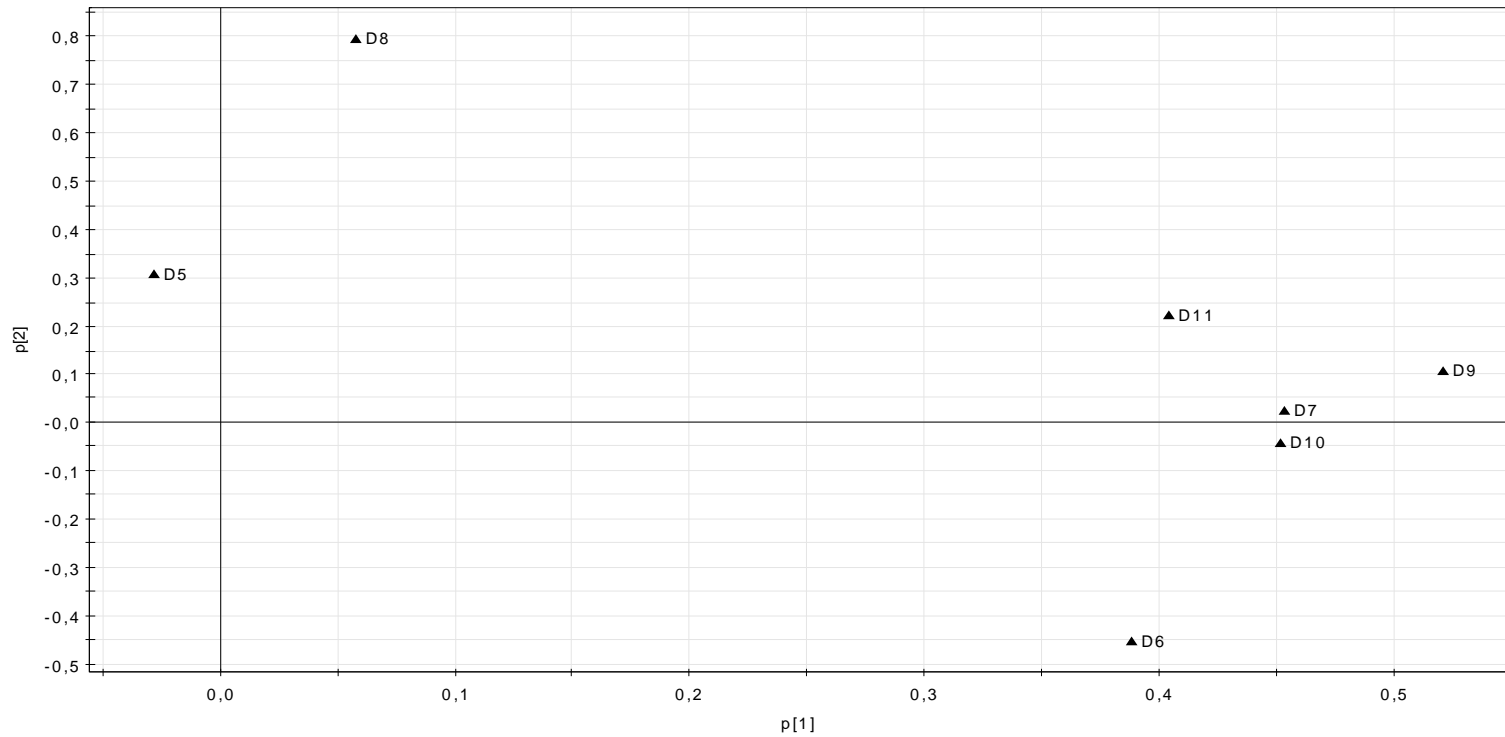
# Self-efficacy



R2X[1] = 0,437369 R2X[2] = 0,11551

SIMCA-P+ 11 - 2008-06-04 14:33:39

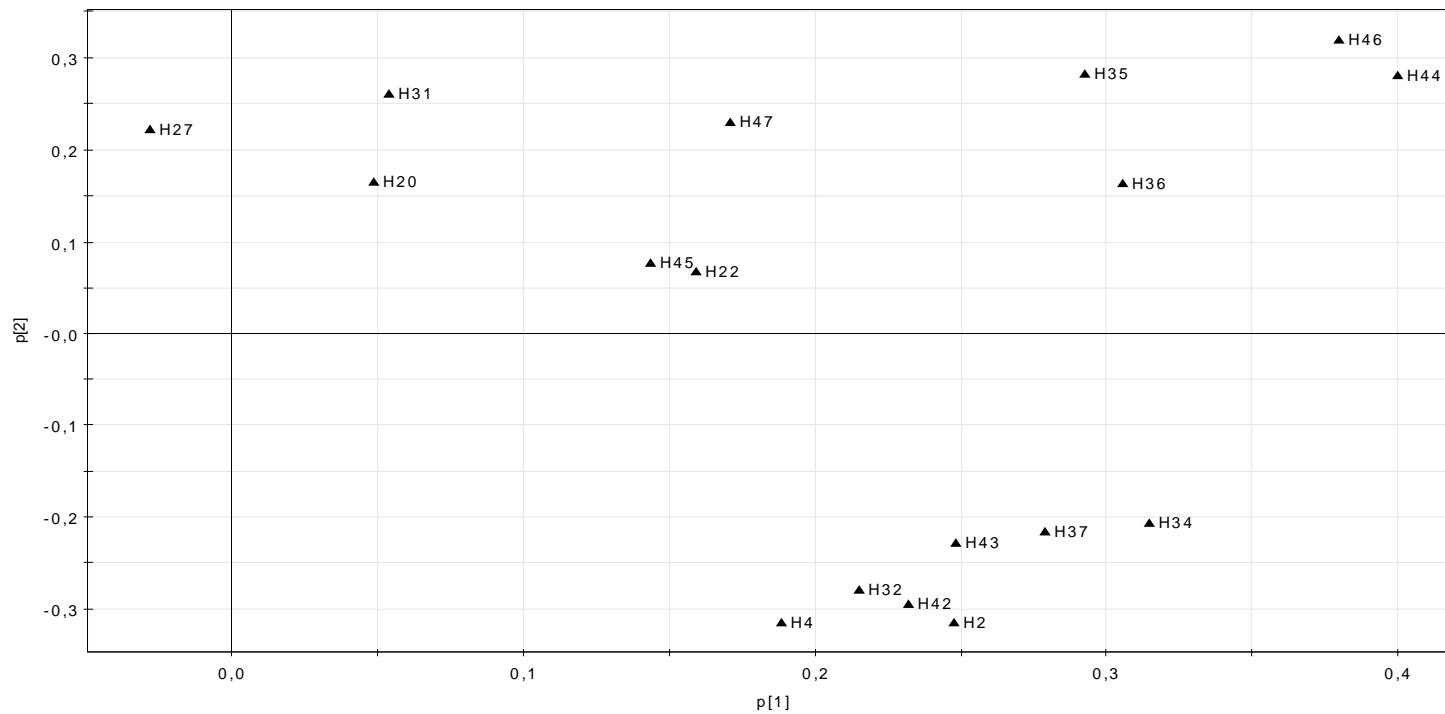
# Ordinary work forms



R 2 X [ 1 ] = 0 , 2 8 4 6 6 1 R 2 X [ 2 ] = 0 , 1 7 0 0 2 1

SIMCA-P+ 11 - 2008-06-04 14:34:38

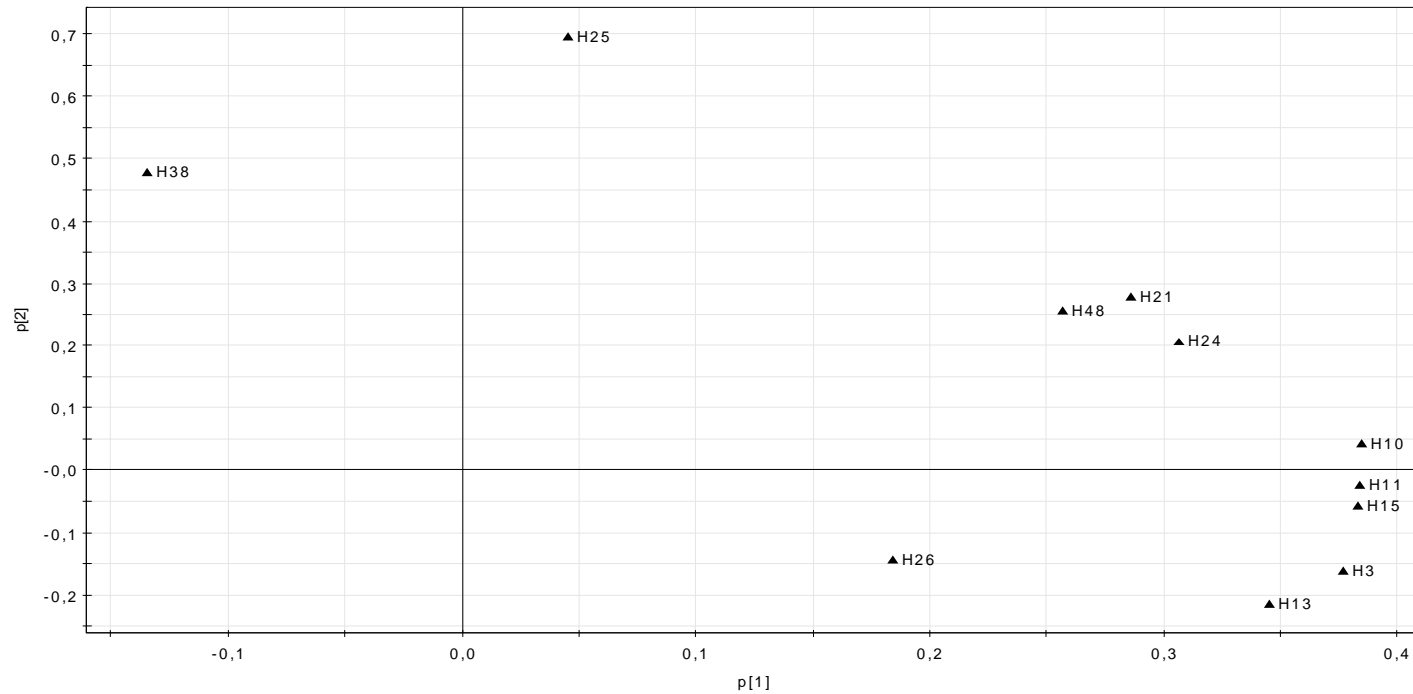
# Work forms during SSI



R2X[1] = 0,159557 R2X[2] = 0,120406

SIMCA-P+ 11 - 2008-06-04 14:38:44

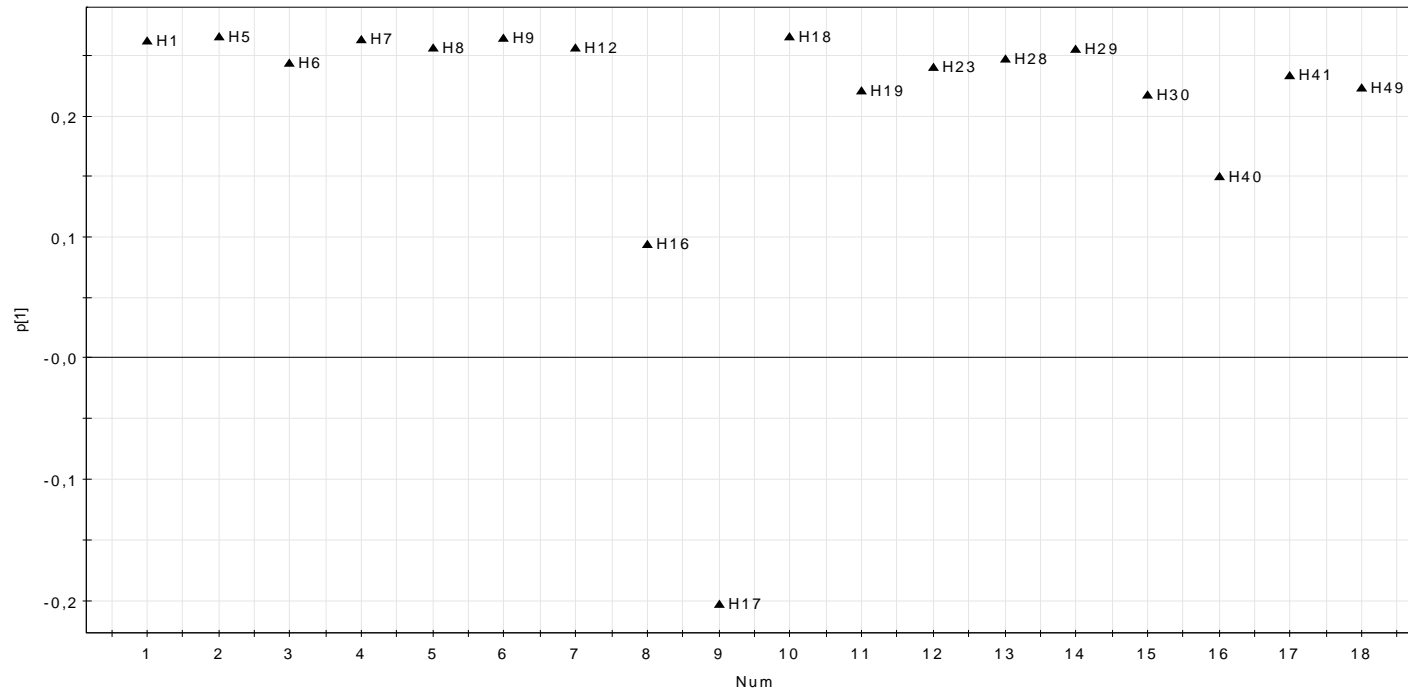
# Cognitive outcomes



R 2 X [ 1 ] = 0 , 3 1 3 2 3 5 R 2 X [ 2 ] = 0 , 1 2 2 3 3 5

SIMCA-P+ 11 - 2008-06-04 14:44:59

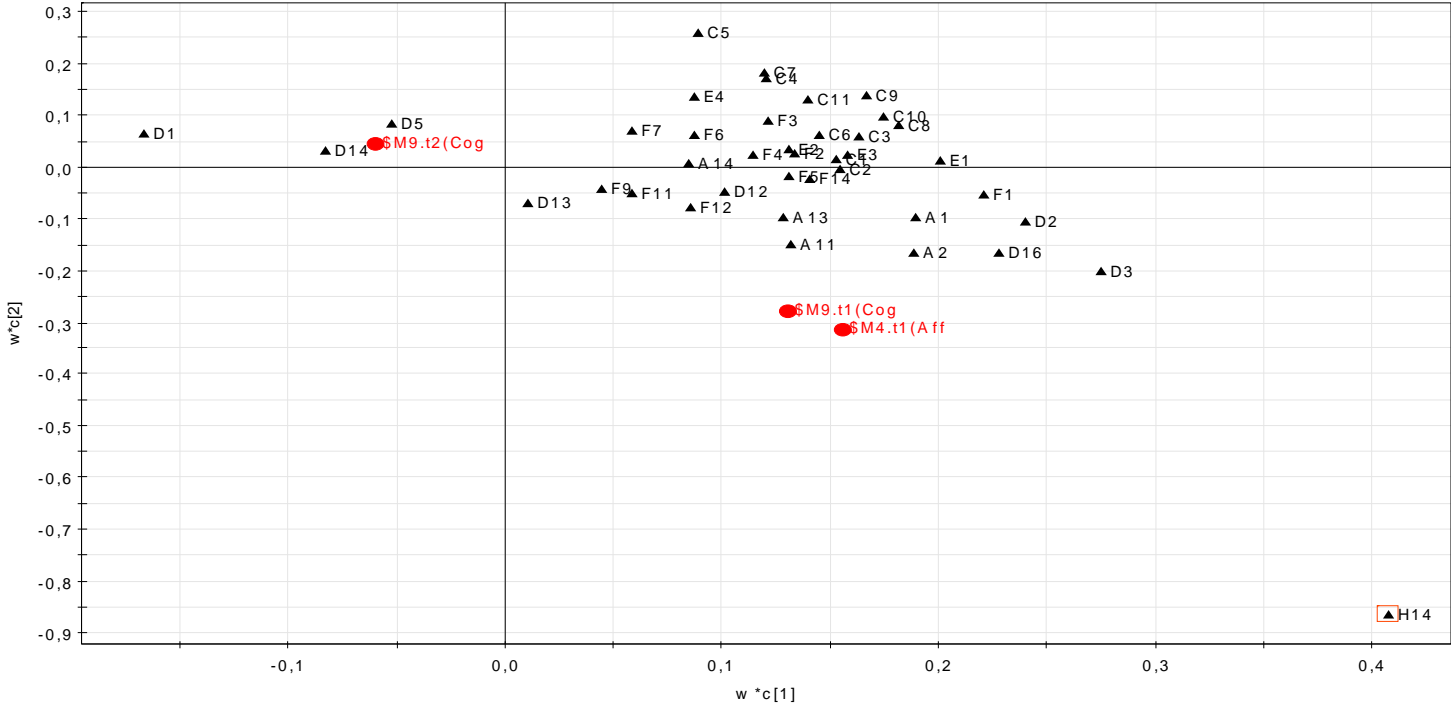
# Affective and motivational outcomes



R 2 X [ 1 ] = 0 , 3 4 9 8 9 5

SIMCA-P+ 11 - 2008-06-04 14:45:59

# Attitudes and goals vs outcomes

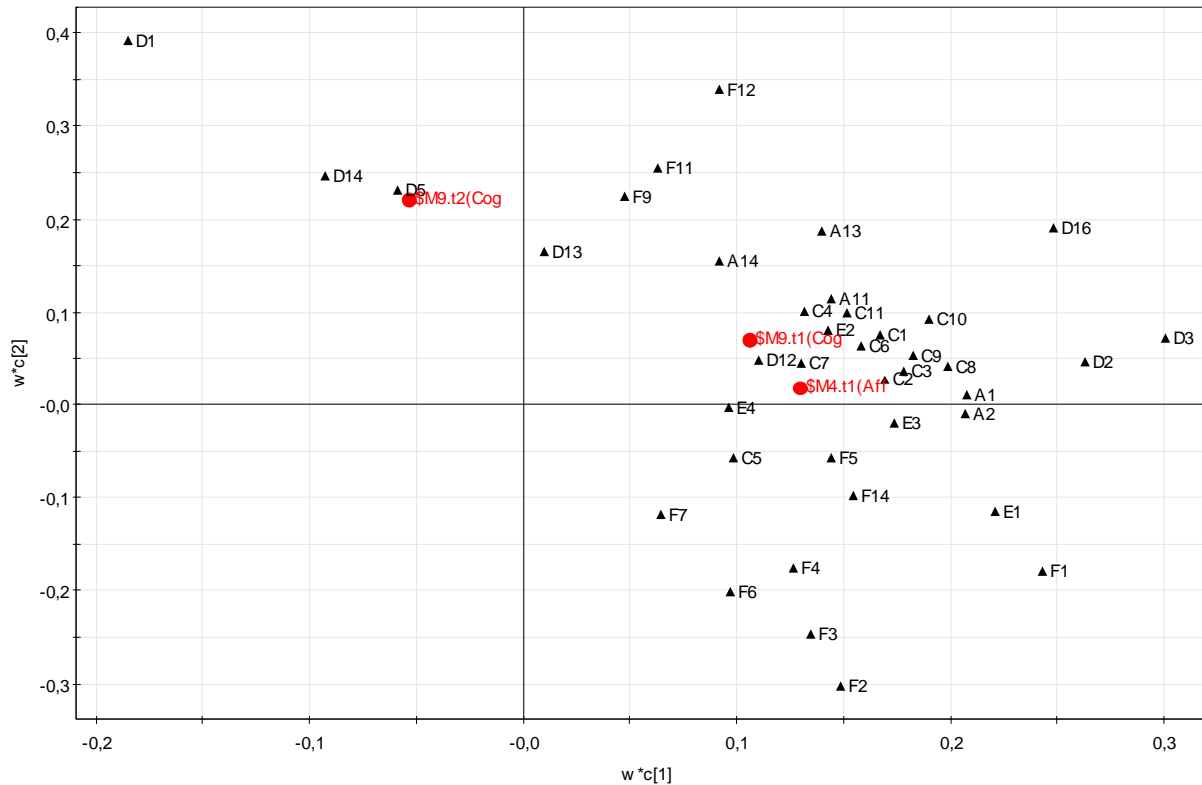


R2X[1] = 0,228682 R2X[2] = 0,0459961

SIMCA-P+ 11 - 2008-06-04 13:56:27

# Attitudes minus goals (har provat att byta ut

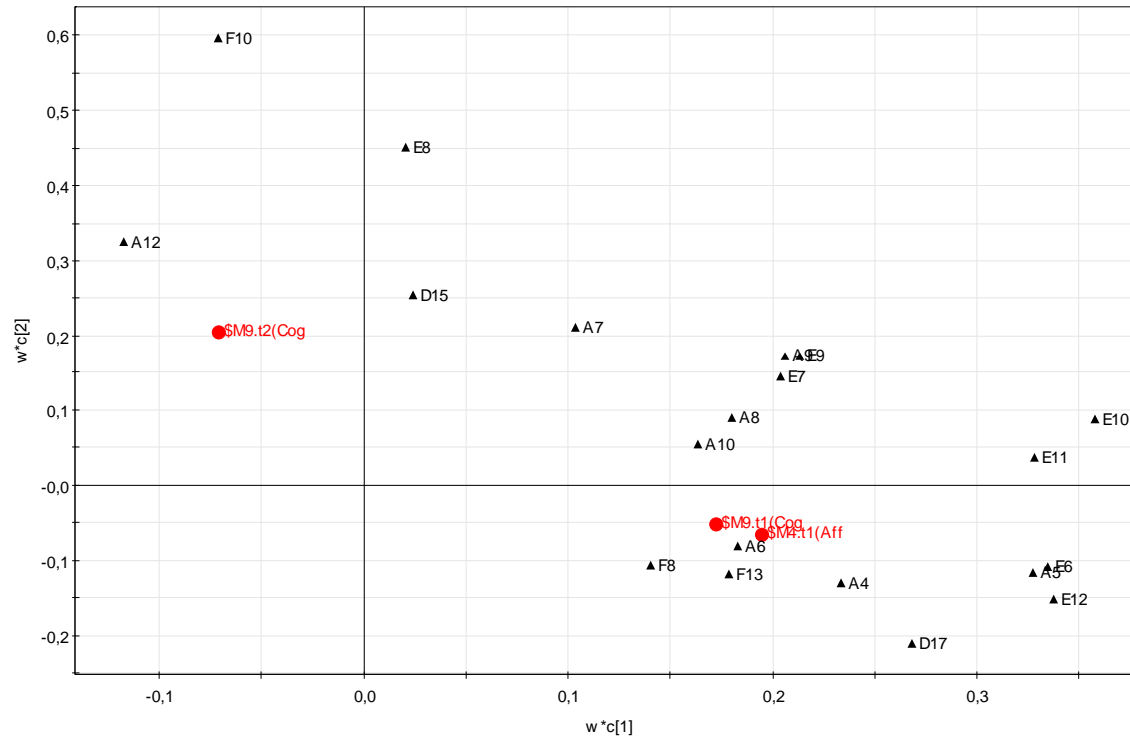
attitydkomponenten i topmodellen till denna → attityder tappar något i betydelse samtidigt som loadings ökar inom denna modelkomponent, dock samma relativa förhållanden mellan variablerna



R2X[1] = 0,237039 R2X[2] = 0,0511594

SIMCA-P+ 11 - 2008-06-04 13:57:38

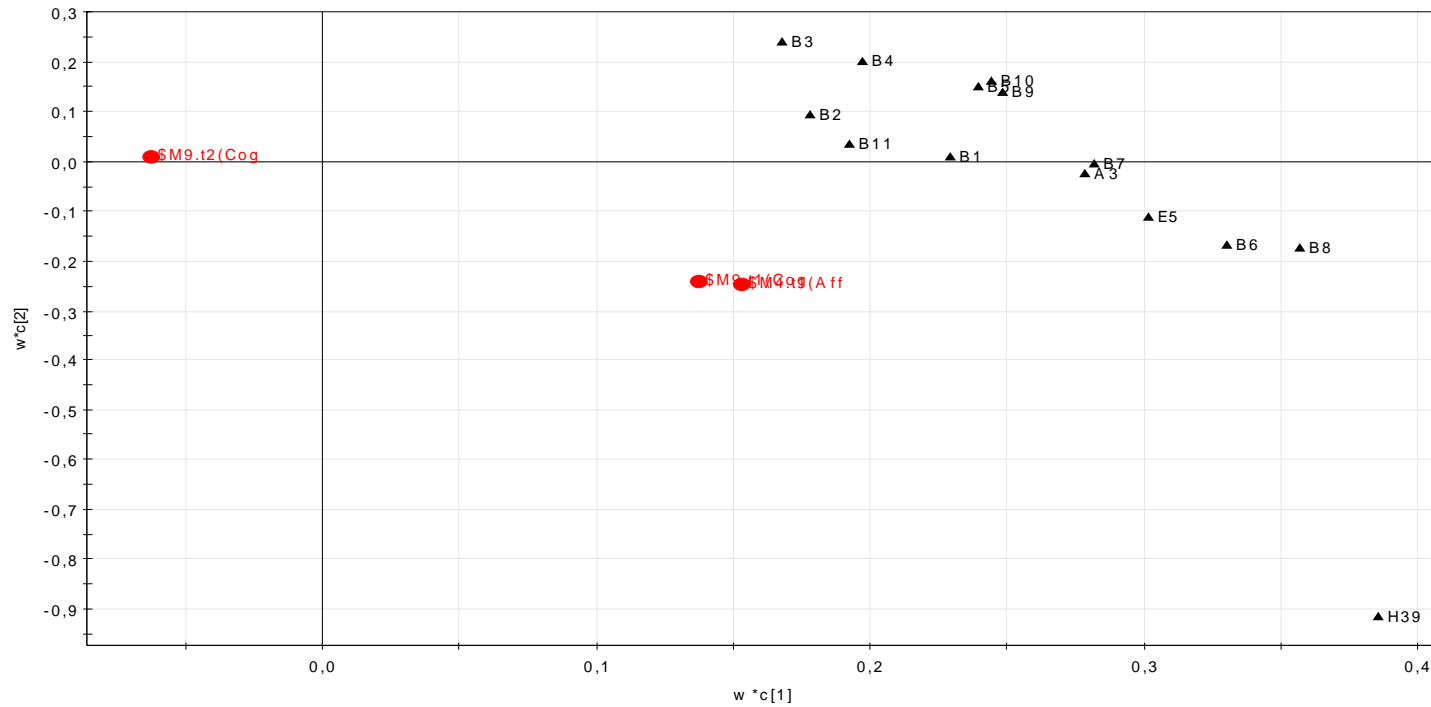
# Beliefs and Attitudes about learning vs Outcomes



R2X[1] = 0,225727 R2X[2] = 0,0618294

SIMCA-P+ 11 - 2008-06-04 15:07:10

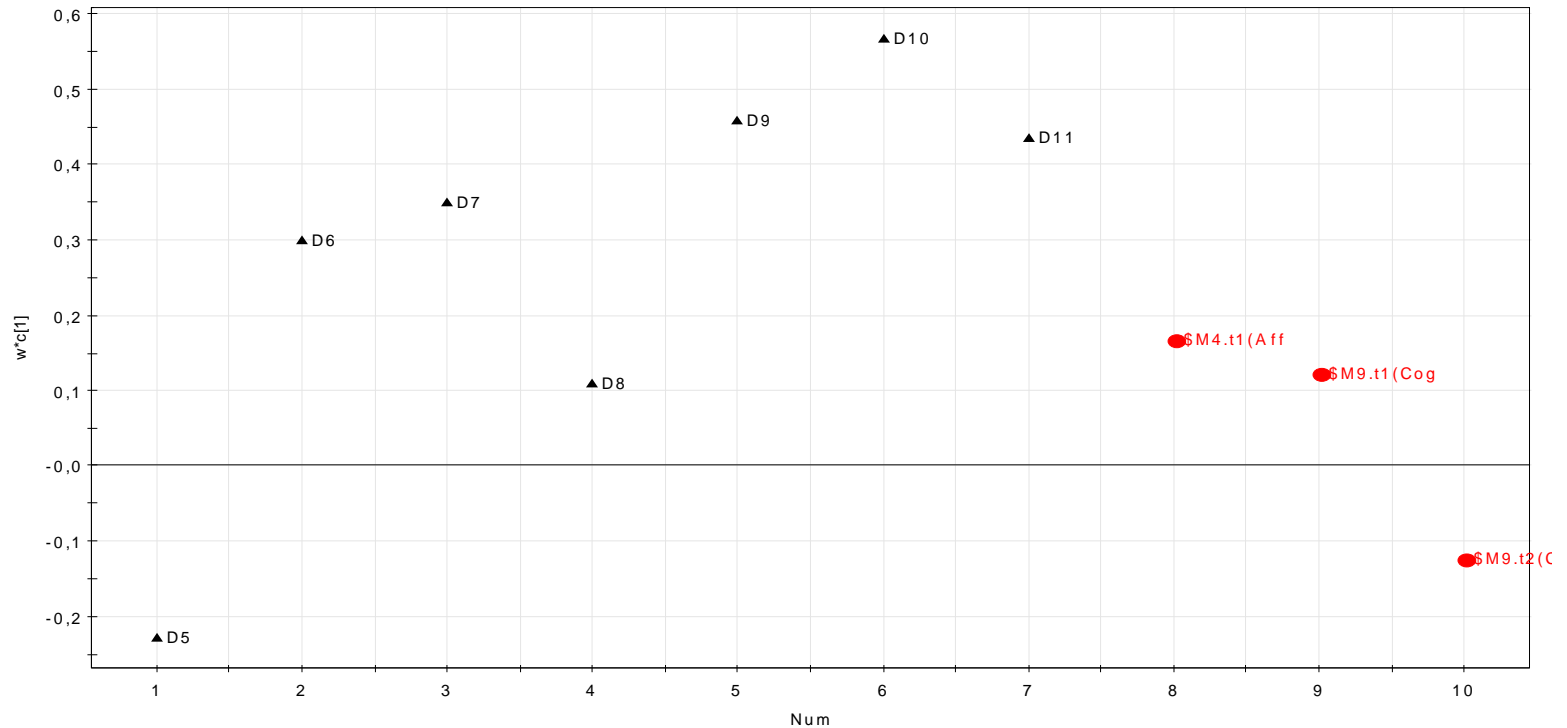
# Self Efficacy vs Outcomes



R2X[1] = 0,413571 R2X[2] = 0,0746718

SIMCA-P+ 11 - 2008-06-04 15:11:10

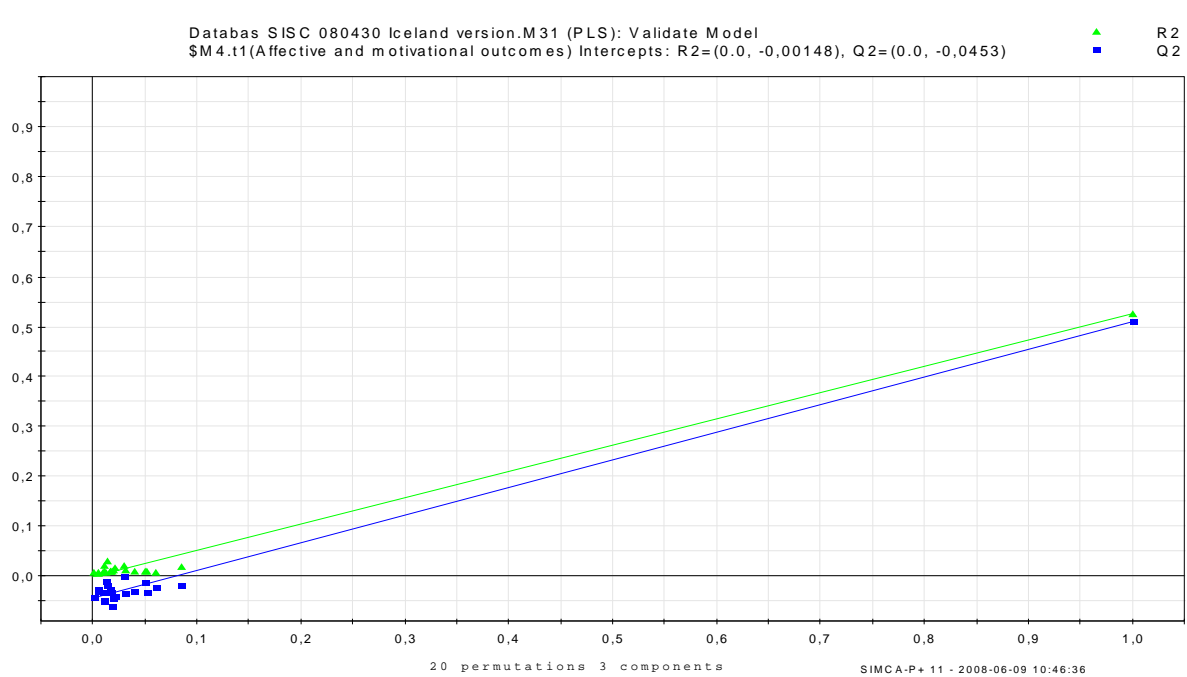
# Common Work Forms vs Outcomes



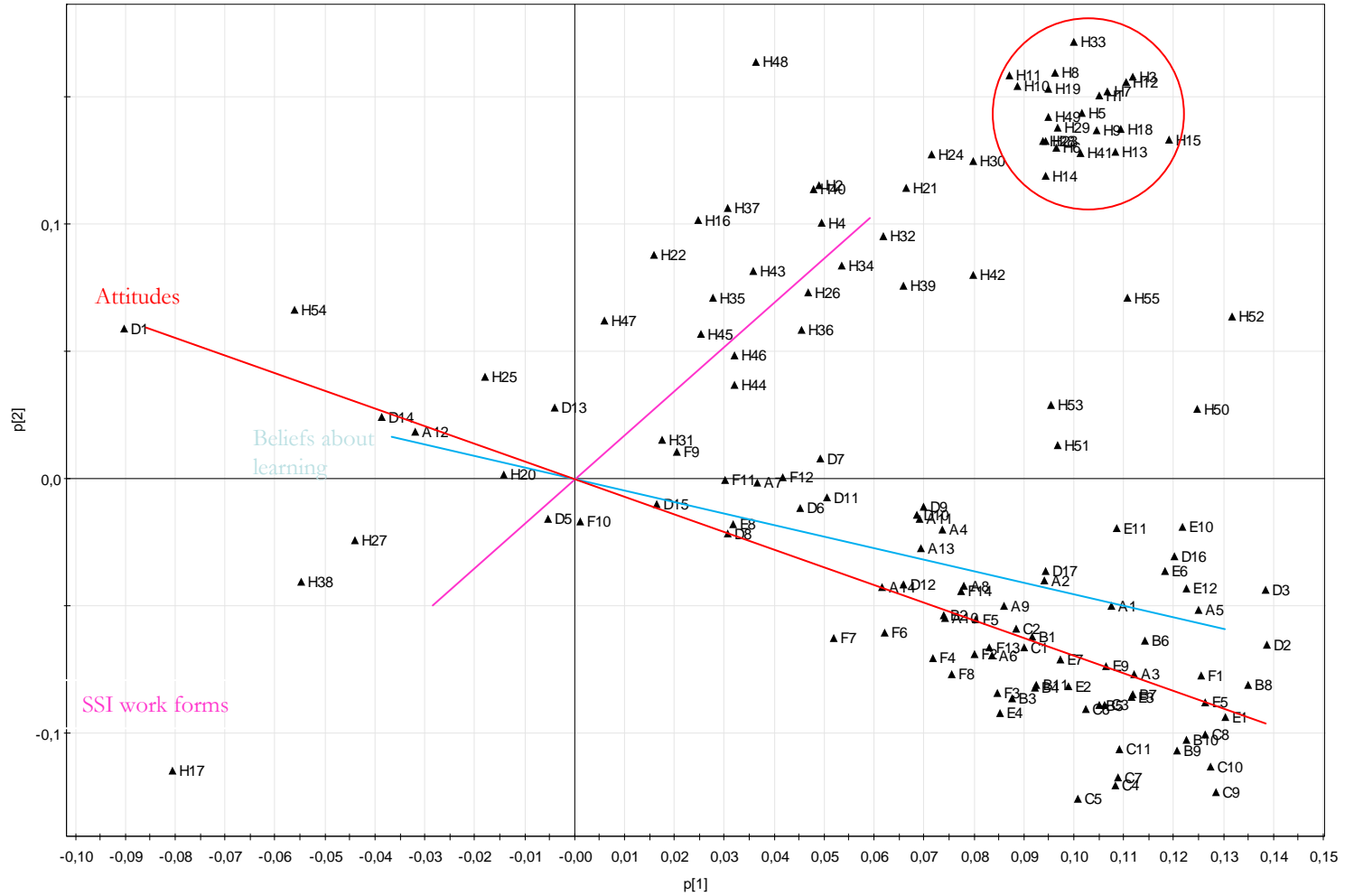
R 2 X [ 1 ] = 0 , 2 8 0 5 2

SIMCA-P+ 11 - 2008-06-04 15:12:35

# Response Permutation Test



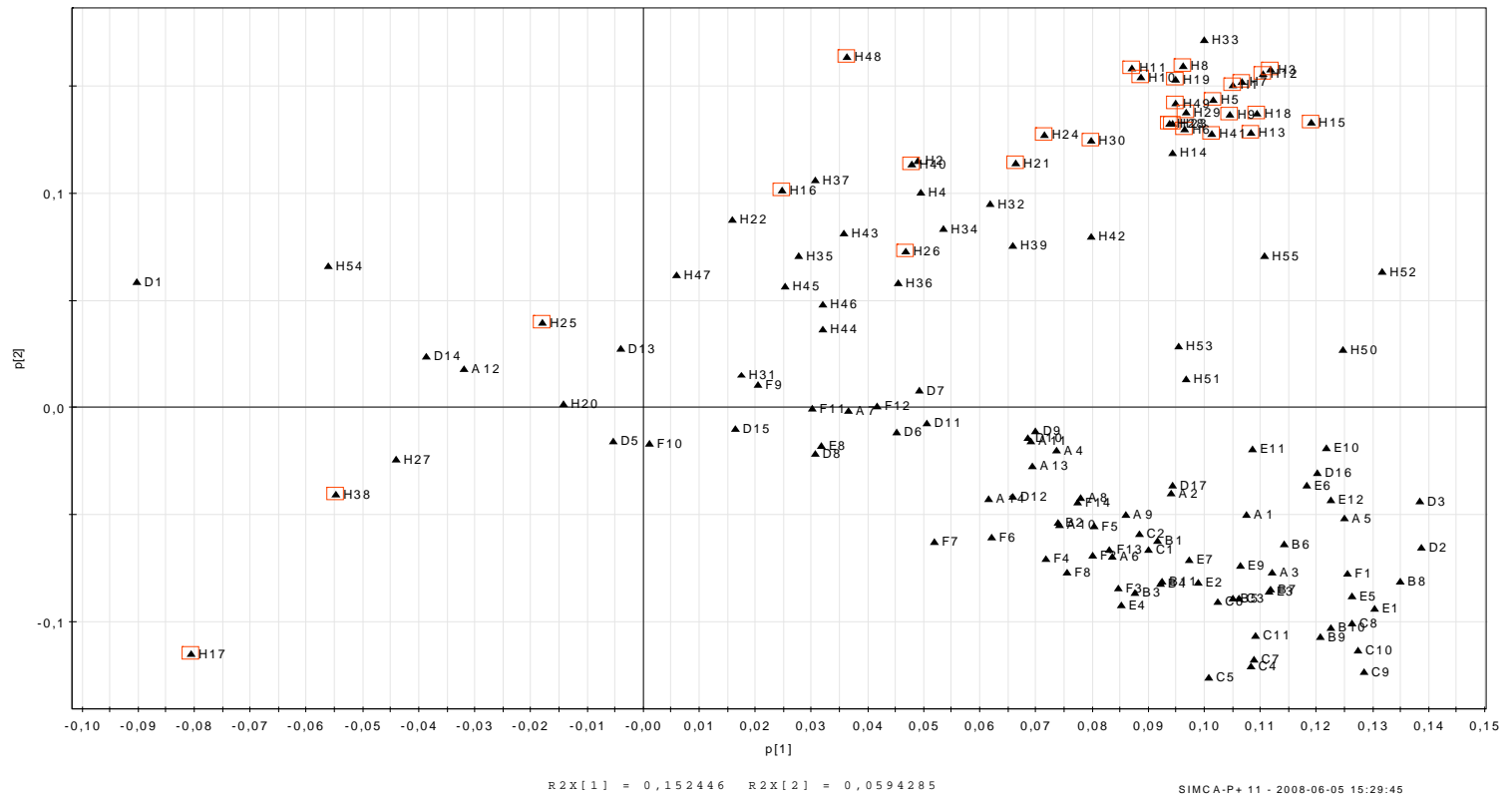
Affective and motivational outcomes



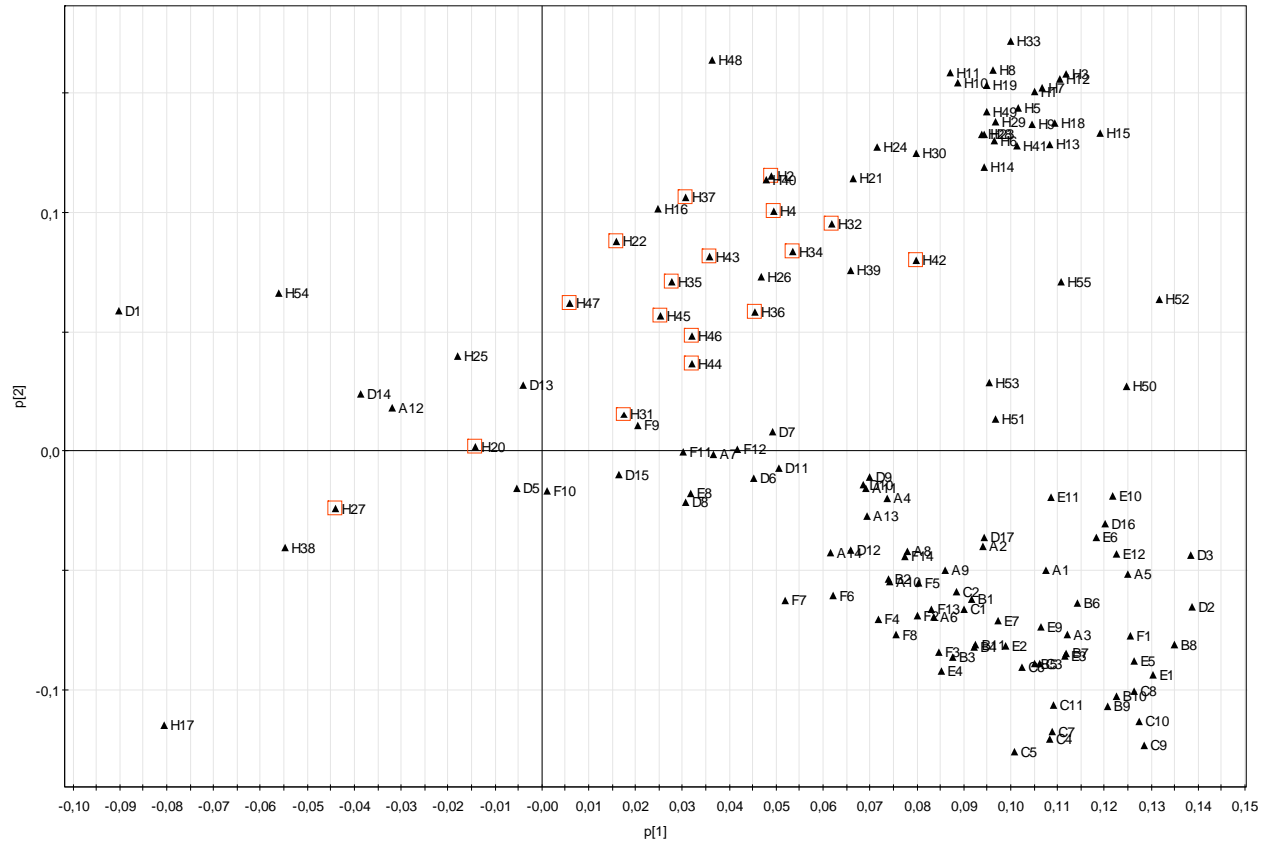
R2X[1] = 0,152446 R2X[2] = 0,0594285

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# Cognitive and Affective Outcomes



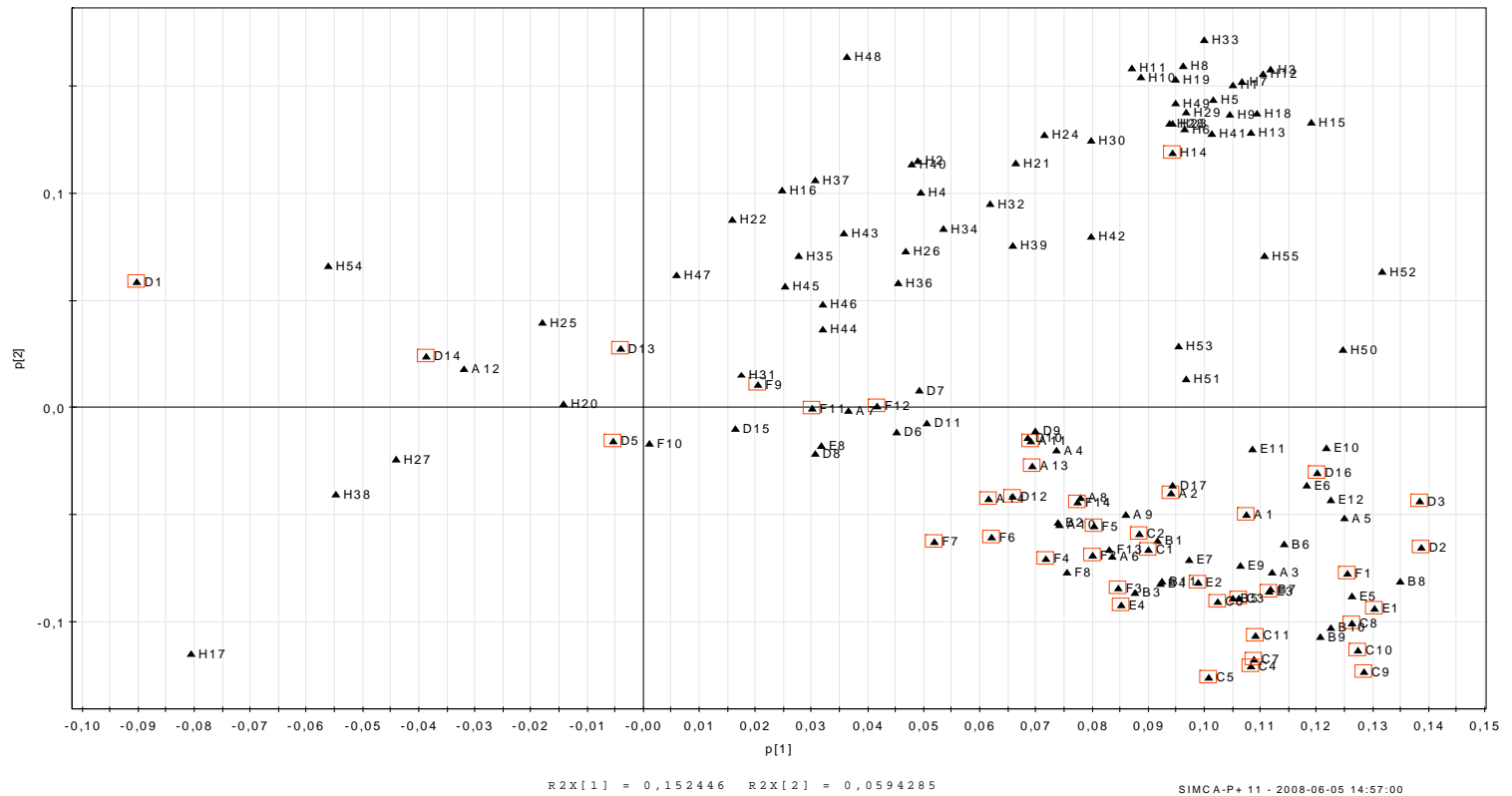
# SSI Workforms



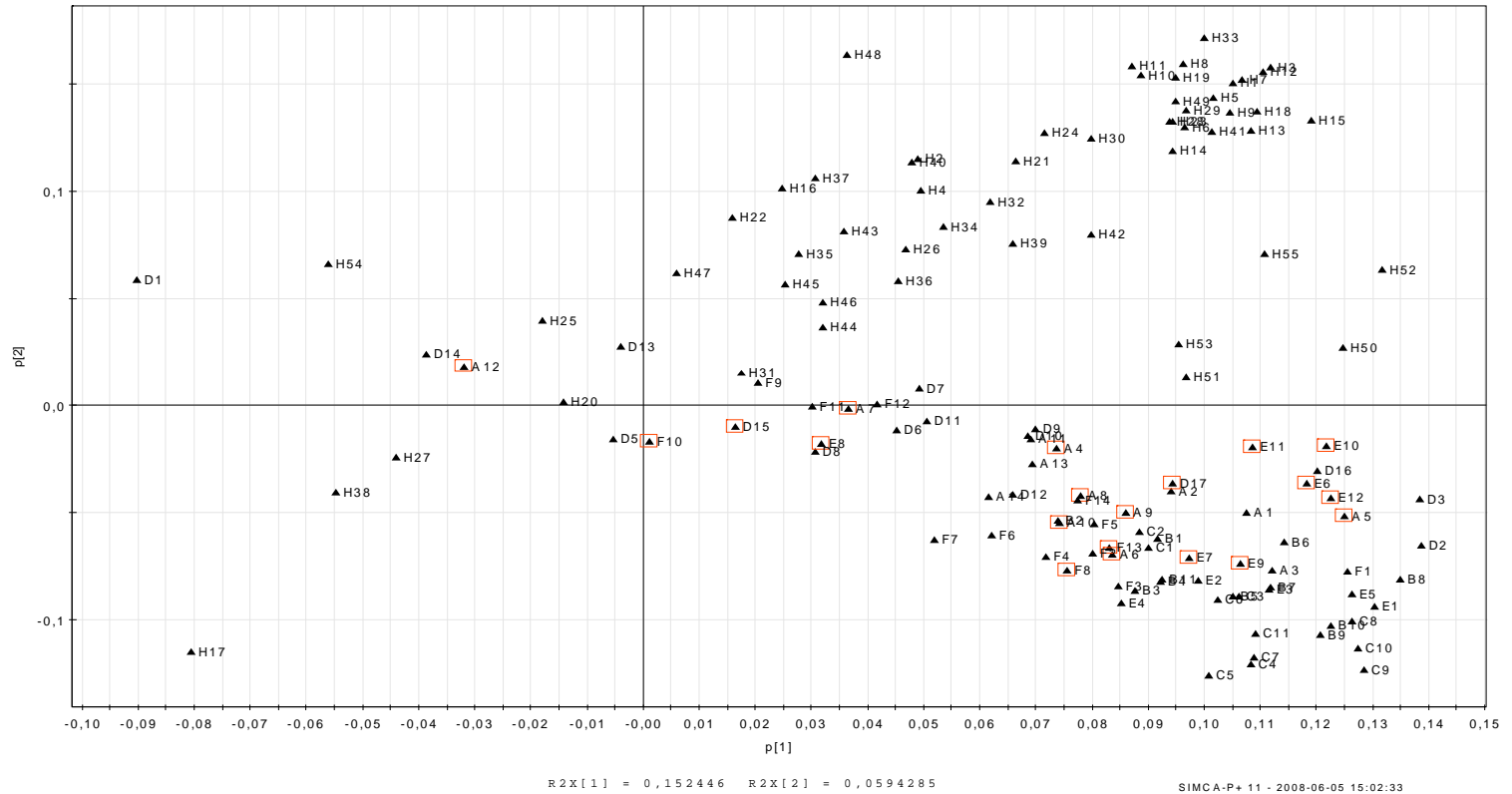
R2X[1] = 0,152446 R2X[2] = 0,0594285

SIMCA-P+ 11 - 2008-06-05 14:52:44

# Attitudes and Goals

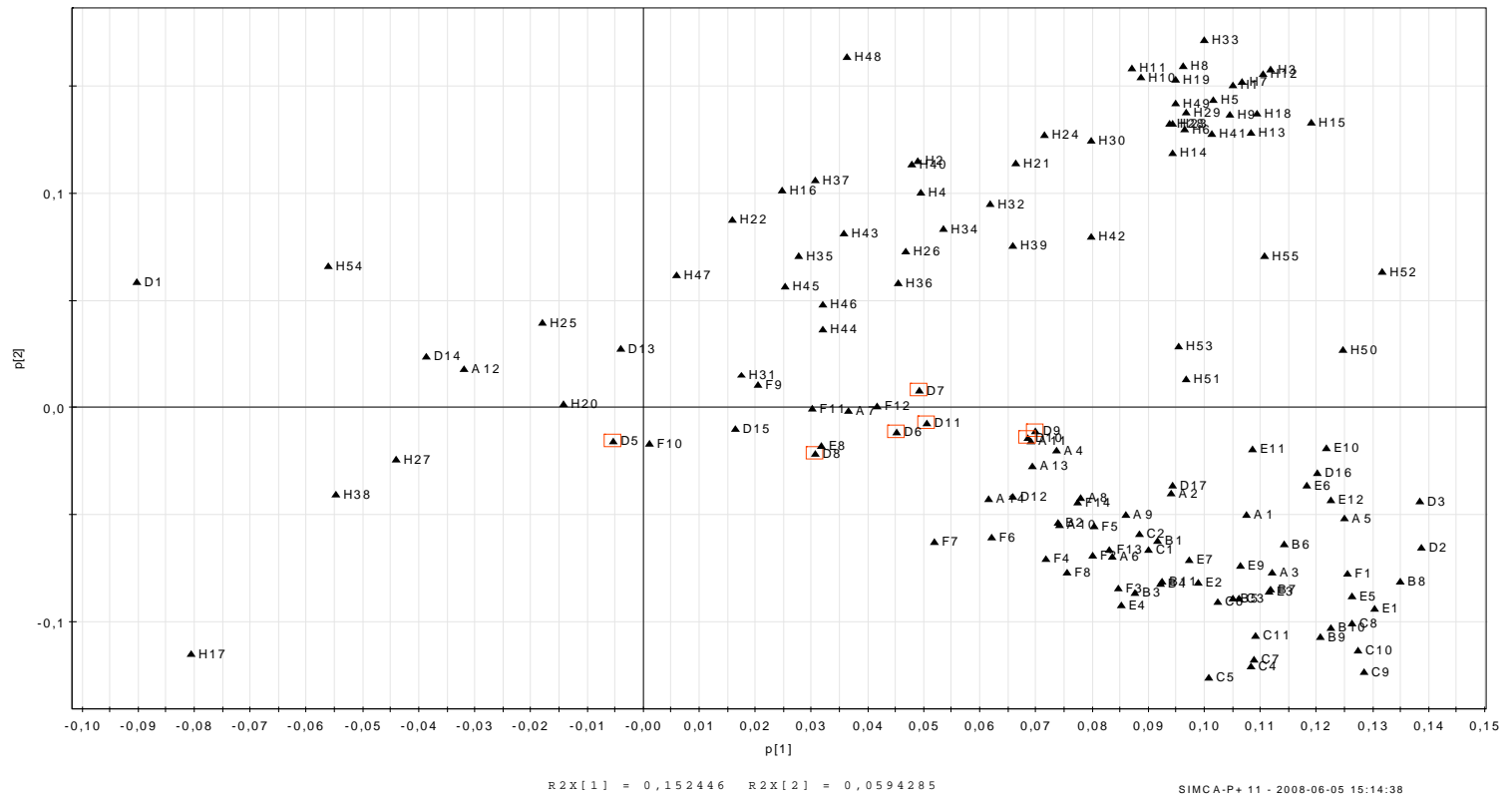


# Beliefs about Learning

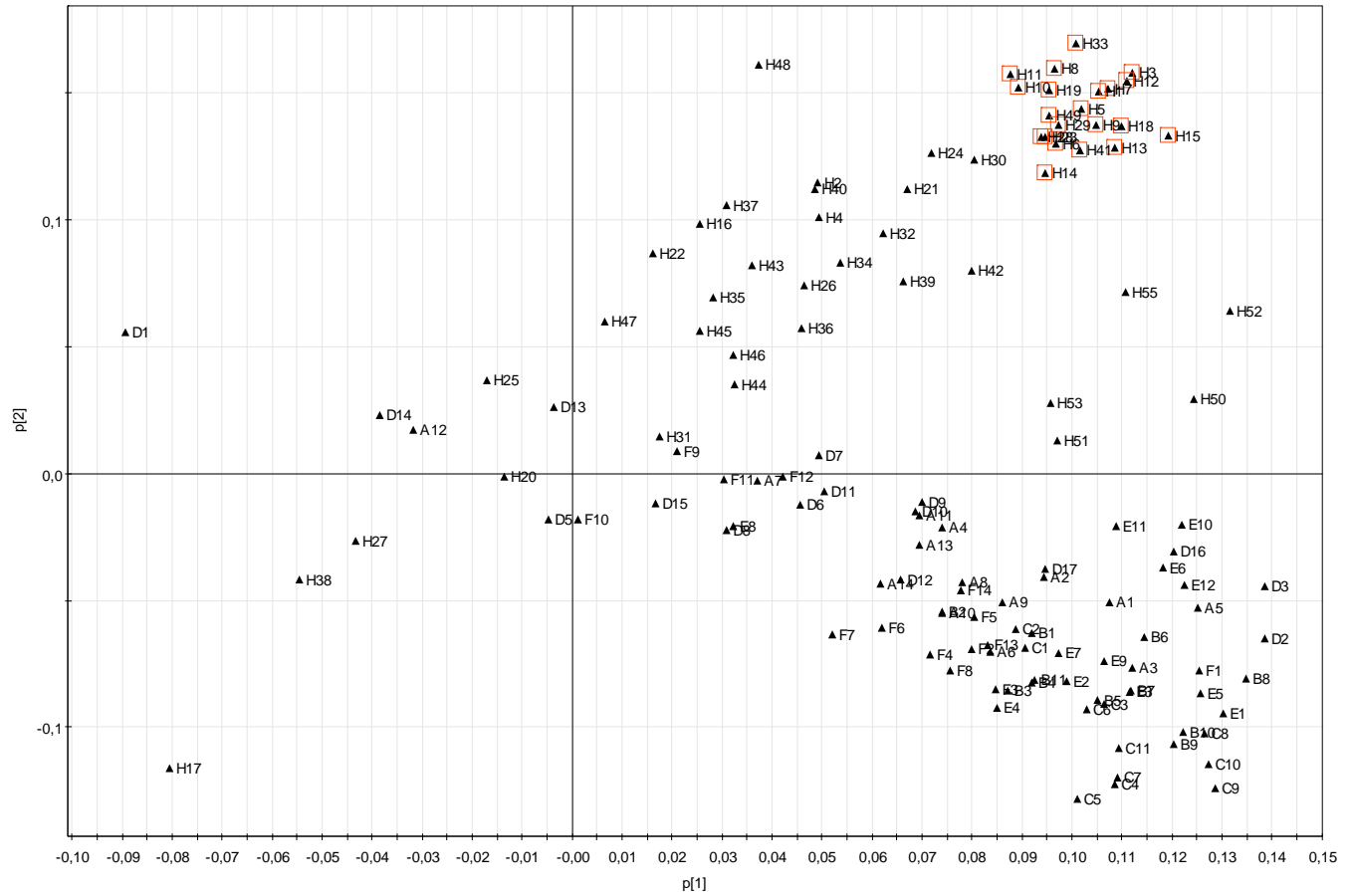




# Ordinary Workforms



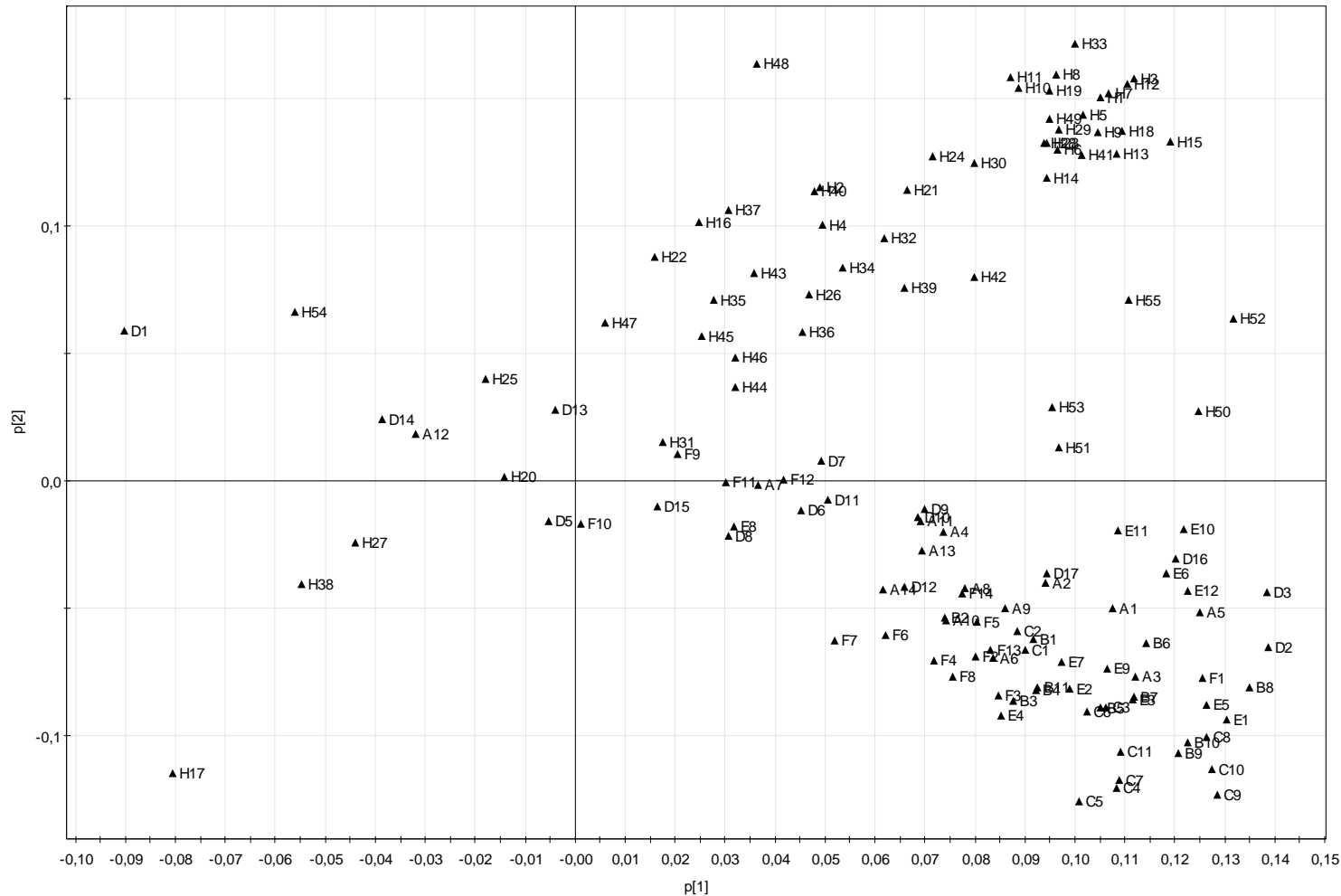
Databas SISC 080430 på slutlig databas\_restored.M36 (PCA-X)  
p[Comp. 1]/p[Comp. 2]



R2X[1] = 0,153139 R2X[2] = 0,0596412

SIMCA-P+ 11 - 2008-06-02 20:21:31

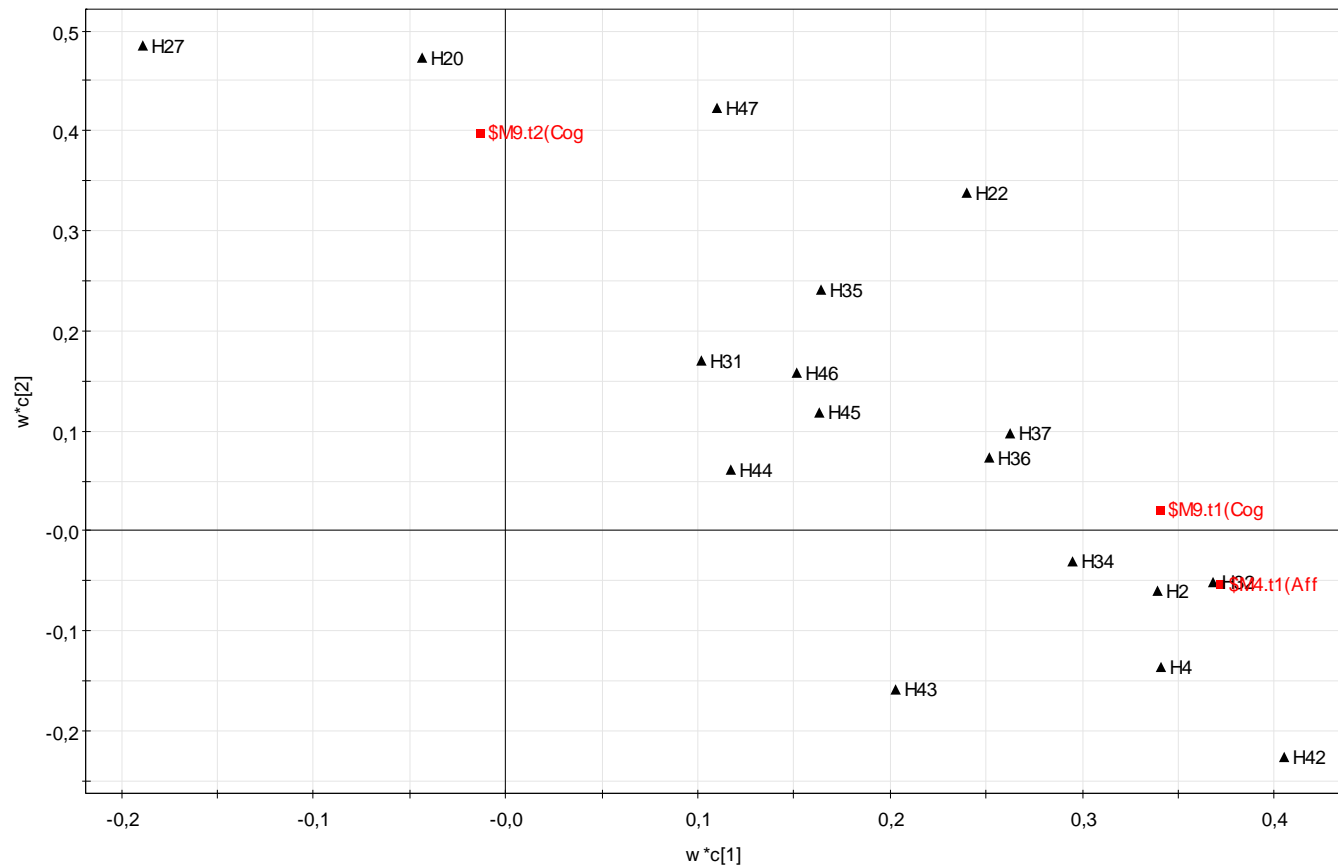
# Relations between items from questionnaire 1 and 2 (Showing 2 out of 6 components)



R2X[1] = 0,152446 R2X[2] = 0,0594285

SIMCA-P+ 11 - 2008-06-02 19:54:06

# Base-model: SSI work forms vs outcomes (2 out of 3 components shown)



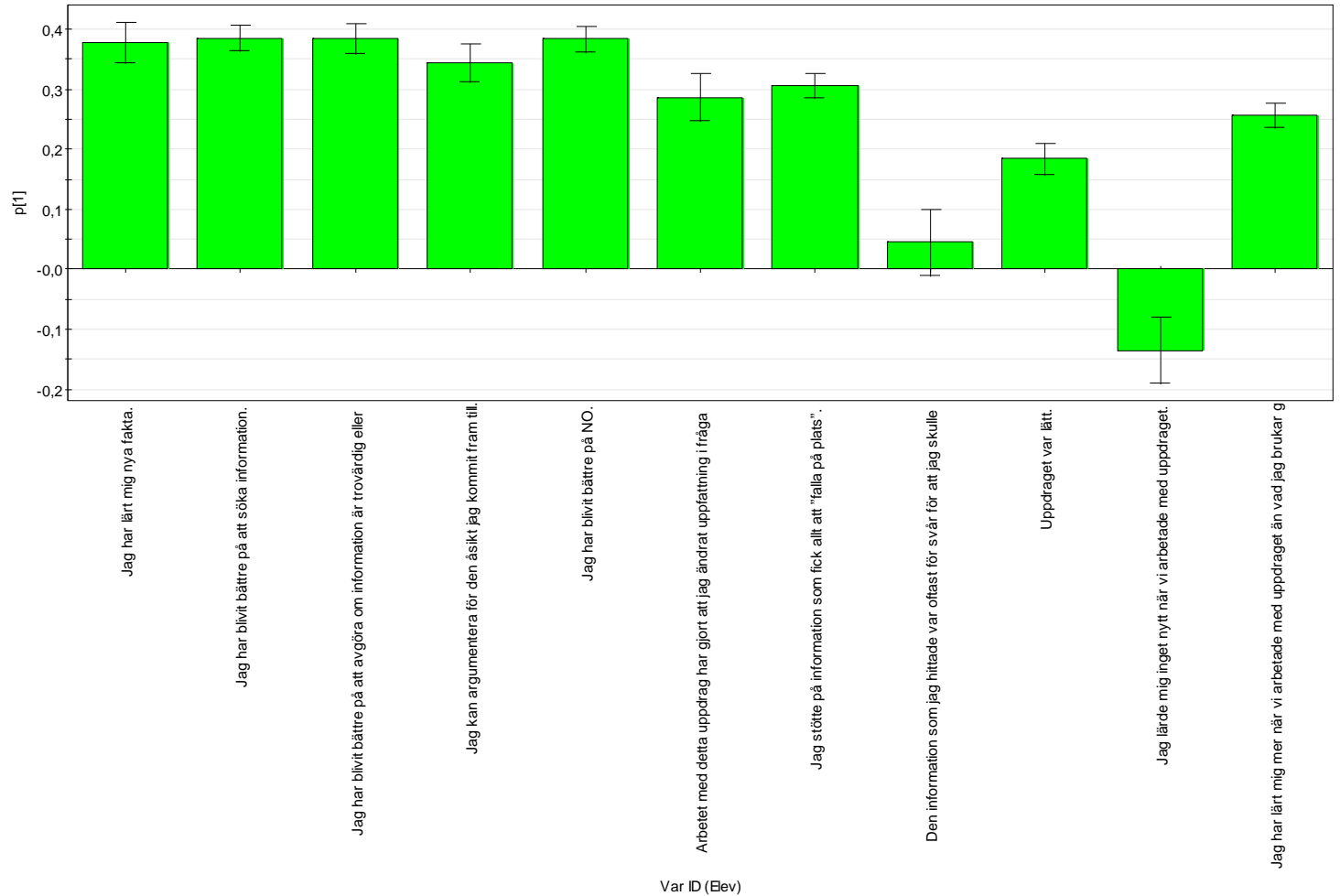
R2X[1] = 0,149921 R2X[2] = 0,108977

SIMCA-P+ 11 - 2008-06-02 20:40:28

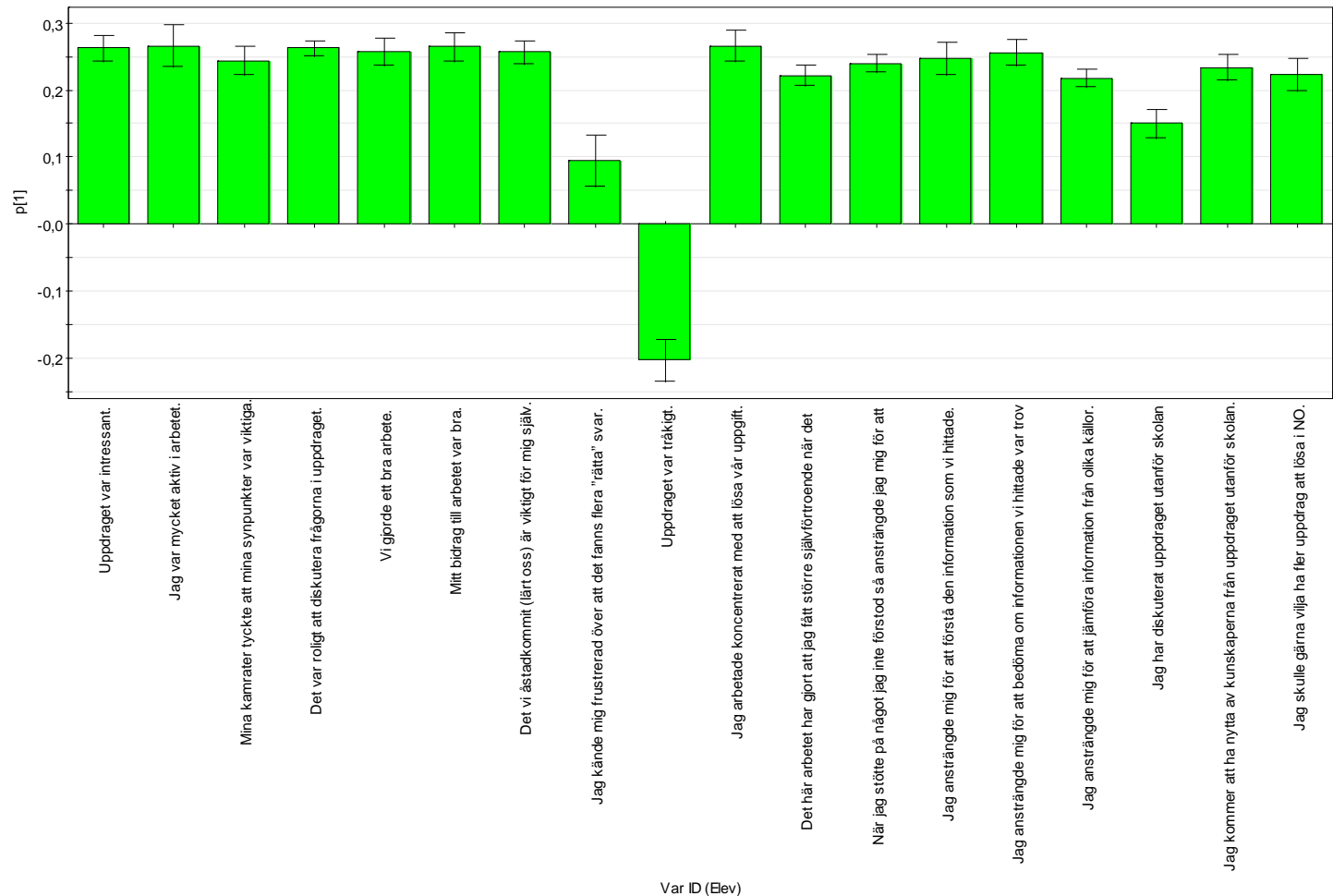
# Students scores on the 17 original SSI-variables (17) are condensed into to 3 new variables

Obs ID (Primary)	Obs ID (Klass)	SSI work forms.t[1]	SSI work forms.t[2]	SSI work forms.t[3]
1001	k1	0,0968416	0,714331	0,68492
1002	k1	0,585207	-0,514674	0,61226
1003	k1	0,835925	-0,305806	0,302621
1004	k1	1,57174	-1,27065	-1,57449
1005	k1	-1,16318	-0,368735	0,388579
1006	k1	0,601566	-0,395448	1,74385
1007	k1	-1,24767	-1,96408	-0,520295
1008	k1	0,360199	-3,12196	0,241689
1009	k1	-1,39461	1,05845	1,3334
1010	k1	-1,82256	-1,46825	0,802342
1011	k1	0,258272	-0,989461	1,07062
1012	k1	-1,59299	-2,33919	0,370512
1013	k1	-0,166452	-2,28577	0,663077
1014	k1	-0,624798	0,751691	0,325756
1015	k1	0,803529	-0,650214	2,08034
1016	k1	0,918887	-0,932716	0,152874
1017	k1	-2,16136	-0,98013	-0,379588
1018	k1	2,57908	-1,51995	-1,0218
1019	k1	-3,7894	0,342161	-1,04223
1020	k1	0,566496	-1,6093	1,41954
1021	k1	0,610989	-2,37593	1,3644
1022	k1	0,983734	-3,14479	1,25121
1023	k1	-0,668987	-0,414911	-1,3708
1024	k1	-0,61901	1,06094	-0,0235017
1025	k1	0,323662	-2,02597	0,880764
1026	k1	-2,08344	0,0538481	0,785675
1027	k1	-1,3157	-1,88513	-0,0330383
1906	k1	0,82364	-2,47772	-0,925137
1206	k11	1,36704	-0,675007	-2,15833
1207	k11	0,711186	2,58343	-0,745352
1209	k11	-5,4088	-1,20987	-0,588157

# 1:st component of 'Cognitive outcomes' base model



# 1:st component of 'Affective and Motivational Outcomes' base model

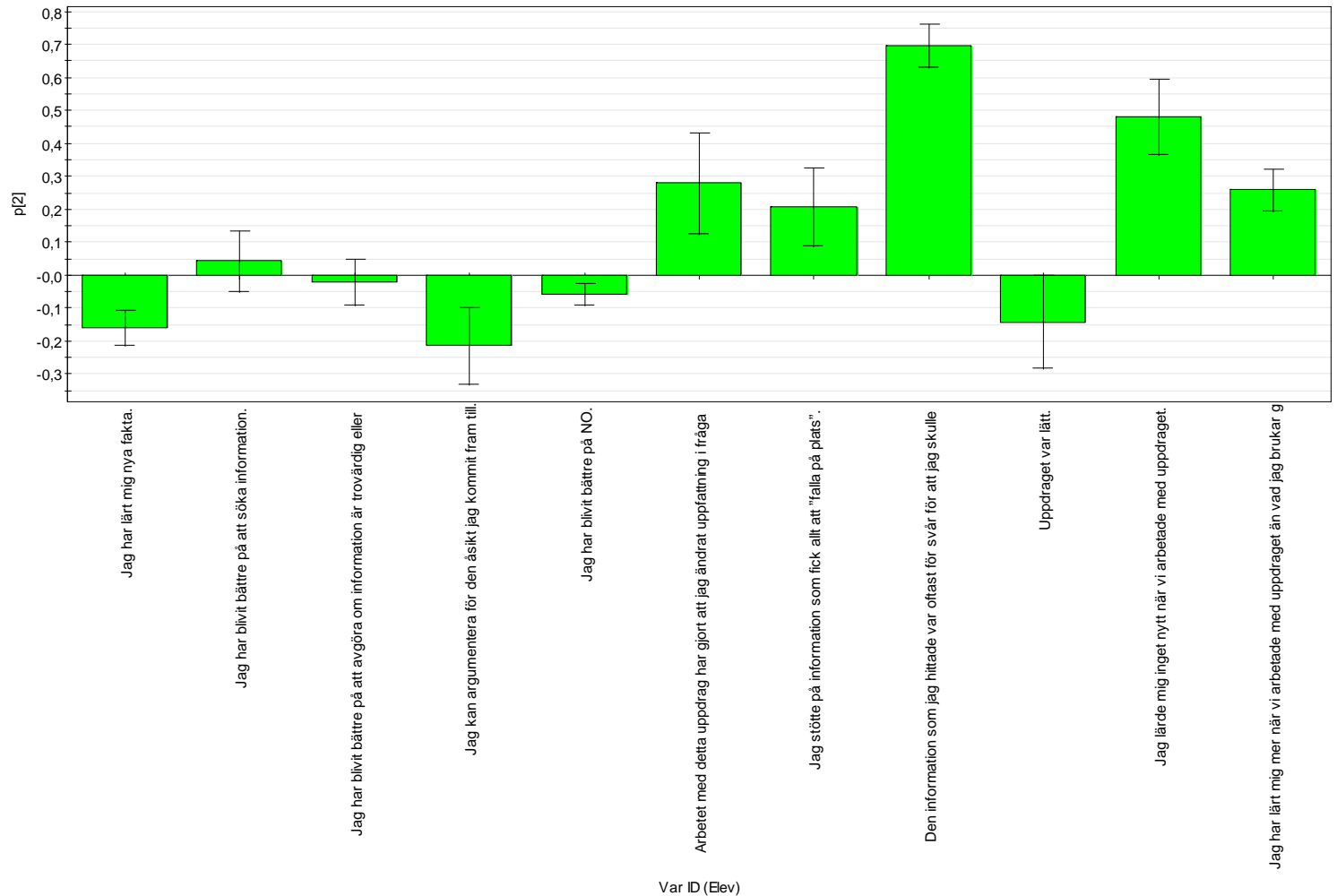


Var ID (Elev)

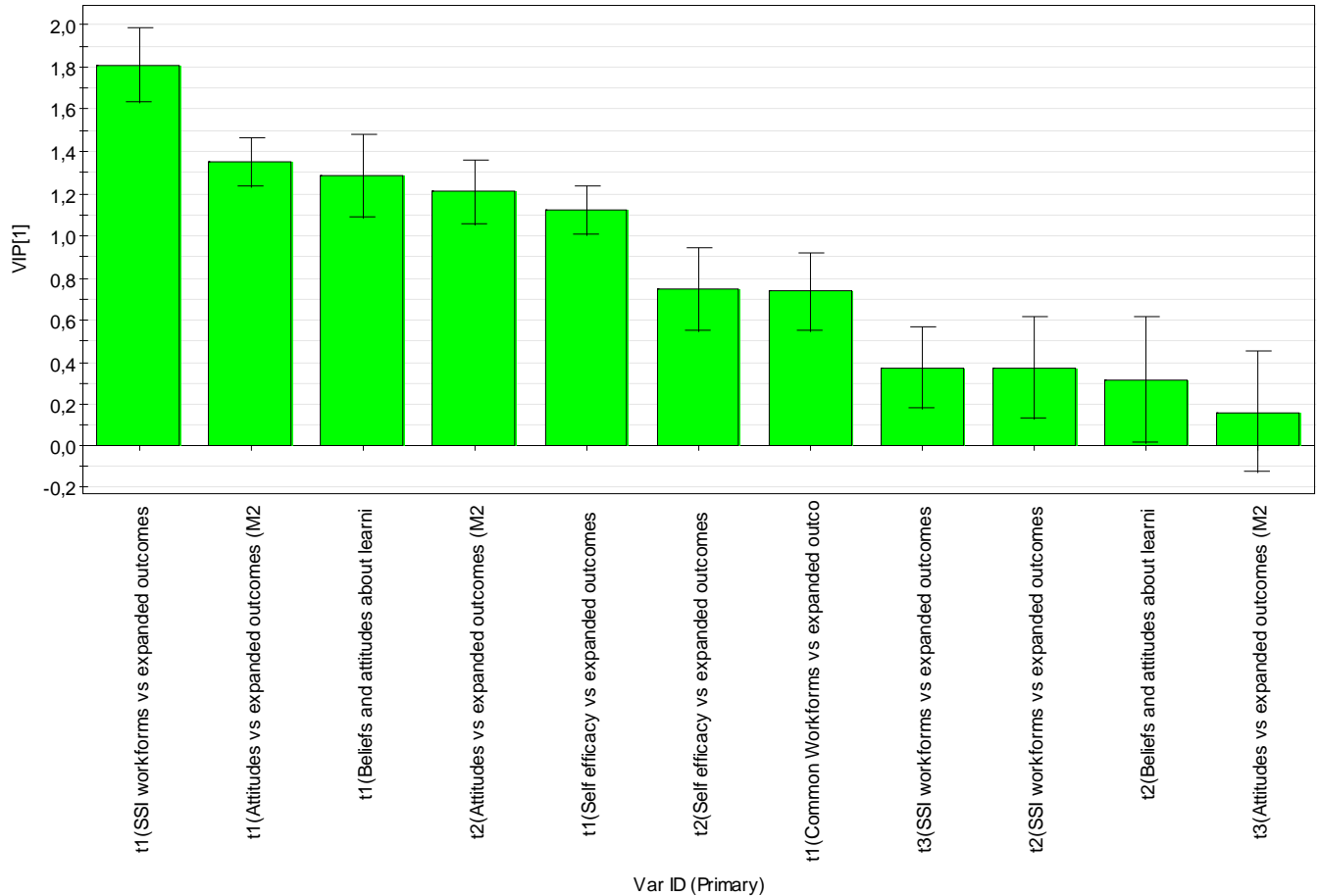
R2X[1] = 0,349895

SIMCA-P+ 11 - 2008-05-19 17:10:02

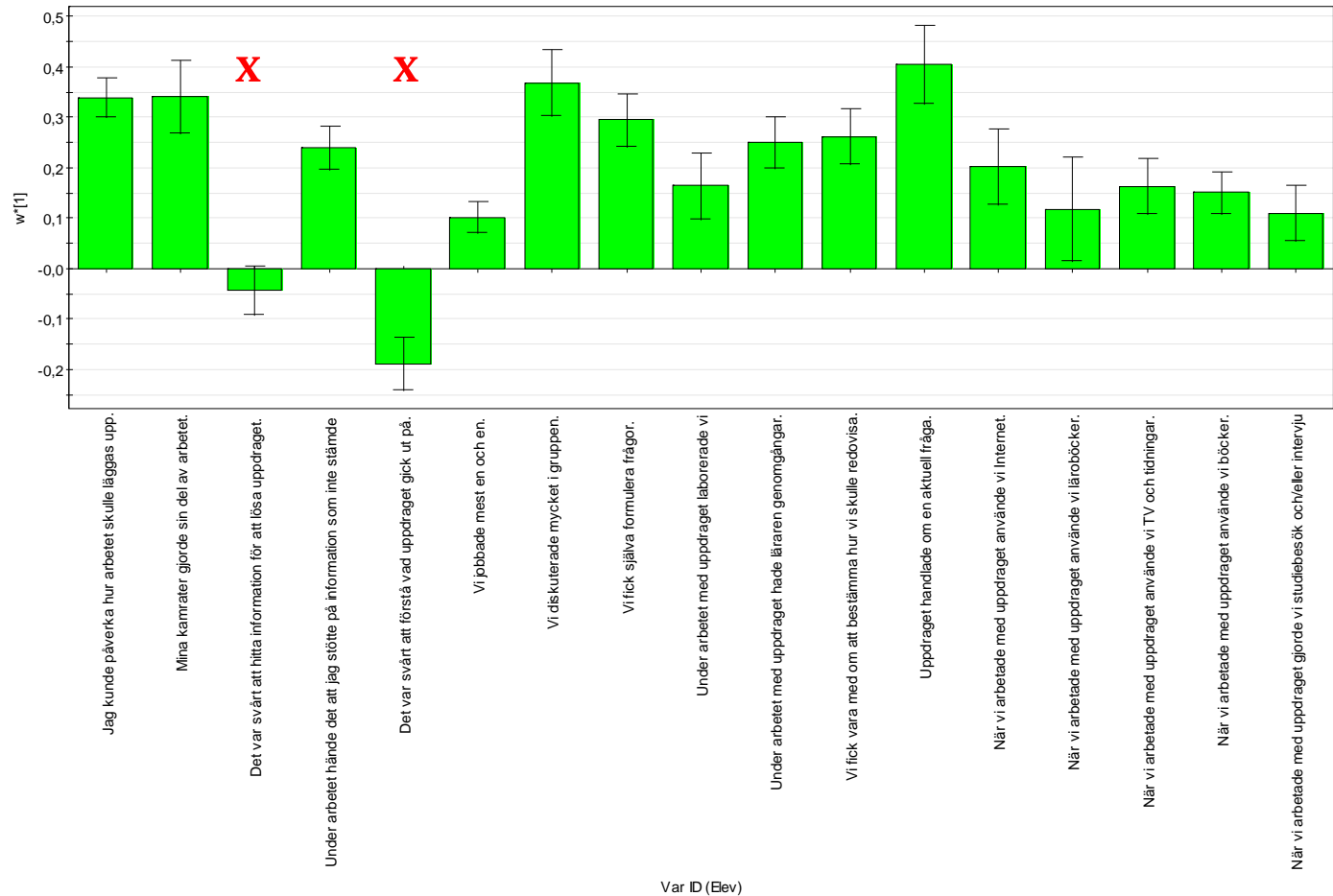
# 2:nd component of 'Cognitive outcomes' base model



# Relative importance of base model components to explain positive affective and cognitive outcomes



# 1:st component in the 'SSI-work forms' base model

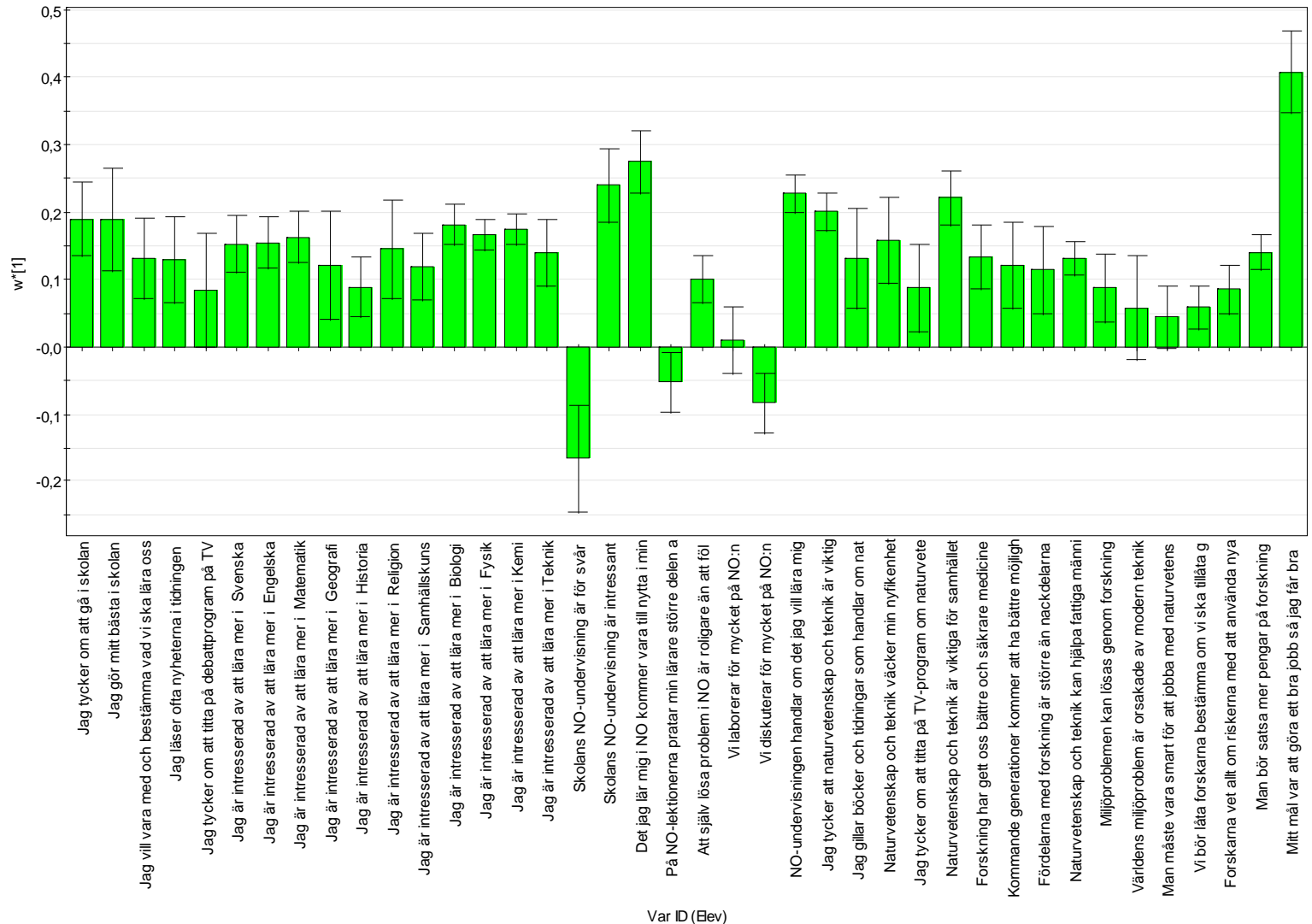


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R2X[1] = 0,149921

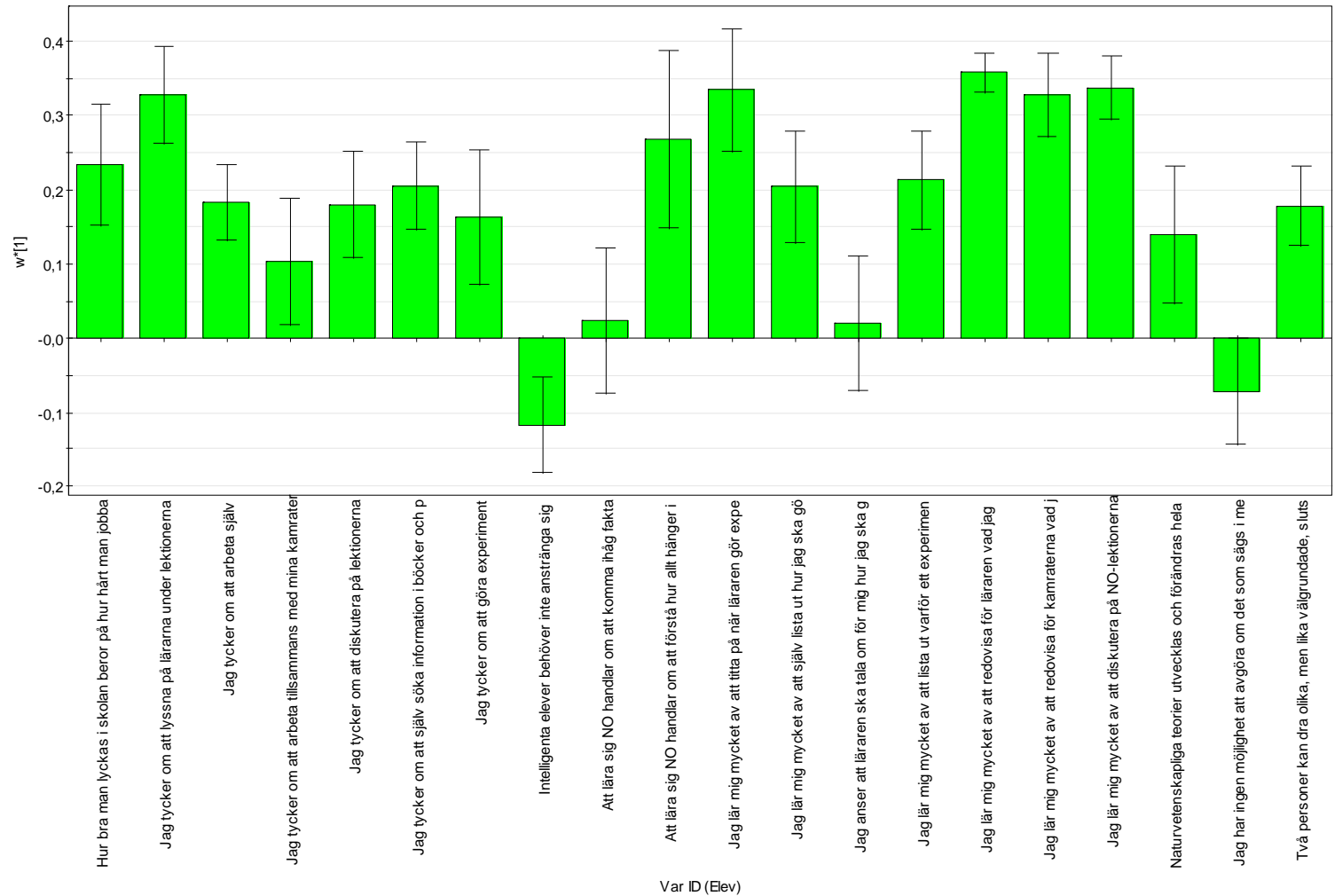
SIMCA-P+ 11 - 2008-05-14 15:43:30

# 1:st component in the 'Attitudes...' base model

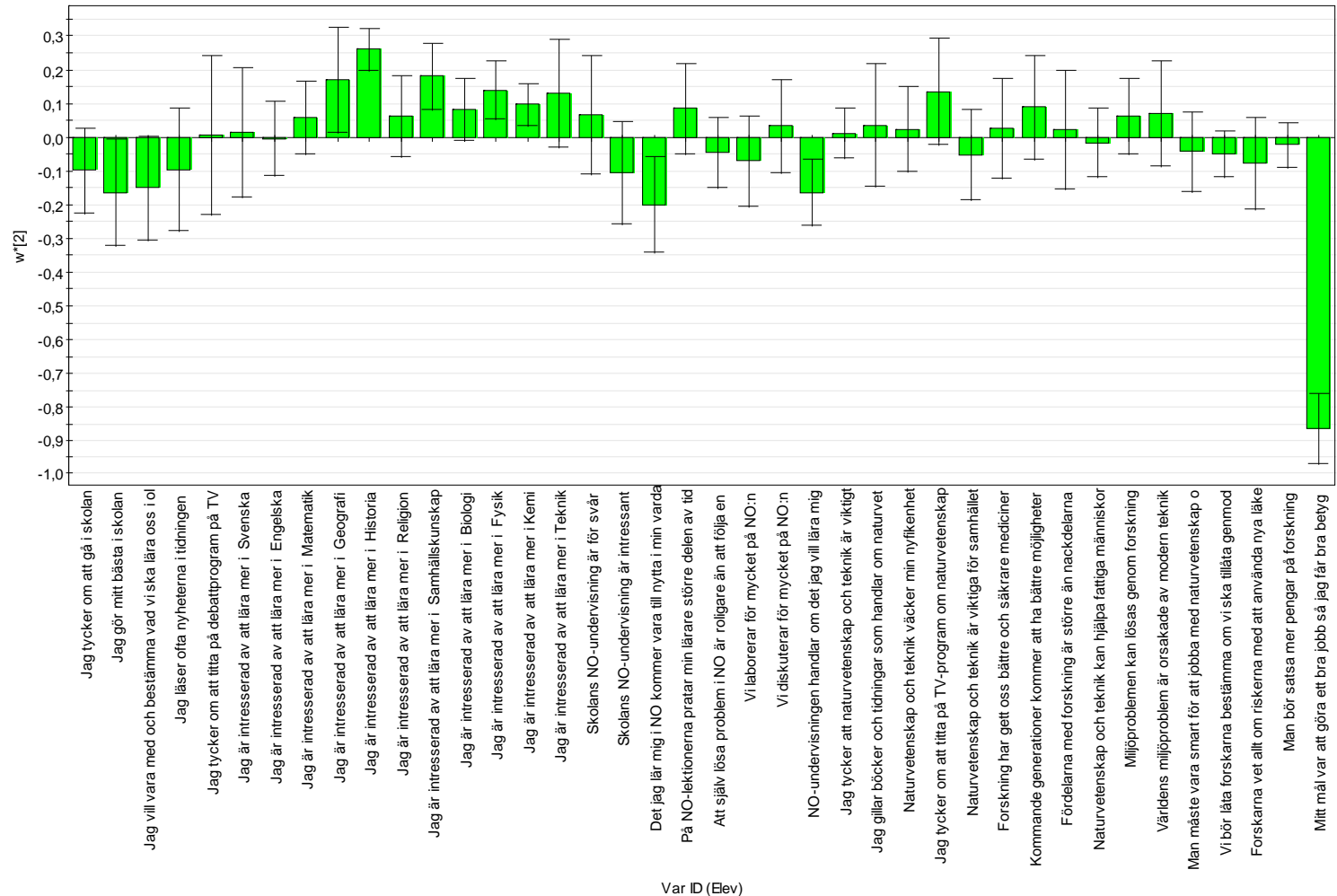


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# 1:st component of the 'Beliefs and attitudes about learning' base model



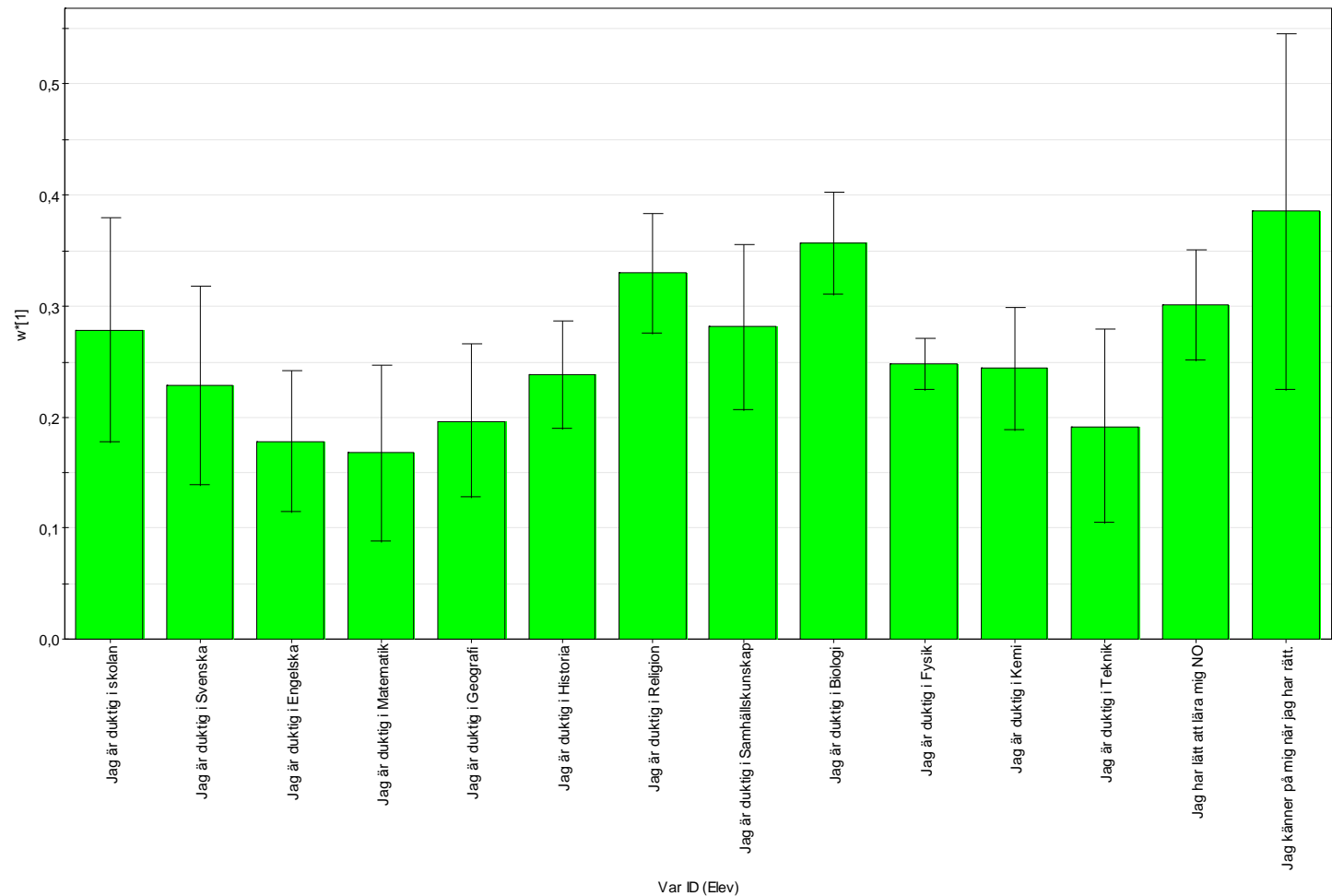
# 2:nd component of 'Attitude' base model



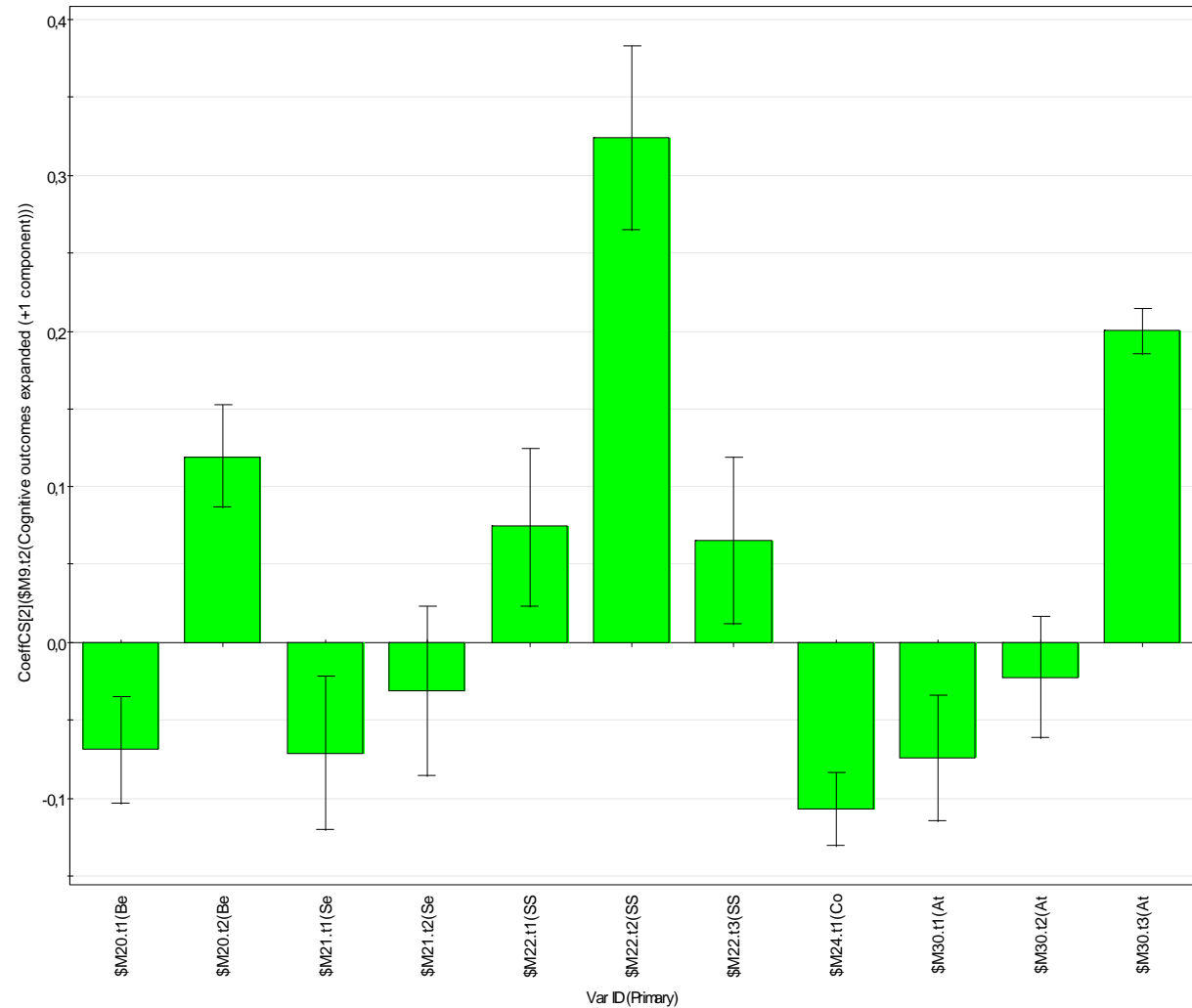
R2X[2] = 0,0459961

SIMCA-P+ 11 - 2008-05-15 16:00:41

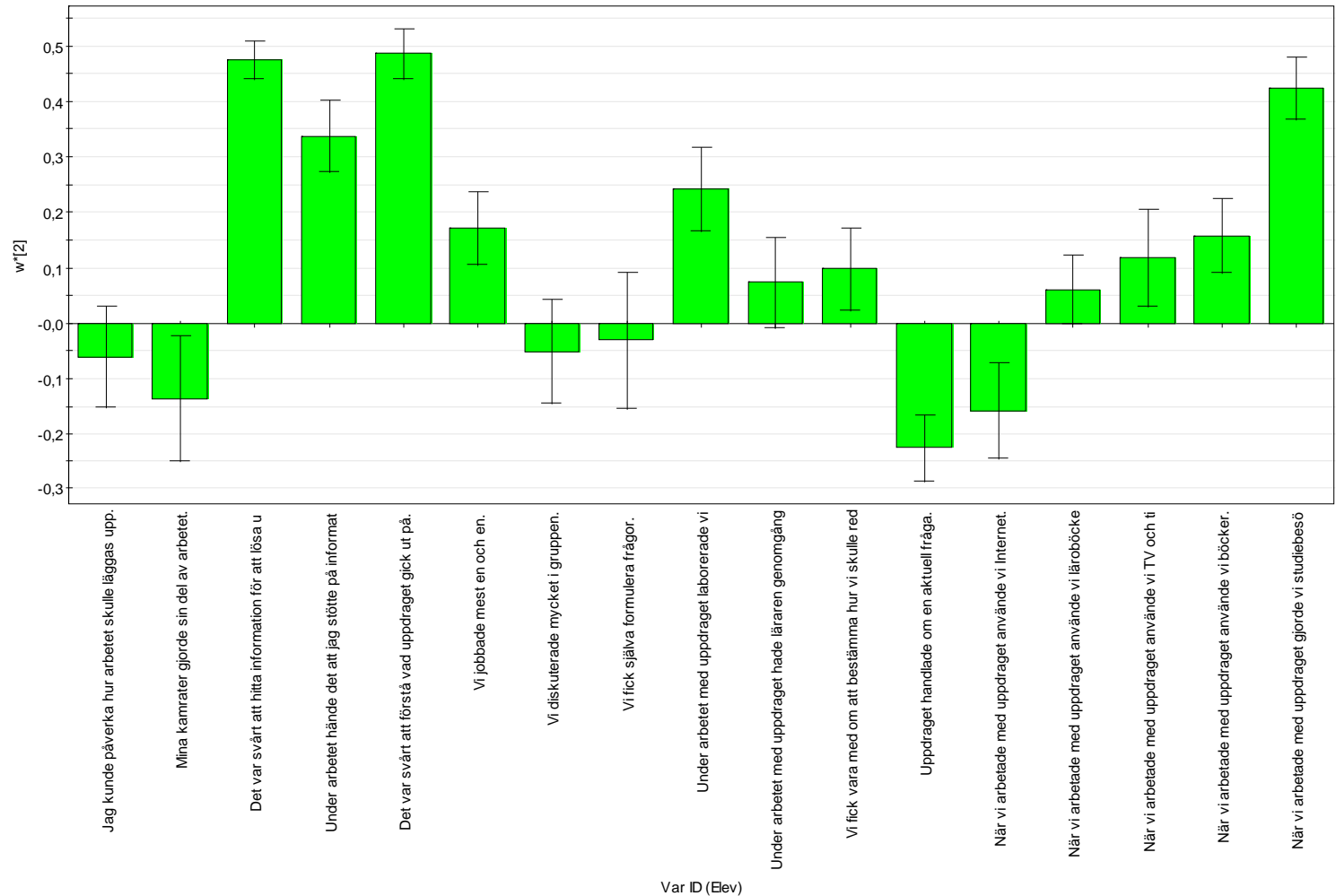
# 1:st component of 'Self Efficacy' base model



# The relative importance of base model components for explaining *negative* cognitive outcome

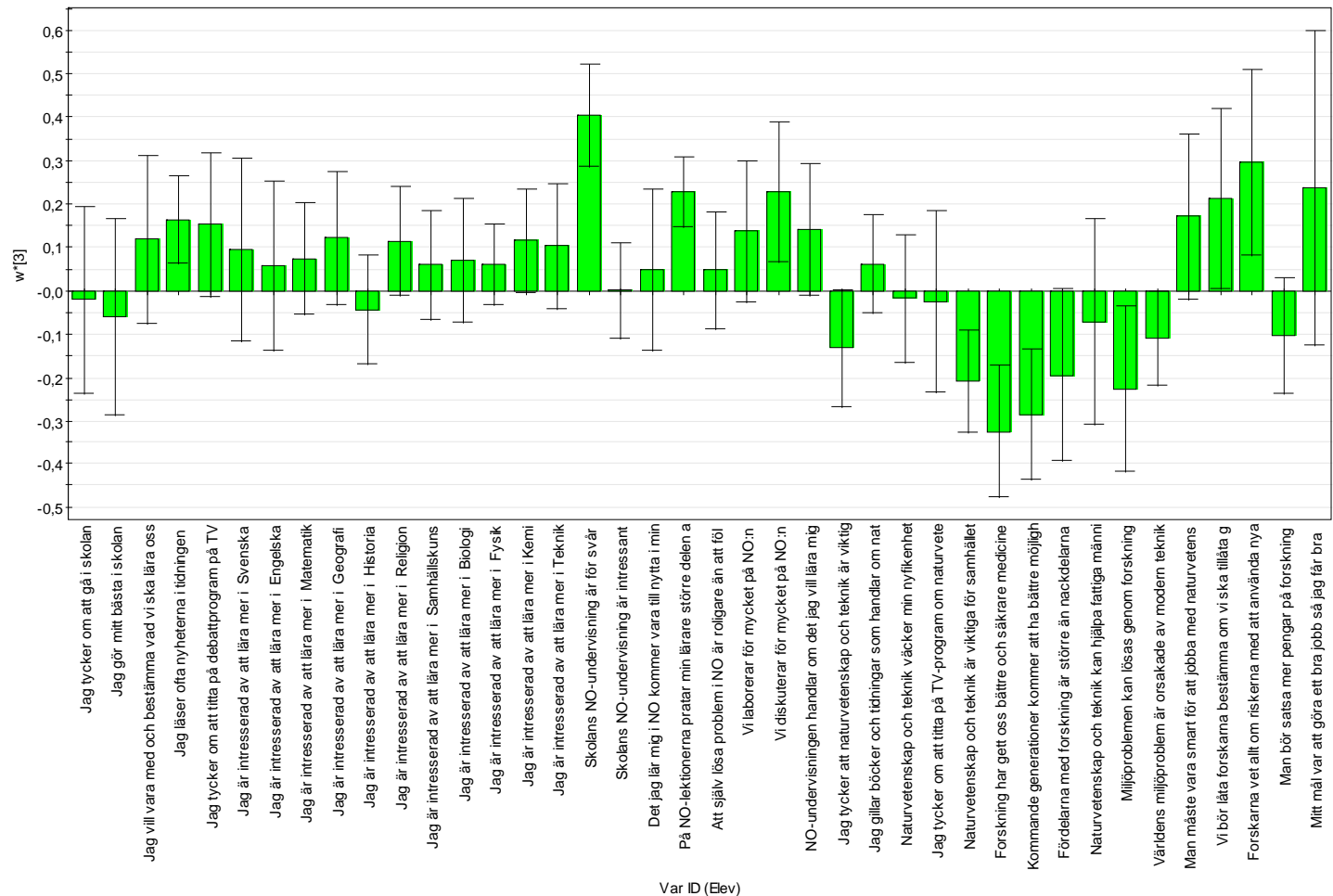


# 2:nd component in 'SSI work forms' base model



# 3:rd component in 'Attitudes' base model

Databas SISC 080430 på slutlig databas.M30 (PLS), Attitudes vs expanded outcomes (M23), minus post-attitudes  
 $w^*[Comp. 3]$



R2X[3] = 0,0526231

SIMCA-P+ 11 - 2008-05-15 16:46:58