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Abstraction level of a physics test and intelligence quotients

The measurement

Hungary, Baranya county, 1999.
Number of schools: 69
Number of pupils: 442
Number of classes: 23
The Physics test contained 16 tasks, having 38 items
Pupils' working time: 45min.
Pupils' age: 12 years

Classification of tasks by the degree of their abstraction level

P PHENOMENON: if the answer requires the knowledge of a physical phenomenon.
N NOTION: if the answer requires the knowledge of a physical concept (notion).
V VISUAL REPRESENTATION OF A CONCEPT (NOTION): The next level of abstraction, which contains connection and function diagram too.
R RELATION: when the pupil must make a judgement about <, =, > relations.
L LAW: when the pupil must know the quantitative relation or formula among certain physical quantities.
U UNIT OF MEASURE: when the pupil must write a unit of measure as an answer.
C CALCULATION: when the pupil must make a calculation (computation) to get the result.

Representation of the abstraction levels of a physics test

The pass mark was decided for each category. It is shown in Table:

Table 1. Maximum, mean and limit of different item categories

CATEGORY	*MAXIMUM*	*MEAN*	*PASS MARK*
J	2	1,04	1
F	6	2,11	2
V	6	1,83	2
R	6	1,67	2
T	4	0,99	1
M	4	0,79	1
S	10	1,39	3

Table 2. shows the points reached by pupils in class No. 23. and their Intelligent Quotients. Later we explain the notation of IQs.

Table 2. The points reached by pupils in class No. 23. and their IQ values

	P	*N*	*V*	*R*	*L*	*U*	*C*	*W*	*BM*	*M*	*G*	*VG*	*R*	*E*
1.	0	0	0	0	0	1	1							1
2.	2	0	0	1	0	0	0			1				
3.	2	0	0	2	0	0	0							1
4.	0	0	0	0	0	0	0				1			
5.	2	0	1	2	0	0	3					1		
6.	0	0	0	2	0	0	1			1				
7.	0	0	0	1	0	1	1				1			
8.	0	0	0	1	0	1	1			1				
9.	0	0	0	2	0	1	1			1				
10.	2	0	0	3	0	0	3			1				
11.	0	2	0	0	0	0	0		1					
12.	2	0	0	2	0	1	1						1	
13.	2	0	0	1	0	0	3							1
14.	0	0	0	0	0	0	1			1				
15.	0	0	0	1	0	1	1							1
16.	2	1	0	0	0	1	1				1			
17.	0	0	0	1	0	1	1			1				
18.	0	1	0	1	0	0	2				1			
19.	2	0	0	0	0	1	1							1
20.	0	4	3	1	0	1	3				1			

A binary table was made on the basis of Table 2.

Table 3. Binary table of class No. 23. Tasks on different abstraction levels

Pupils	*P*	*N*	*V*	*R*	*L*	*U*	*C*
1	0	0	0	0	0	1	0
2	1	0	0	0	0	0	0
3	1	0	0	1	0	0	0
4	0	0	0	0	0	0	0
5	1	0	0	1	0	0	1
6	0	0	0	1	0	0	0
7	0	0	0	0	0	1	0
8	0	0	0	0	0	1	0
9	0	0	0	1	0	1	0
10	1	0	0	1	0	0	1
11	0	1	0	0	0	0	0
12	1	0	0	1	0	1	0
13	1	0	0	0	0	0	1
14	0	0	0	0	0	0	0
15	0	0	0	0	0	1	0
16	1	0	0	0	0	1	0
17	0	0	0	0	0	1	0
18	0	0	0	0	0	0	0
19	1	0	0	0	0	1	0
20	0	1	1	0	0	1	1

The Galois-graph on *Fig. 1.* was made on the basis of *Table 3.*

In this graph, any point means a maximal group in which all pupils solved a certain maximal group of task categories. On the other hand, this point means the maximal group of task categories in question that all members of the pupils' group solved too.

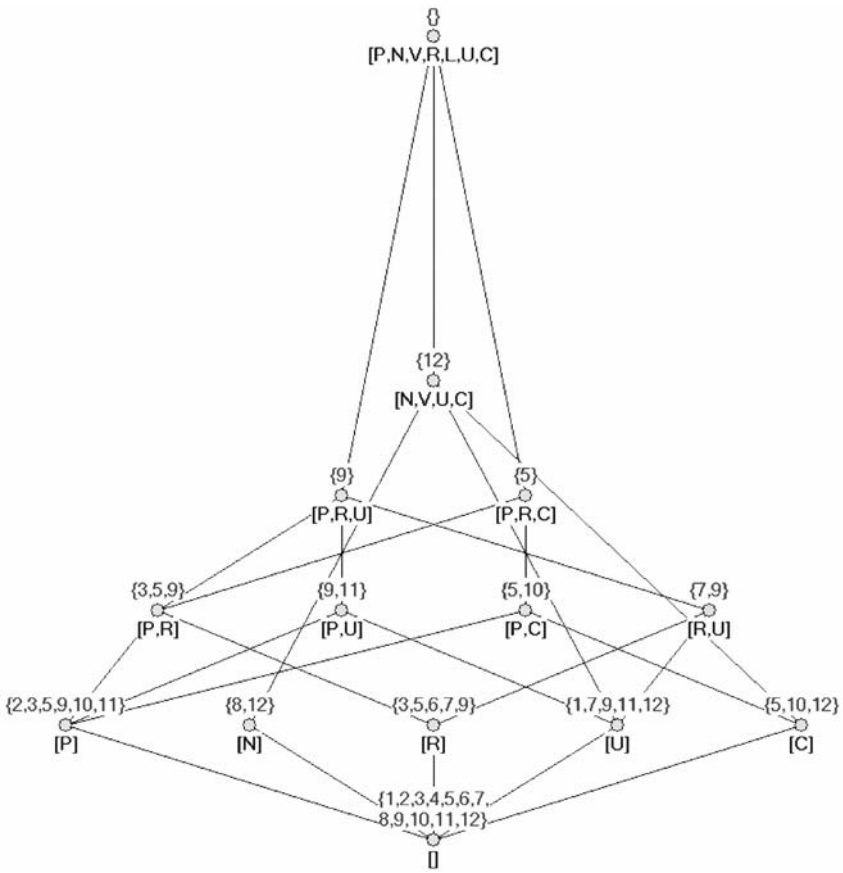

Figure 1. The Galois-graph of class No.23. Different abstraction level of tasks – Pupils

The graphs of all the 23 classes were prepared the same way. This series of drawing gives conclusions for teaching but here it is used for one goal only: to read off the pupils' solution of the maximum number of tasks in all classes.

Iq – the pupils' intelligence quotients

IQ	*Category*	*Notation*
0–69	Weak	W
70–89	Below the mean	B
90–109	Mean	M
110–119	Good	G
120–129	Very good	VG
130–139	Remarkable	R
Above 140	Exceptional	E

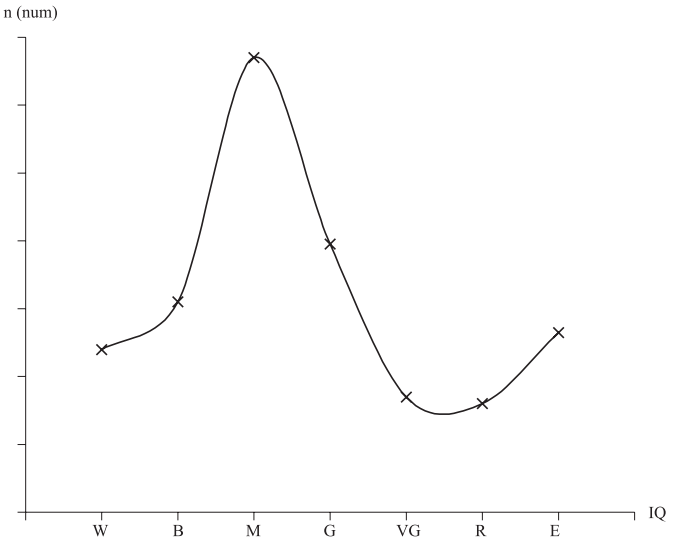

Figure 2. Distribution of the pupils' IQ categories

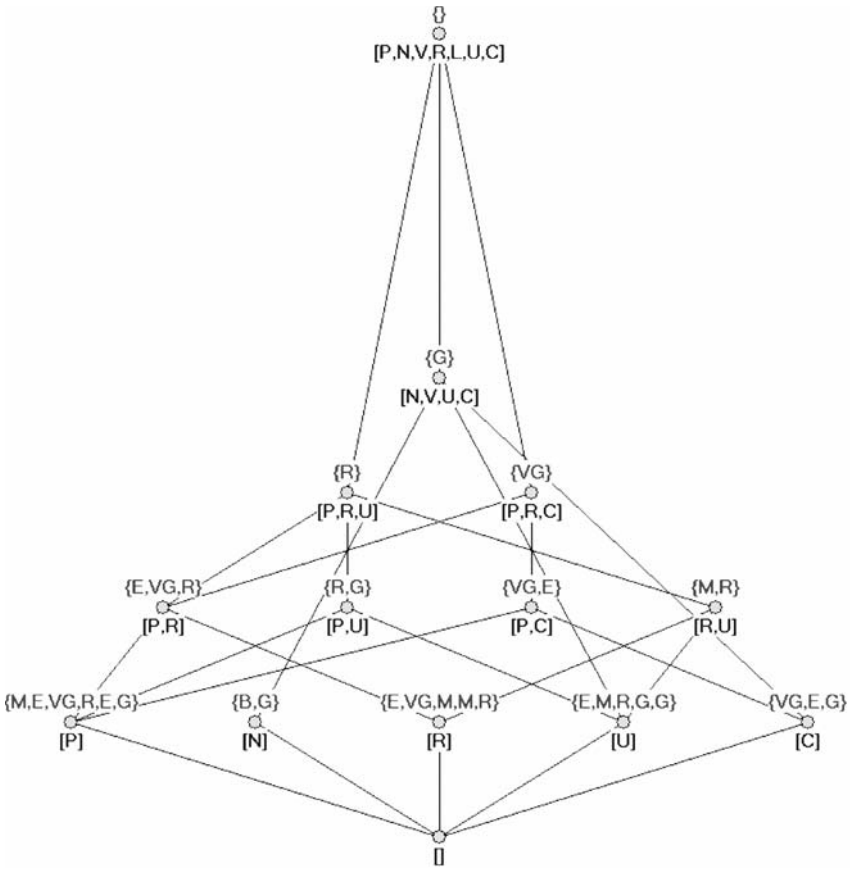

Figure 3. The Galois-graph of class No.23. Items having different abstraction levels – pupils' IQ values

Relations: achievement – abstraction level – IQ

We read off what items of abstraction level are related to each IQ category by classes. E.g. in *Fig. 2*., one can see that the solved maximum number of items reached are N, V, U and C abstraction level having G IQ. P is solved too, but this group did not solve the maximum number of items among G–S. In this way one gets the following data, shown in *Table 4.*

Table 4. Table of AC – AL – IQ, class No.23. (Actually in this class there is no W)

	W	*B*	*M*	*G*	*VG*	*R*	*E*
P		0	0	0	1	1	1
N		1	0	1	0	0	0
V		0	0	1	0	0	0
R		0	1	0	1	1	1
L		0	0	0	0	0	0
U		0	1	1	0	1	0
C		0	0	1	1	0	1

One has to make the procedure for all the 23 classes and finally unify these tables. The next table shows the means of 49 columns from W – P to E – C.

Table 5. United results of AC – AL – IQ (Achievements by %)

AL - IQ	*P*	*N*	*V*	*R*	*L*	*U*	*C*	*Mean*
W	59	65	65	59	82	65	23	60
B	45	70	65	55	85	45	10	54
M	77	73	68	73	82	77	45	71
G	74	95	68	68	84	84	47	74
VG	69	69	46	54	69	62	38	51
R	79	79	79	79	79	86	50	76
E	86	64	71	86	86	93	57	78
Mean	*70*	*74*	*66*	*68*	*81*	*73*	*39*	–

These three variations give the possibility for two diagrams.

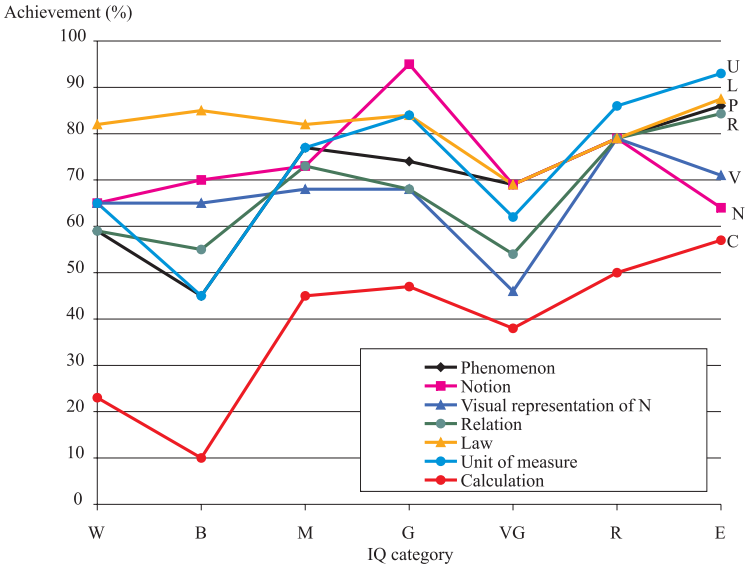

Figure 4. Function AC - IQ (Achievement as a function of IQ)

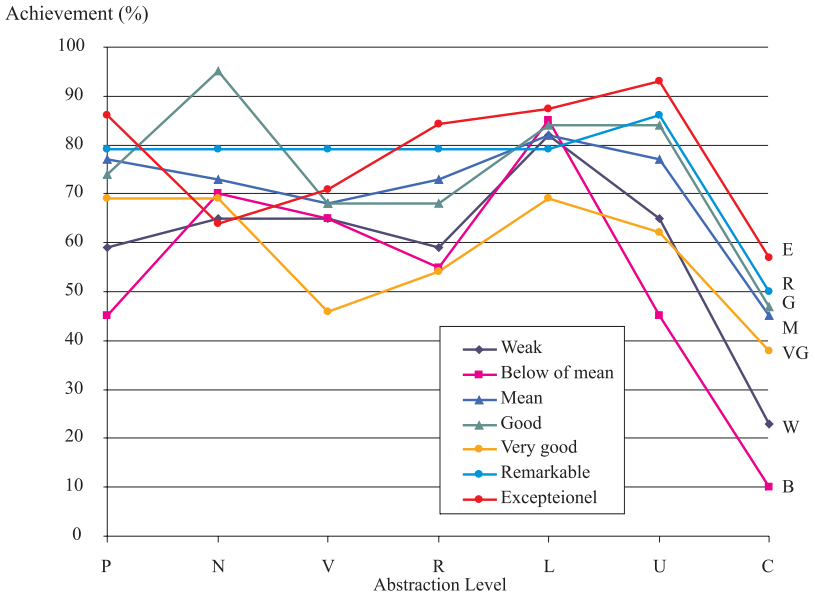

Figure 5. Function AC – AL (Achievement as a function of Abstraction Level)

Diagram analysis

Let us analyse the seven curves of *Fig. 4*. All of them show a gently increasing tendency. It means that, in general, if the IQ increases, the pupils' achievement increases too.

The curve of C (Calculation) is situated essentially lower than the others, independently of IQ.

The order of abstraction levels based upon the % values are the following:

L – Law	81
N – Notion	74
U – Unit of measure	73
P – Phenomenon	70
R – Relation	68
V – Visual representation of N	66
C – Calculation	39

Let us now analyse the other seven curves of *Fig.5*. All of them show a gently decreasing tendency. The order of IQ categories are the following, based upon the visual representation and also the % values:

VG – Very Good	51
B – Below the mean	54
W – Weak	60
M – Mean	71
G – Good	74
R – Remarkable	76
E – Exceptional	78

In both figures *(No. 4. & 5.)* one can see a certain anomaly at the IQ category of VG, probably due to the special distribution of the sample, see *Fig. 2.*

Conclusions

It is not surprising that the more talented pupils' achievement – in general – is better. That is not a rigorous correspondence but rather a trend.

The same expectable result is visible in *Fig. 5*.: in general, when the item's abstraction level grows, the pupils' achievement decreases.

A few differences occur, but they are not essential. What we cannot interpret is that items at different levels of abstraction have a local minimum at VG IQ.

The highest situations appear on *Fig. 4.* among the curves L (Law) and U (Unit of measure); however, one can suppose that the best results occur on P (Phenomenon) & N (Notion).

A possible conclusion: teachers do not take enough care of the knowledge of phenomena and notions (concepts), but they over evaluate the memorization of laws and units of measurements.

According to all our previous examinations the results of tasks that require calculations are unacceptably low.

We do not give numerical data but trends because of the method used, Galois-graphs.

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