



# Fostering Numeracy Skills and Understanding Among Students in Helsingør Municipality

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METTE THOMPSON

# 8 Guidelines

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- Students must be tested annually
- Math conferences based on the test data
- Students in difficulty must be identified and interventions initiated

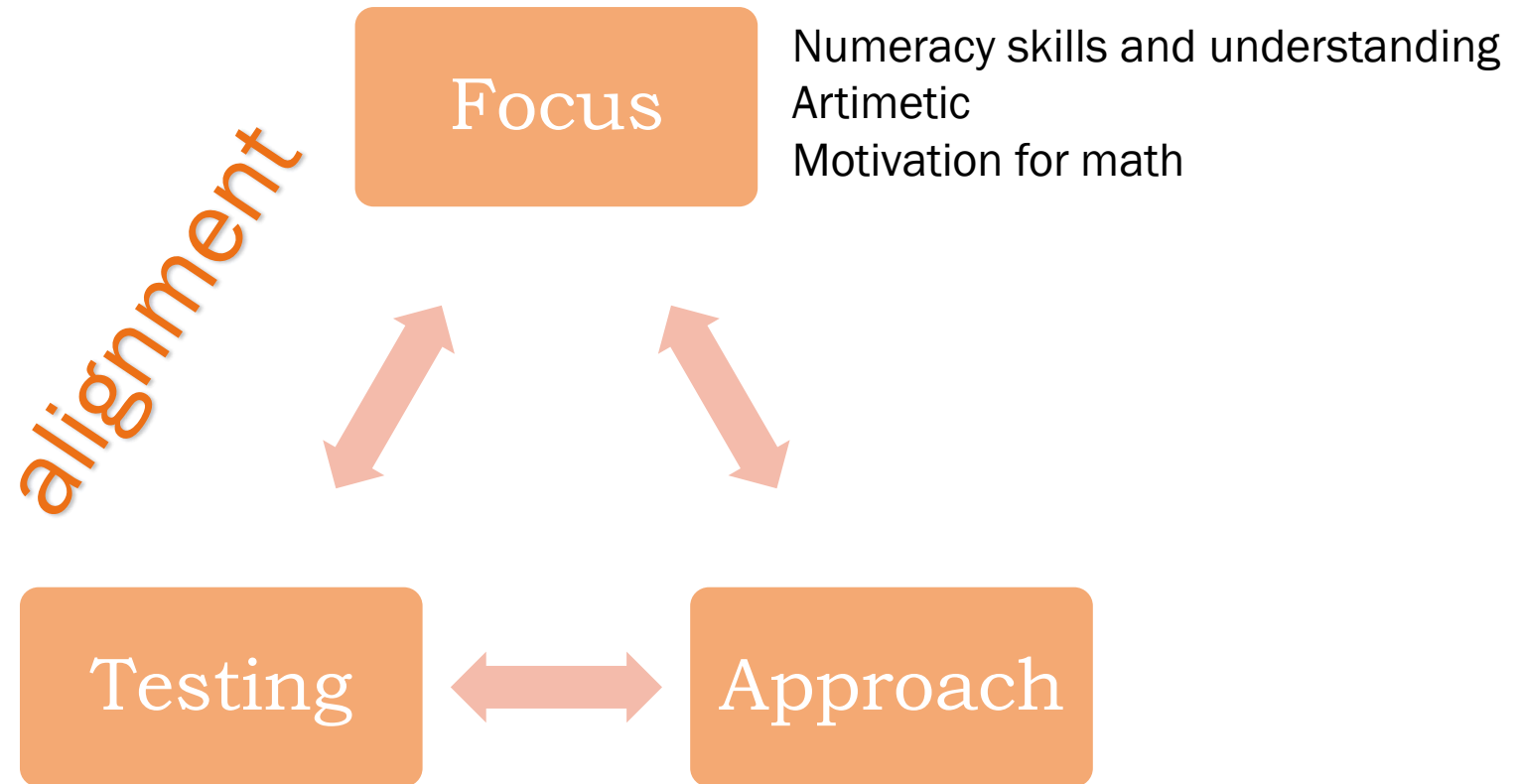


OPDATERET EFTERÅR 2020

RETNINGSLINJER  
FOR MATEMATIK FOR  
DE 0 TIL 18 ÅRIGE I  
HELSINGØR KOMMUNE

# Alignment in a trinity

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“Education is slow to change, but testing is even slower” (von der Huevel-Panhuizen, 2000)

# The back page

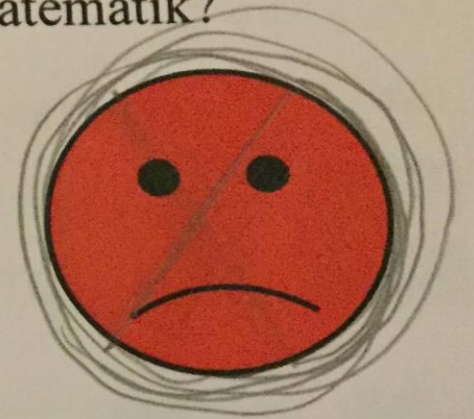
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“How do you feel for the most when you are doing mathematics?”

Red smiley is marked

“Because I am really bad at mathematics, and I get really upset with myself when I can't figure something out, and I always get stressed because I feel behind compared to others”

Hvordan har du det mest, når du laver matematik?



Fordi..... Jeg er rigtig dårlig til matematik og jeg bliver rigtig sur på mig selv, når jeg ikke kan finde ud af noget, og jeg bliver altid stresset fordi jeg føler mig bag ud i forhold til de andre



# The back page

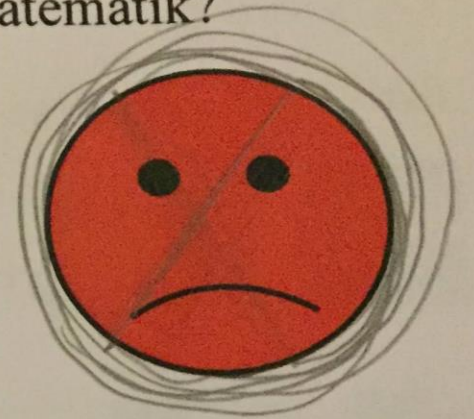
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Students with the "red smileys" have three common replies

The feeling of:

- Not being good enough
- Being upset/stressed while doing math
- Being behind/left out

Hvordan har du det mest, når du laver matematik?



Fordi..... Jeg er rigtig dårlig til matematik og jeg bliver rigtig sur på mig selv når jeg ikke kan finde ud af noget, og jeg bliver altid stresset fordi jeg føler mig bag ud i forhold til de andre



# Agenda

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- What do we know?  
From practice and research
- The design process
- Examples
- Three levels of interventions
- Findings and points of attention







# From practice we found

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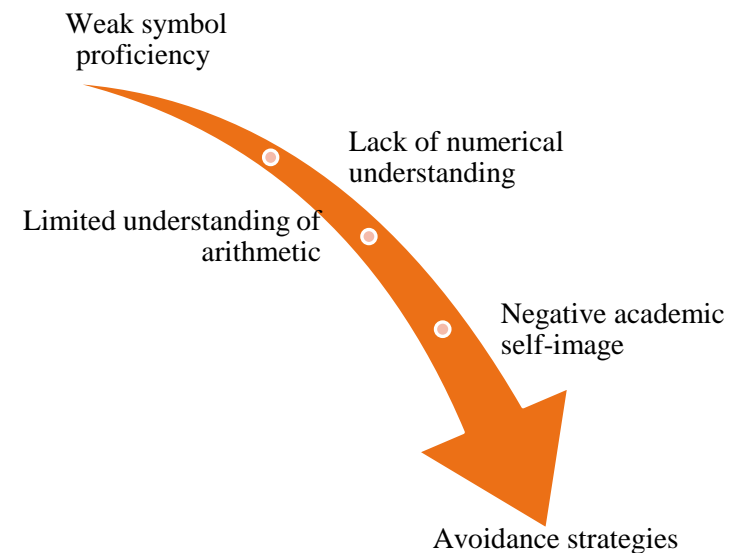
That some students have difficulty learning number names in the early grades.

It is more challenging for students to write the numbers based on dictation, compared to their ability to read a number.

They are often rigid in their use of numbers.

- 17 is 17 and not  $10+5+2$ ."

This turns into what I call  
“the downward spiral”:







# Research finds

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We are born with a natural number sense - subitizing and ANS (Feigensen et al. 2004)

Children's number sense as the ability to decompose numbers (Sowder, 1992)

Strong indicators of later math achievement:

- Early numeracy (Ngyen et al., 2016)
- Understanding of numerical magnitudes (Laski & Siegler, 2007)
- Understanding of fractions (Pedersen, 2021)
- Students early understanding of numbers and arithmetic (Sunde, 2019)

Understanding in mathematics is making connections between representations as a part of an internal network. The degree of understanding is determined by the number of links and strength of these connections (Hiebert & Carpenter, 1992).





# Definitions

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## **Numeracy skills:**

- Number sense
- Number comprehension
- Numerical magnitudes
- Symbolic proficiency

## **Numeracy understanding:**

- links and strength of connections in a internal network

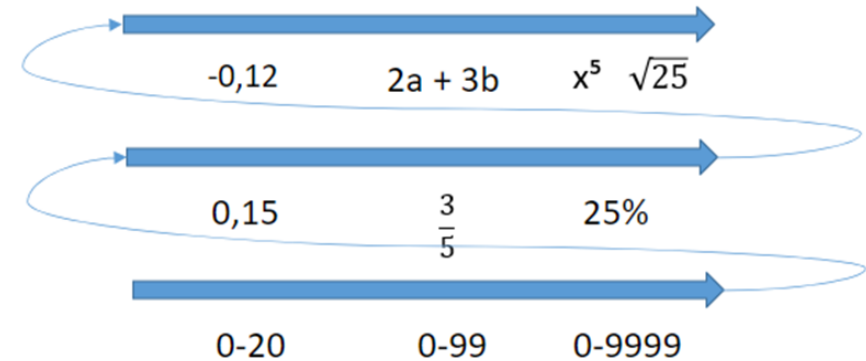
# The Design Process

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One test developed, testet on 25-50 student, changes made, re-testet until we were satisfied with the test. Then another level was developed.

40 items, maximum 30 min. – overall screening





# Examples

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

47				
74				
_7				

## Opgave 5

Dobbelt op og halvering

$\frac{1}{4}$  dobbelt op er  $\frac{2}{4}$  ✓

$\frac{1}{5}$  dobbelt op er  $\frac{2}{10}$  ✓

Eleven kan godt fordoble men ikke halvering

$\frac{1}{4}$  halveret er  $\frac{1}{2}$

$\frac{1}{5}$  halveret er  $\frac{1}{2,50}$

Sæt tallene i størrelsesorden, med det mindste tal først.

-9       $\frac{3}{4}$       3,3      -0,2      3,17  
\_\_\_\_\_

-0,9      -3,3      3,3      -0,2      3,17

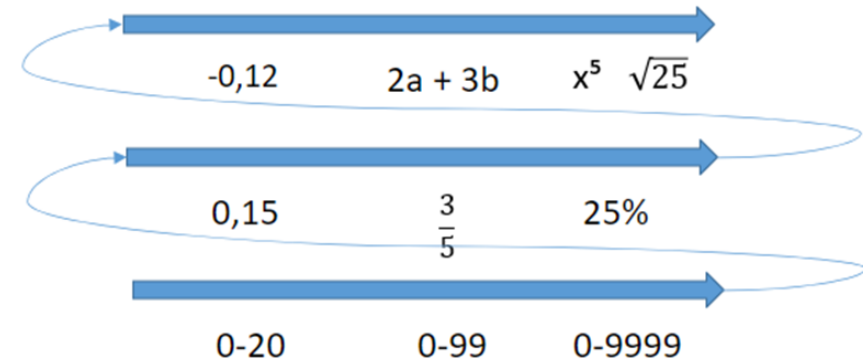
-3,3   -0,9   -0,2   3,3   3,17

# The Design Process

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Then tested on 300-400 students and Rasch analysed and the test scores are used for criterion-referenced classification of proficiency level.





# Criterion-referenced classification of proficiency levels

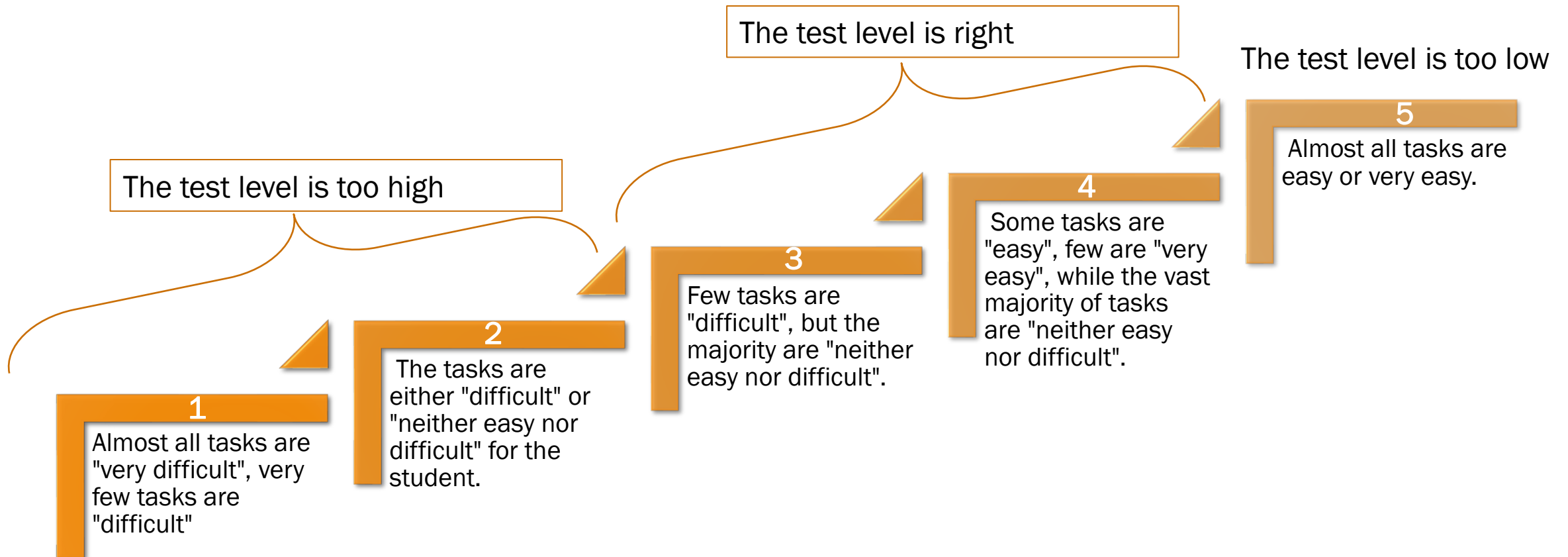
Summary

At task is...	If the probability of a...
Very easy	correct answer is greater than 90%
Easy	correct answer is greater than 75%
Difficult	wrong answer is greater than 75%
Very difficult	wrong answer is greater than 90%

Score	Theta	Very easy	Easy	----	Difficult	Very difficult
1	-4.97	0	0	0	3	36
2	-4.18	0	0	2	6	31
3	-3.68	0	0	5	3	31
4	-3.29	0	0	6	6	27
5	-2.98	0	0	8	6	25
6	-2.70	0	0	8	9	22
7	-2.46	0	0	8	10	21
8	-2.25	0	0	12	6	21
9	-2.05	0	2	12	7	18
10	-1.88	0	2	14	6	17
11	-1.72	0	3	14	6	16
12	-1.58	0	5	13	9	12
13	-1.44	0	5	14	10	10
14	-1.32	0	6	15	10	8
15	-1.22	0	7	16	11	5
16	-1.12	0	7	17	10	5
17	-1.02	2	5	18	10	4
18	-0.94	2	6	19	9	3
19	-0.85	2	8	18	10	1
20	-0.77	2	8	19	9	1
21	-0.69	3	7	20	8	1
22	-0.61	4	7	20	7	1
23	-0.52	6	7	20	6	0
24	-0.44	7	7	21	4	0
25	-0.34	7	10	21	1	0
26	-0.25	9	10	19	1	0
27	-0.15	10	11	17	1	0
28	-0.04	13	9	16	1	0
29	0.07	14	9	15	1	0
30	0.19	16	7	15	1	0
31	0.32	17	8	13	1	0
32	0.47	18	10	10	1	0
33	0.64	19	13	7	0	0
34	0.84	21	12	6	0	0
35	1.08	25	9	5	0	0
36	1.40	31	5	3	0	0
37	1.86	34	4	1	0	0
38	2.63	36	2	1	0	0

# Criterion-referenced classification of proficiency levels

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# Criterion-referenced classification of proficiency levels

Score	Theta	Very easy	Easy	----	Difficult	Very difficult
1	-4.97	0	0	0	3	36
2	-4.18	0	0	2	6	31
3	-3.68	0	0	5	3	31
4	-3.29	0	0	6	6	27
5	-2.98	0	0	8	6	25
6	-2.70	0	0	8	9	22
7	-2.46	0	0	8	10	21
8	-2.25	0	0	12	6	21
9	-2.05	0	2	12	7	18
10	-1.88	0	2	14	6	17
11	-1.72	0	3	14	6	16
12	-1.58	0	5	13	9	12
13	-1.44	0	5	14	10	10
14	-1.32	0	6	15	10	8
15	-1.22	0	7	16	11	5
16	-1.12	0	7	17	10	5
17	-1.02	2	5	18	10	4
18	-0.94	2	6	19	9	3
19	-0.85	2	8	18	10	1
20	-0.77	2	8	19	9	1
21	-0.69	3	7	20	8	1
22	-0.61	4	7	20	7	1
23	-0.52	6	7	20	6	0
24	-0.44	7	7	21	4	0
25	-0.34	7	10	21	1	0
26	-0.25	9	10	19	1	0
27	-0.15	10	11	17	1	0
28	-0.04	13	9	16	1	0
29	0.07	14	9	15	1	0
30	0.19	16	7	15	1	0
31	0.32	17	8	13	1	0
32	0.47	18	10	10	1	0
33	0.64	19	13	7	0	0
34	0.84	21	12	6	0	0
35	1.08	25	9	5	0	0
36	1.40	31	5	3	0	0
37	1.86	34	4	1	0	0
38	2.63	36	2	1	0	0

Score = 8, Person parameter = -2.25

Difficult items: Opg1\_37 Opg2\_17 Opg2\_22 Opg3\_69 Opg4\_48 Opg4\_51  
 Very difficult items: Opg1\_74 Opg1\_52 Opg1\_69 Opg1\_91 Opg1\_83 Opg3\_99 Opg3\_100  
 Opg4\_16 Opg4\_23 Opg4\_26 Opg4\_32 Opg4\_62 Opg4\_20 Opg4\_18 Opg4\_24 Opg5\_69 Opg5\_83  
 Opg5\_95 Opg5\_36 Opg5\_42 Opg5\_50

Item	0	1	Mean	SD
Opg1_14	0.497	0.503	0.50	0.50
Opg1_40	0.559	0.441	0.44	0.50
Opg1_74	0.907	0.093	0.09	0.29
Opg1_17	0.695	0.305	0.31	0.46
Opg1_52	0.963	0.037	0.04	0.19
Opg1_69	0.962	0.038	0.04	0.19
Opg1_37	0.783	0.217	0.22	0.41
Opg1_91	0.976	0.024	0.02	0.19
Opg1_83	0.961	0.039	0.04	0.19
Opg2_13	0.719	0.281	0.28	0.45
Opg2_17	0.849	0.151	0.15	0.36
Opg2_22	0.811	0.189	0.19	0.39
Opg3_6	0.271	0.729	0.73	0.44
Opg3_8	0.271	0.729	0.73	0.44
Opg3_14	0.382	0.618	0.62	0.49
Opg3_17	0.382	0.618	0.62	0.49
Opg3_32	0.330	0.670	0.67	0.47
Opg3_33	0.429	0.571	0.57	0.49
Opg3_69	0.764	0.236	0.24	0.42
Opg3_99	0.917	0.083	0.08	0.28
Opg3_100	0.937	0.063	0.06	0.24
Opg4_8	0.712	0.288	0.29	0.45
Opg4_16	0.965	0.035	0.03	0.18
Opg4_23	0.970	0.030	0.03	0.17
Opg4_26	0.996	0.004	0.00	0.06
Opg4_32	0.995	0.005	0.01	0.07
Opg4_62	0.950	0.050	0.05	0.22
Opg4_48	0.794	0.206	0.21	0.40
Opg4_46	0.727	0.273	0.27	0.45
Opg4_51	0.849	0.151	0.15	0.36
Opg4_20	0.942	0.058	0.05	0.23
Opg4_18	0.944	0.056	0.05	0.23
Opg4_24	0.980	0.020	0.02	0.14
Opg5_69	0.907	0.093	0.09	0.29
Opg5_83	0.961	0.039	0.04	0.19
Opg5_95	0.976	0.024	0.02	0.15
Opg5_36	0.984	0.016	0.02	0.13
Opg5_42	0.987	0.013	0.01	0.12
Opg5_50	0.993	0.007	0.01	0.08

Score = 21, Person parameter = -0.69

Very easy items: Opg3\_6 Opg3\_8 Opg3\_32  
 Easy items: Opg1\_14 Opg1\_40 Opg1\_17 Opg3\_14 Opg3\_17 Opg3\_33 Opg4\_8  
 Difficult items: Opg1\_91 Opg4\_20 Opg4\_18 Opg5\_83 Opg5\_95 Opg5\_36 Opg5\_42  
 Opg5\_50  
 Very difficult items: Opg4\_24

Item	0	1	Mean	SD
Opg1_14	0.130	0.870	0.87	0.34
Opg1_40	0.211	0.789	0.79	0.41
Opg1_74	0.583	0.417	0.42	0.49
Opg1_17	0.200	0.800	0.80	0.40
Opg1_52	0.681	0.319	0.32	0.47
Opg1_69	0.709	0.291	0.29	0.45
Opg1_37	0.285	0.715	0.71	0.45
Opg1_91	0.763	0.237	0.24	0.43
Opg1_83	0.750	0.250	0.25	0.43
Opg2_13	0.350	0.650	0.65	0.48
Opg2_17	0.418	0.582	0.58	0.49
Opg2_22	0.362	0.638	0.64	0.48
Opg3_6	0.073	0.927	0.93	0.26
Opg3_8	0.073	0.927	0.93	0.26
Opg3_14	0.115	0.885	0.88	0.32
Opg3_17	0.115	0.885	0.88	0.32
Opg3_32	0.094	0.906	0.91	0.29
Opg3_33	0.137	0.863	0.86	0.34
Opg3_69	0.405	0.595	0.59	0.49
Opg3_99	0.378	0.622	0.62	0.48
Opg3_100	0.419	0.581	0.58	0.49
Opg4_8	0.119	0.881	0.88	0.32
Opg4_16	0.320	0.680	0.68	0.47
Opg4_23	0.310	0.690	0.69	0.46
Opg4_26	0.470	0.530	0.53	0.50
Opg4_32	0.485	0.515	0.52	0.50
Opg4_62	0.414	0.586	0.52	0.49
Opg4_48	0.448	0.552	0.52	0.50
Opg4_46	0.360	0.640	0.64	0.48
Opg4_51	0.543	0.457	0.46	0.50
Opg4_20	0.775	0.225	0.23	0.42
Opg4_18	0.781	0.219	0.22	0.41
Opg4_24	0.910	0.090	0.09	0.29
Opg5_69	0.673	0.327	0.33	0.47
Opg5_83	0.777	0.223	0.22	0.42
Opg5_95	0.831	0.169	0.17	0.37
Opg5_36	0.850	0.150	0.15	0.36
Opg5_42	0.834	0.166	0.17	0.37
Opg5_50	0.848	0.152	0.18	0.36

# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+
| Score = 6 Person parameter = -2.70 |
+-----+
```

```
Difficult items: Opg1_17 Opg1_37 Opg2_13 Opg2_22 Opg3_69 Opg4_8 Opg4_48
Opg4_46 Opg4_51
Very difficult items: Opg1_74 Opg1_52 Opg1_69 Opg1_91 Opg1_83 Opg2_17 Opg3_99
Opg3_100 Opg4_16 Opg4_23 Opg4_26 Opg4_32 Opg4_62 Opg4_20 Opg4_18 Opg4_24 Opg5_69
Opg5_83 Opg5_95 Opg5_36 Opg5_42 Opg5_50
```

Item	0	1	Mean	SD	
Opg1_14	0.619	0.381	0.38	0.49	
Opg1_40	0.667	0.333	0.33	0.47	
Opg1_74	0.948	0.052	0.05	0.22	** very difficult
Opg1_17	0.805	0.195	0.19	0.40	* difficult
Opg1_52	0.979	0.021	0.02	0.14	** very difficult
Opg1_69	0.978	0.022	0.02	0.15	** very difficult
Opg1_37	0.873	0.127	0.13	0.33	* difficult
Opg1_91	0.987	0.013	0.01	0.12	** very difficult
Opg1_83	0.976	0.024	0.02	0.15	** very difficult



# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+
| Score = 10 Person parameter = -1.88 |
+-----+
```

```
Easy items:      Opg3_6 Opg3_8
Difficult items: Opg1_74 Opg2_17 Opg3_99 Opg3_100 Opg4_51 Opg5_69
Very difficult items: Opg1_52 Opg1_69 Opg1_91 Opg1_83 Opg4_16 Opg4_23 Opg4_26
Opg4_32 Opg4_62 Opg4_20 Opg4_18 Opg4_24 Opg5_83 Opg5_95 Opg5_36 Opg5_42 Opg5_50
```

Item	0	1	Mean	SD	
Opg1_14	0.394	0.606	0.61	0.49	
Opg1_40	0.467	0.533	0.53	0.50	
Opg1_74	0.857	0.143	0.14	0.35	* difficult
Opg1_17	0.578	0.422	0.42	0.49	
Opg1_52	0.940	0.060	0.06	0.24	** very difficult
Opg1_69	0.940	0.060	0.06	0.24	** very difficult
Opg1_37	0.680	0.320	0.32	0.47	
Opg1_91	0.961	0.039	0.04	0.19	** very difficult
Opg1_83	0.942	0.058	0.06	0.23	** very difficult

# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+
| Score = 15 Person parameter = -1.22 |
+-----+
```

```
Easy items:      Opg1_14 Opg3_6 Opg3_8 Opg3_14 Opg3_17 Opg3_32 Opg3_33
Difficult items: Opg1_52 Opg1_69 Opg1_91 Opg1_83 Opg4_26 Opg4_32 Opg4_62
Opg4_20 Opg4_18 Opg5_69 Opg5_83
Very difficult items: Opg4_24 Opg5_95 Opg5_36 Opg5_42 Opg5_50
```

Item	0	1	Mean	SD	
Opg1_14	0.227	0.773	0.77	0.42	* easy
Opg1_40	0.311	0.689	0.69	0.46	
Opg1_74	0.722	0.278	0.28	0.45	
Opg1_17	0.348	0.652	0.65	0.48	
Opg1_52	0.848	0.152	0.15	0.36	* difficult
Opg1_69	0.856	0.144	0.14	0.35	* difficult
Opg1_37	0.451	0.549	0.55	0.50	
Opg1_91	0.895	0.105	0.10	0.31	* difficult
Opg1_83	0.871	0.129	0.13	0.33	* difficult



# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+  
| Score = 19. Person parameter = -0.85 |  
+-----+
```

```
Very easy items:      Opg3_6 Opg3_8  
Easy items:          Opg1_14 Opg1_40 Opg1_17 Opg3_14 Opg3_17 Opg3_32 Opg3_33  
Opg4_8  
Difficult items:     Opg1_69 Opg1_91 Opg1_83 Opg4_20 Opg4_18 Opg5_83 Opg5_95  
Opg5_36 Opg5_42 Opg5_50  
Very difficult items: Opg4_24
```

Item	0	1	Mean	SD	
Opg1_14	0.156	0.844	0.84	0.36	* easy
Opg1_40	0.239	0.761	0.76	0.43	* easy
Opg1_74	0.628	0.372	0.37	0.48	
Opg1_17	0.240	0.760	0.76	0.43	* easy
Opg1_52	0.745	0.255	0.26	0.44	
Opg1_69	0.765	0.235	0.24	0.42	* difficult
Opg1_37	0.332	0.668	0.67	0.47	
Opg1_91	0.815	0.185	0.18	0.39	* difficult
Opg1_83	0.796	0.204	0.20	0.40	* difficult

# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+
| Score = 20 Person parameter = -0.77 |
+-----+
```

```
Very easy items: Opg3_6 Opg3_8
Easy items: Opg1_14 Opg1_40 Opg1_17 Opg3_14 Opg3_17 Opg3_32 Opg3_33
Opg4_8
Difficult items: Opg1_91 Opg1_83 Opg4_20 Opg4_18 Opg5_83 Opg5_95 Opg5_36
Opg5_42 Opg5_50
Very difficult items: Opg4_24
```

Item	0	1	Mean	SD	
Opg1_14	0.143	0.857	0.86	0.35	* easy
Opg1_40	0.225	0.775	0.78	0.42	* easy
Opg1_74	0.606	0.394	0.39	0.49	
Opg1_17	0.220	0.780	0.78	0.41	* easy
Opg1_52	0.714	0.286	0.29	0.45	
Opg1_69	0.738	0.262	0.26	0.44	
Opg1_37	0.308	0.692	0.69	0.46	
Opg1_91	0.790	0.210	0.21	0.41	* difficult
Opg1_83	0.774	0.226	0.23	0.42	* difficult

# TF2 task 1

## Opgave 1

Taldiktat. Skriv de tal, som din lærer siger

9	14	40	74	17
52	69	37	91	83

```
+-----+
| Score = 21. Person parameter = -0.69 |
+-----+
```

```
Very easy items:  Opg3_6 Opg3_8 Opg3_32
Easy items:       Opg1_14 Opg1_40 Opg1_17 Opg3_14 Opg3_17 Opg3_33 Opg4_8
Difficult items:  Opg1_91 Opg4_20 Opg4_18 Opg5_83 Opg5_95 Opg5_36 Opg5_42
Opg5_50
Very difficult items: Opg4_24
```

Item	0	1	Mean	SD	
Opg1_14	0.130	0.870	0.87	0.34	* easy
Opg1_40	0.211	0.789	0.79	0.41	* easy
Opg1_74	0.583	0.417	0.42	0.49	
Opg1_17	0.200	0.800	0.80	0.40	* easy
Opg1_52	0.681	0.319	0.32	0.47	
Opg1_69	0.709	0.291	0.29	0.45	
Opg1_37	0.285	0.715	0.71	0.45	
Opg1_91	0.763	0.237	0.24	0.43	* difficult
Opg1_83	0.750	0.250	0.25	0.43	




# TF5

## Begrebs-kort for TF5

Problem	Opgave
Sortere brøker	Opgave4b
Decimaltal <-> Brøk	Opgave 8
Udfylde decimaltal	Opgave 2
Skala -> brøk -> decimaltal	Opgave 6
Sortere decimaltal	Opgave1
Brøk -> illustration	Opgave 4a
Decimaltal-> Skala	Opgave5a
Skala -> decimaltal	Opgave5b
Illustration -> brøk	Opgave 7
Udpege decimaltal	Opgave 3

**Opgave 4**  
Farv brøkerne



$\frac{3}{4}$     $\frac{1}{4}$     $\frac{1}{3}$     $\frac{1}{2}$     $\frac{1}{6}$

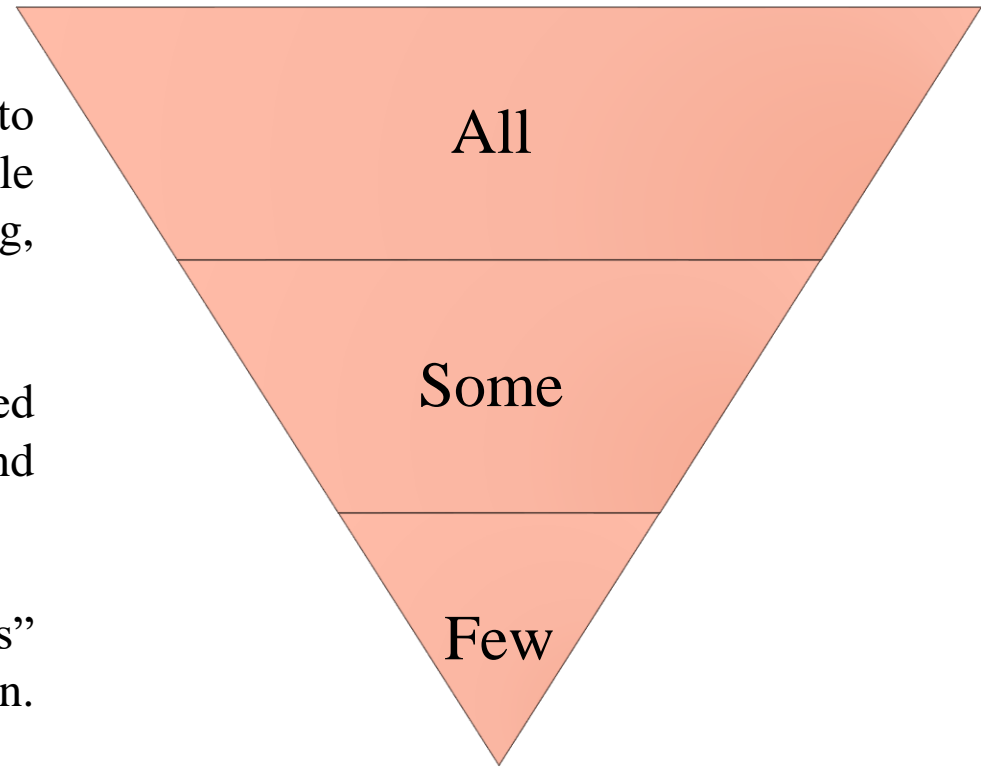
Sæt nu de samme brøker i størrelsesorden, med den mindste brøk først

\_\_\_\_\_

# Interventions

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- there is something “all students” need to work on to develop a fluent and flexible understanding,
- there is something “some students” need to work on, and
- there is something that a “few students” need to work on.



1. årg

Vi har fokus på:

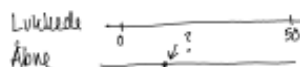
- talforståelsen 0-99
- 10'ere og 1'er
- plusstrategierne - talpar - 10'erevenner

### DAGENS TAL

- tallets betydning
- beregning
- tegning
- tælling
- materialer
- hverdag



### TALLINJER



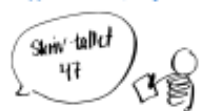
### TALKORT

- træk et kort
- vis tallet



hop (10'ere) | byg tallet | tegn tallet  
10 (10'ere) | 10 (1'er)

### TALDIKTAT

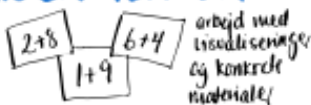


### TALPAR



- er automatisme/
- færd. ved stjernetek,
- vandspil eller stætted

### 10'ER VENNER



arbejd med  
visualiseringer  
og konkrete  
materialer!



# All Students

Posters to specify what numeracy skills and understanding was at different grade levels.

Discussed what characterizes good practice

- Low floor and high ceiling activities
- Easily accessible in terms of materials
- Understanding instead of completing tasks
- A clear focus
- Multiple representations (creating mental images and links)
- Allows for expansion



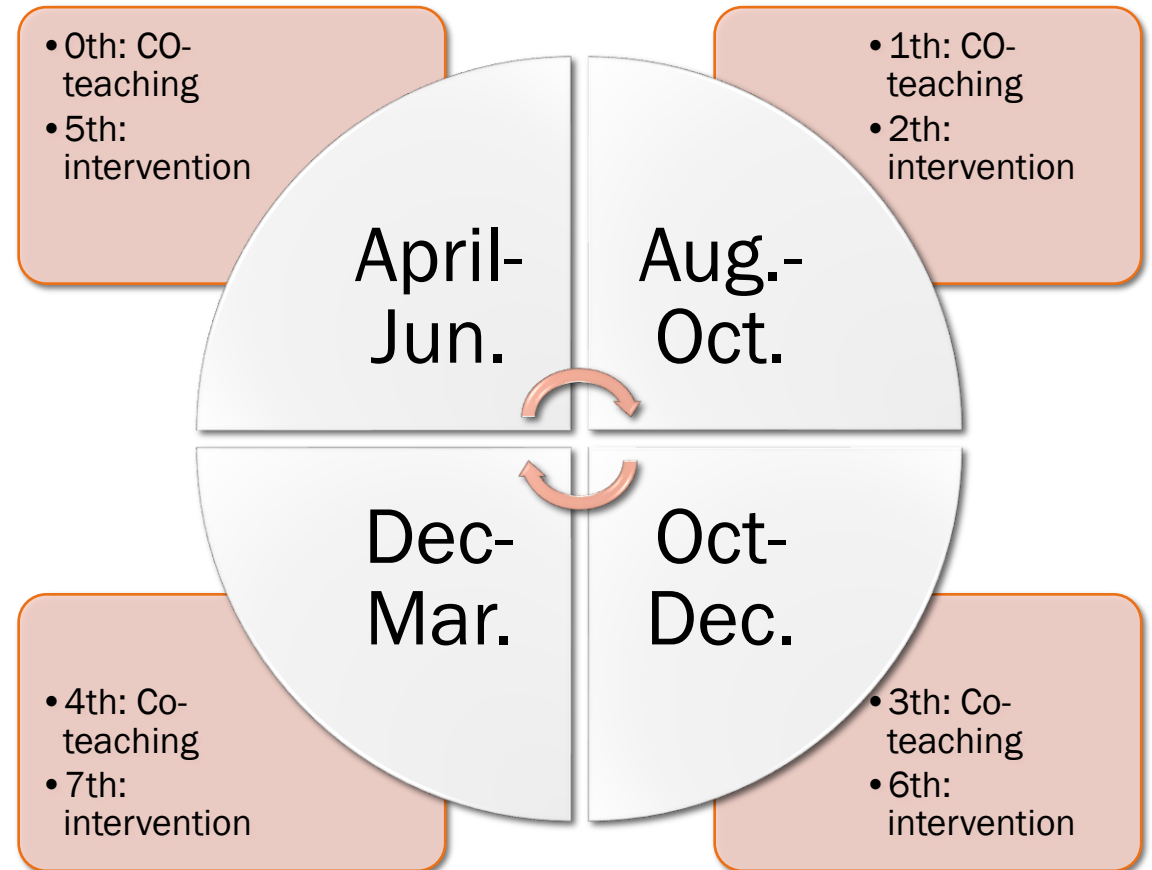
# Some Students

Co-teaching in some grades

Getting students in situations where they are likely to engage in tasks that involve relevant content.

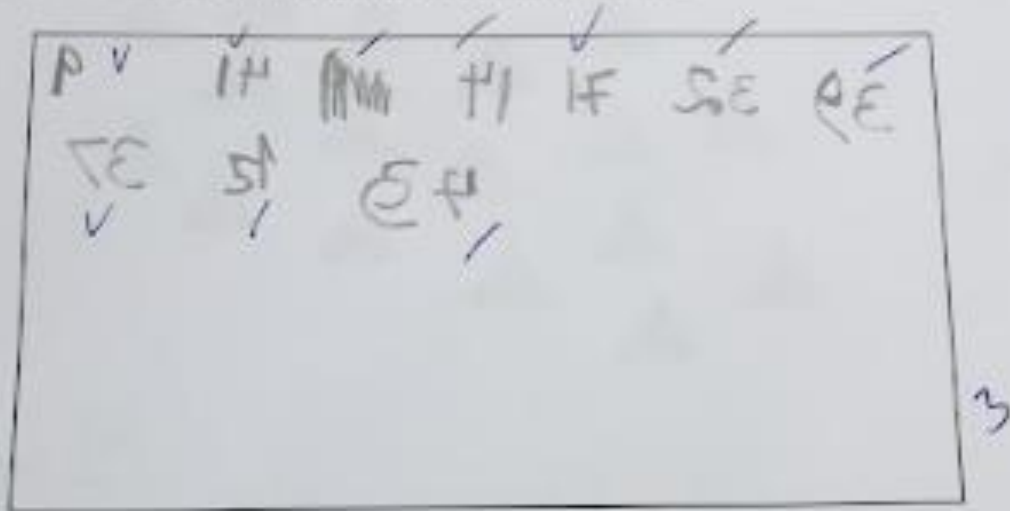
Includes

- listening,
- speaking,
- writing and
- reasoning



## Opgave 1

Du skal skrive de tal, som din lærer nævner i boksen.



# A Few Students

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All students in primary school who make errors in number dictation receive some kind of an intervention.

We are currently experimenting with an intervention of 10 minutes, 3-4 times a week.

The math tutor designs a intervention – the interventions done when the student master the numbers or after 10 weeks.

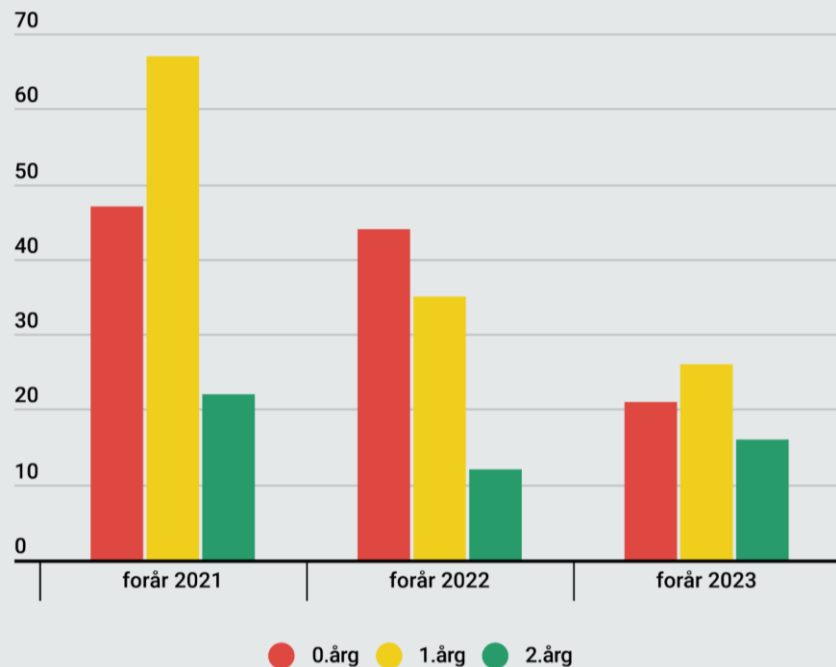


# Points of attention

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## We find that

- Students who make errors in dictation are students that have a low proficiency level
- After a focus on numeracy skills and understanding fewer students require intervention.
  - At Dorthe's school, we found over 60% of the students in 1th grade with errors in the number dictation in 2021. This year it was reduced to 26%.
- Students receive shorter interventions if the math tutor works as a co-teacher in the students class.
- The majority of students receiving intervention are girls.





# Open source

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All tests and resources are shared on the website



M4T3M4T1K

<https://sites.google.com/g.helsingor.dk/matematik/startside>

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Thank you



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