

IEA Research for Education

A Series of In-depth Analyses Based on Data of the International Association for the Evaluation of Educational Achievement (IEA)



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# Motivational Profiles in TIMSS Mathematics

Exploring Student Clusters Across Countries and Time



## Motivational Profiles in TIMSS Mathematics. Exploring student clusters across countries and time.

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- This study is part of the IEA Research for Education Series.
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# Introduction

- From the early endeavors of the IEA:
  - a broad objective was to understand the relationships between inputs and outputs in education (Wagemaker, 2014).
- **Student motivation, self-efficacy, self-concept** have been consistent predictors of student achievement  
(Marsh, Abduljabbar, Abu-Hilal, Morin, Abdelfattah, Leung, et al., 2013)

# Introduction

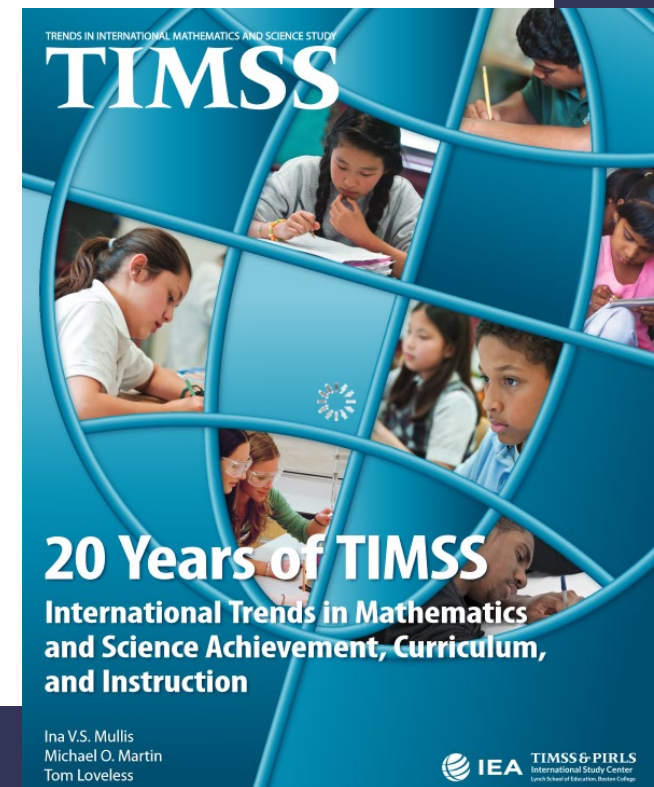
- Motivational variables are considered important predictors of achievement
- Important because it is possible to **support, or train students to adapt their beliefs** about
  - the purpose of assessment (Brown, 2011),
  - interest in school subjects (Alexander, 2003),
  - confidence in their own abilities (Bandura, 1977),
  - goals (Ryan & Deci, 2000), and
  - motives for learning (Eccles & Wigfield, 2002)

## However...

- The strength of the relationship between motivational and affective variables to achievement tends to be weak (i.e.,  $r < .30$ ).

## Chapter 5: What Do Students Think About Mathematics?

**Puzzling Results**—A paradox surfaced in the first TIMSS data from 1995 and has reappeared ever since. Student self-confidence in mathematics and enjoyment studying the subject both are positively correlated with achievement. But when data are aggregated to the national level, many of the highest scoring countries on TIMSS rank near the bottom of all countries on both sentiments.



# The problem

- Is it possible that students who like a subject, might rate themselves as incompetent in the subject?
- Are there students with inconsistent ratings in enjoyment and self-competence, i.e. score high on one and low on the other dimension?  
e.g. 'I value Math, but I do not enjoy and do not feel very competent at Math'
- And how do such profiles relate to achievement and background variables?

# The purpose of this study

- To examine
  - whether there are meaningful profiles that can be extracted with respect to motivational and affective variables,
  - the relationship of these profiles with achievement, and
  - their relationship to gender and a measure of home educational resources
  - their relationship to homework practices



# Sample

- Twelve jurisdictions were examined: those participating in all rounds of TIMSS in 1995, 2007 and 2015 and both grades

<i>Participating jurisdictions</i>	<i>TIMSS 1995</i>				<i>TIMSS 2007</i>		<i>TIMSS 2015</i>	
	<i>Population 1<sup>a</sup> students</i>	<i>Grade 4 students</i>	<i>Population 2<sup>a</sup> students</i>	<i>Grade 8 students</i>	<i>Grade 4 students</i>	<i>Grade 8 students</i>	<i>Grade 4 students</i>	<i>Grade 8 students</i>
<i>Countries</i>								
Australia	11,248	6065 (49.9)	12,852	7392 (51.4)	4108 (50.0)	4069 (45.3)	6057 (48.9)	10338 (50.5)
England <sup>b</sup>	6182	3126 (50.6)	3579	1776 (48.0)	4316 (50.0)	4025 (51.8)	4006 (50.6)	4814 (50.7)
Hong Kong	8807	4411(45.9)	6752	3339 (45.2)	3791 (48.5)	3470 (50.4)	3600 (44.9)	4155 (47.5)
Hungary	6044	3006 (49.8)	5978	2912 (51.1)	4048 (49.7)	4111 (49.9)	5036 (49.8)	4893 (50.6)
Iran	6746	3385 (48.9)	7429	3694 (44.5)	3833 (47.2)	3981 (44.9)	3823 (48.7)	6130 (48.9)
Japan	8612	4306 (50.0)	10,271	5141 (48.5)	4487 (49.3)	4312 (49.7)	4383 (50.2)	4745 (51.0)
Singapore	14169	7139 (47.4)	8285	4644 (49.7)	5041 (49.2)	4599 (48.8)	6517 (48.8)	6116 (48.7)
Slovenia	5087	2566 (50.5)	5606	2708 (51.1)	4351 (49.5)	4043 (50.0)	4445 (48.4)	4257 (48.2)
USA	11,115	7296 (51.4)	10,973	7087 (50.2)	7896 (51.0)	7377 (50.4)	10029 (50.6)	10221 (50.1)
<i>Benchmarking participants</i>								
Norway	4476	N/A <sup>c</sup>	5736	N/A <sup>c</sup>	4108 (49.4)	4627 (49.5)	4164 (49.4)	4795 (50.1)
Ontario	1.416	723 (45.6)	2078	1.059 (49.7)	3496 (49.3)	3448 (50.6)	4574 (48.2)	4520 (49.8)
Quebec	8.470	4488 (50.4)	8378	4245 (50.0)	3885 (51.4)	3956 (49.5)	2798 (50.0)	3950 (52.3)

# Methodology



## Analyses

A two-step clustering approach (SPSS)

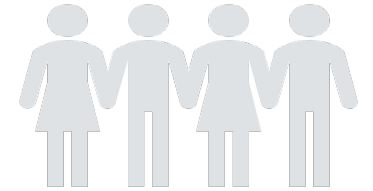
Number of clusters set to range between 3-6



**Pairwise mean comparisons were carried out to compare clusters on mean achievement and on home resources for learning**

weighted statistics and corrected standard errors (IEA's IDB Analyzer)

alpha level of .001



**Chi-square test (gender X cluster)**

## Variables used

1. **Students Like Learning Mathematics**
2. **Student Confident in Mathematics**
3. **Student Values Mathematics (grade 8)**

Partial Credit IRT scaling

**Mathematics achievement**

IRT scores, five plausible values

**Gender**

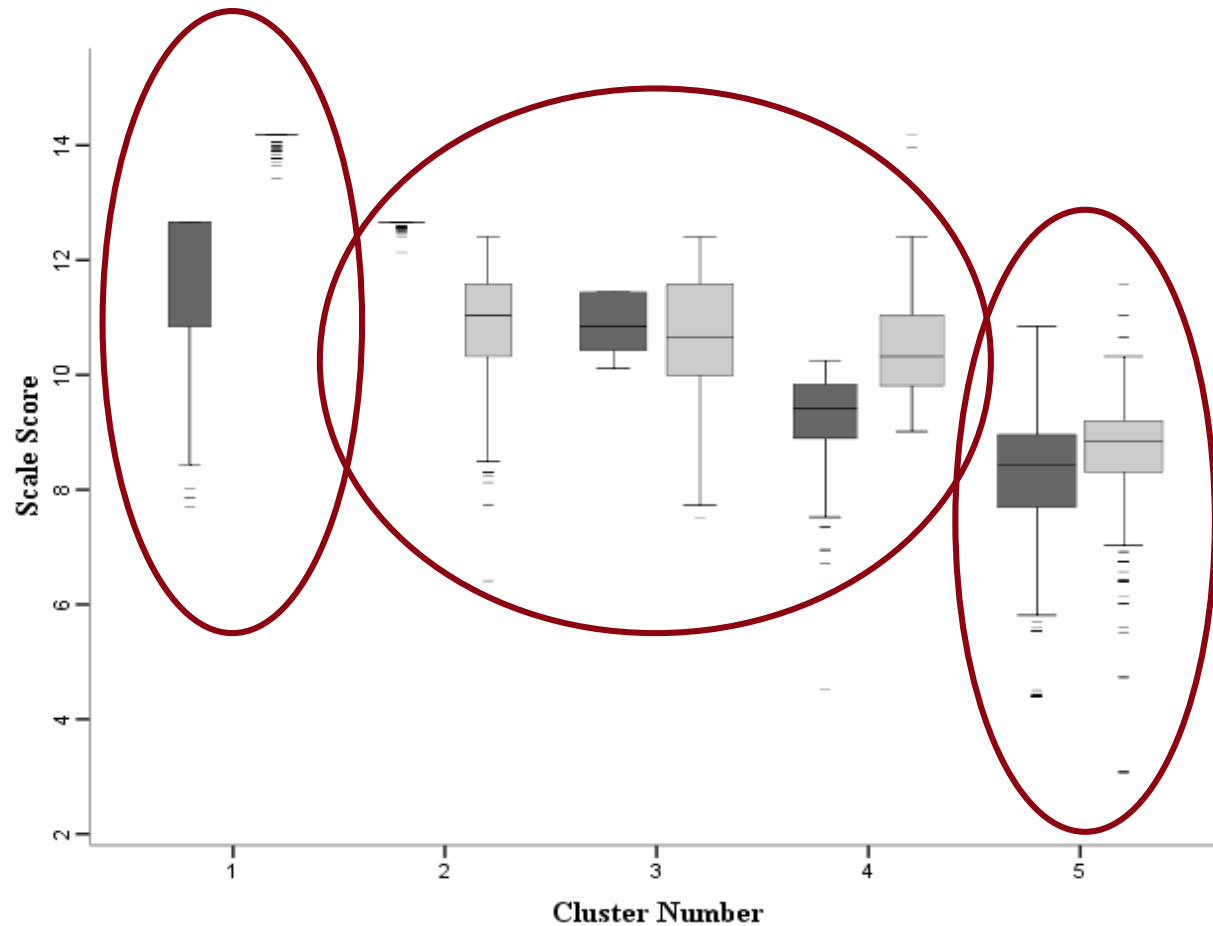
# of books,

**Home educational resources**

#of children's books at home,

own room and internet connection

# Results: Boxplots for motivation variables by cluster – Norway (**Dark grey: Enjoyment**, Light grey: Confidence)



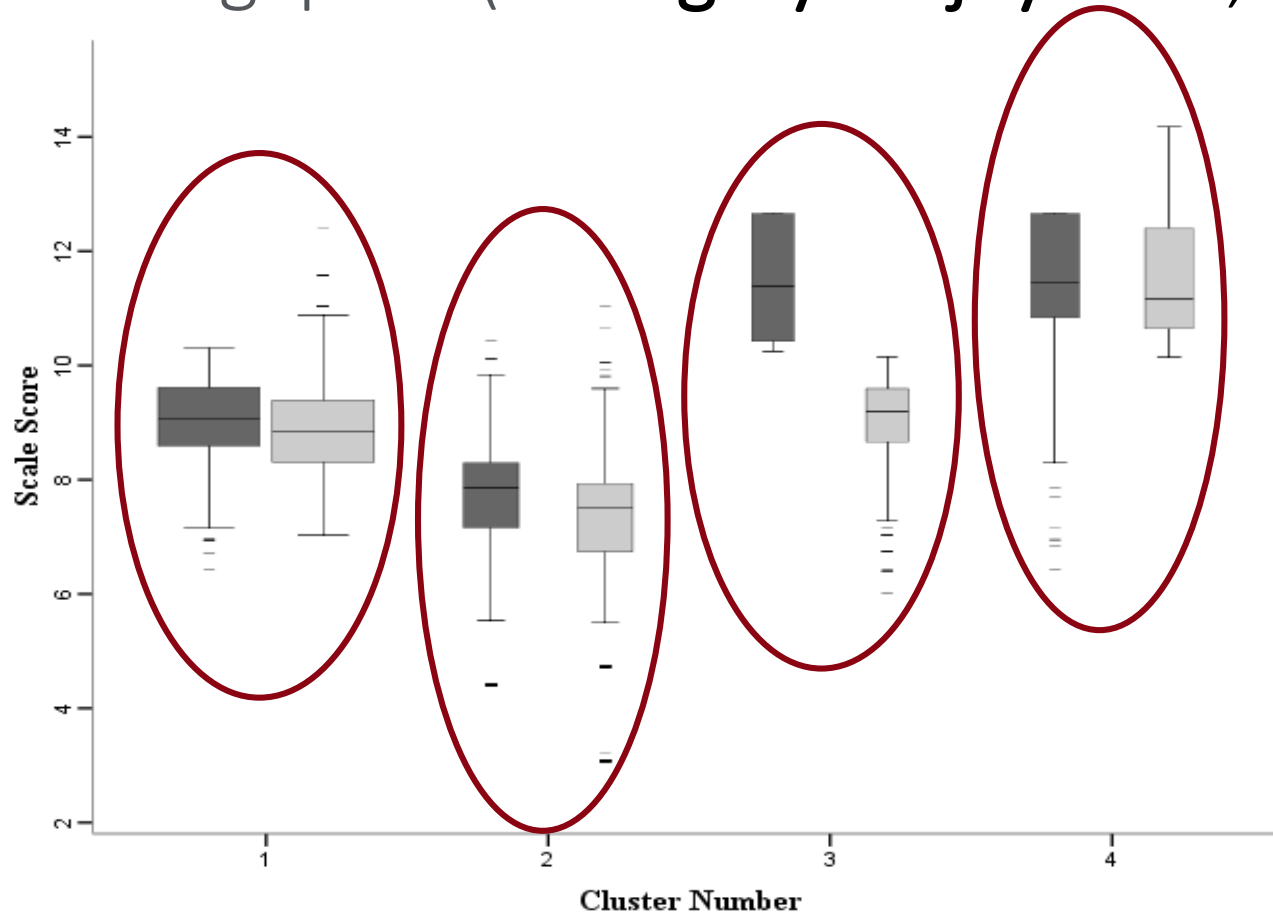
- Cluster 1: highest mean achievement
- Cluster 5: lowest mean achievement
- Clusters 2, 3, 4: no significant difference in mean scores despite differences in “Enjoyment” distributions. “Confidence” distributions are similar.

## Results – Norway (Grade 4, 2015)

Characteristics of clusters	Consistently Very High	Very High in Like, High in Confidence	Consistently High	Moderate in Confidence, Lower in Like	Consistently Very Low
Size in %	14.3%	15.5%	22.4%	21.3%	26.4%
Mean achievement (plausible value)	527.3 <sup>a</sup>	492.3 <sup>b</sup>	499.4 <sup>b</sup>	505.2 <sup>b</sup>	462.5 <sup>c</sup>
% female*	42.2	51.8	51.2	47.5	52.3
Mean home resources for learning	11.5 <sup>a,b</sup>	11.4 <sup>a,b</sup>	11.5 <sup>a,b</sup>	11.7 <sup>a</sup>	11.3 <sup>b</sup>

\*Chi-square test of independence of Gender x Cluster significant ( $\chi^2(4) = 19.689, p=0.001$ ).

# Results: Boxplots for motivation variables by cluster – Singapore (**Dark grey: Enjoyment**, Light grey: Confidence)



- Cluster 4: highest mean achievement
- Cluster 2: lowest mean achievement
- Clusters 1, 3: no significant difference in mean scores despite differences in “Enjoyment” distributions. “Confidence” distributions are similar.

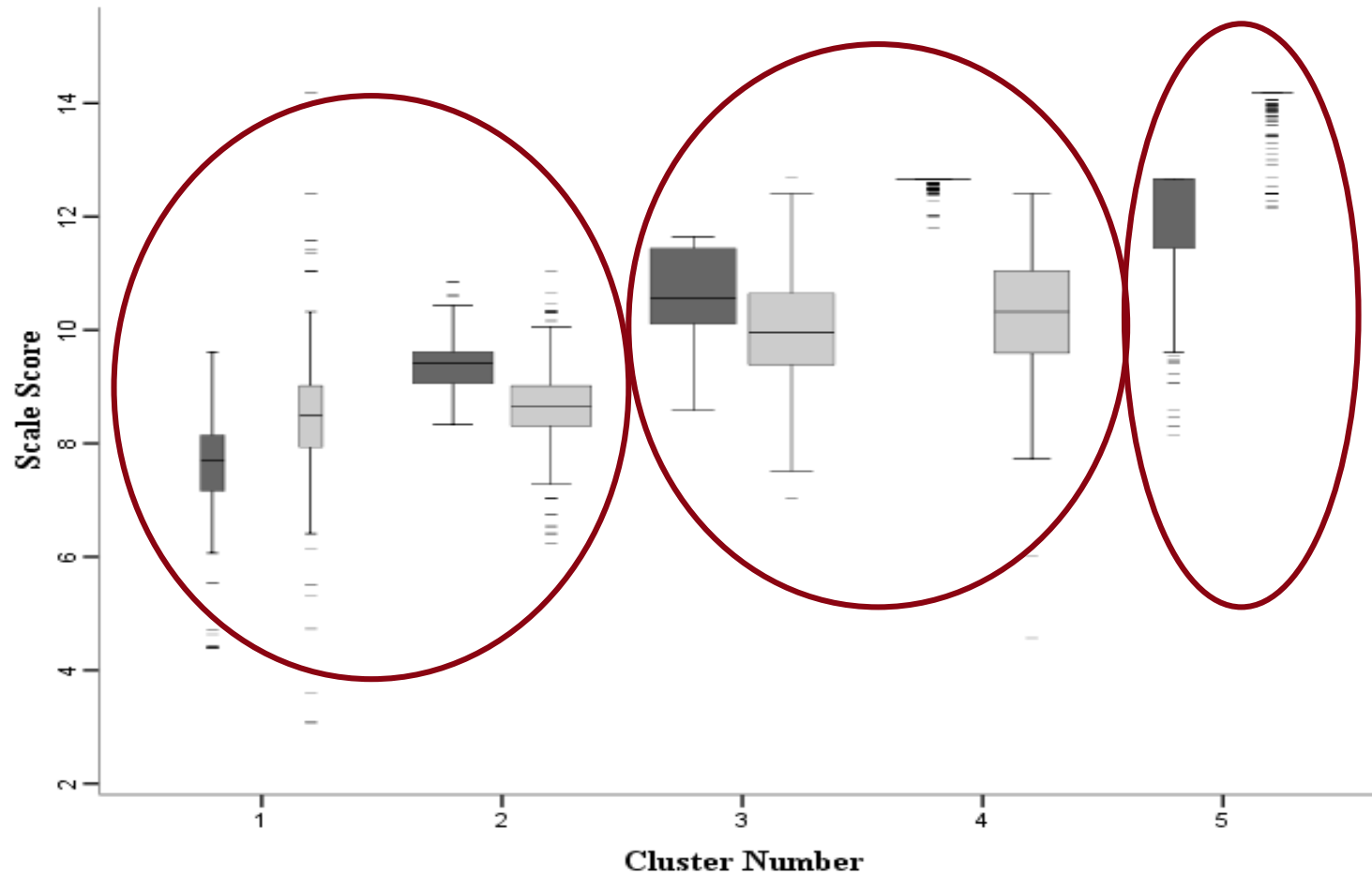
## Results – Singapore (Grade 4, 2015)

Characteristics of clusters	Consistently High	High in Like, Moderate in Confidence	Consistently Moderate	Consistently Very Low
Size in %	19.5%	17.1%	41.2%	22.2%
Mean achievement (plausible value)	<b>676.6<sup>c</sup></b>	605.7 <sup>a</sup>	616.6 <sup>a</sup>	<b>575.1<sup>b</sup></b>
% female*	<b>36.9</b>	50.1	50.8	<b>54.7</b>
Mean home resources for learning	11.4 <sup>c</sup>	10.6 <sup>b</sup>	10.8 <sup>a</sup>	10.5 <sup>b</sup>

\*Chi-square test of independence of Gender x Cluster significant ( $\chi^2(3) = 96.964, p < 0.001$ ).



## Results: Boxplots for motivation variables by cluster – Iran (Dark grey: Enjoyment, Light grey: Confidence)



- Smaller difference across clusters
- Cluster 5: highest mean achievement
- Clusters 1, 2: lowest mean achievement. Despite differences in “Enjoyment” distributions, “Confidence” distributions are similar.
- Clusters 3, 4: no significant difference in mean scores. Despite differences in “Enjoyment” distributions, “Confidence” distributions are similar.

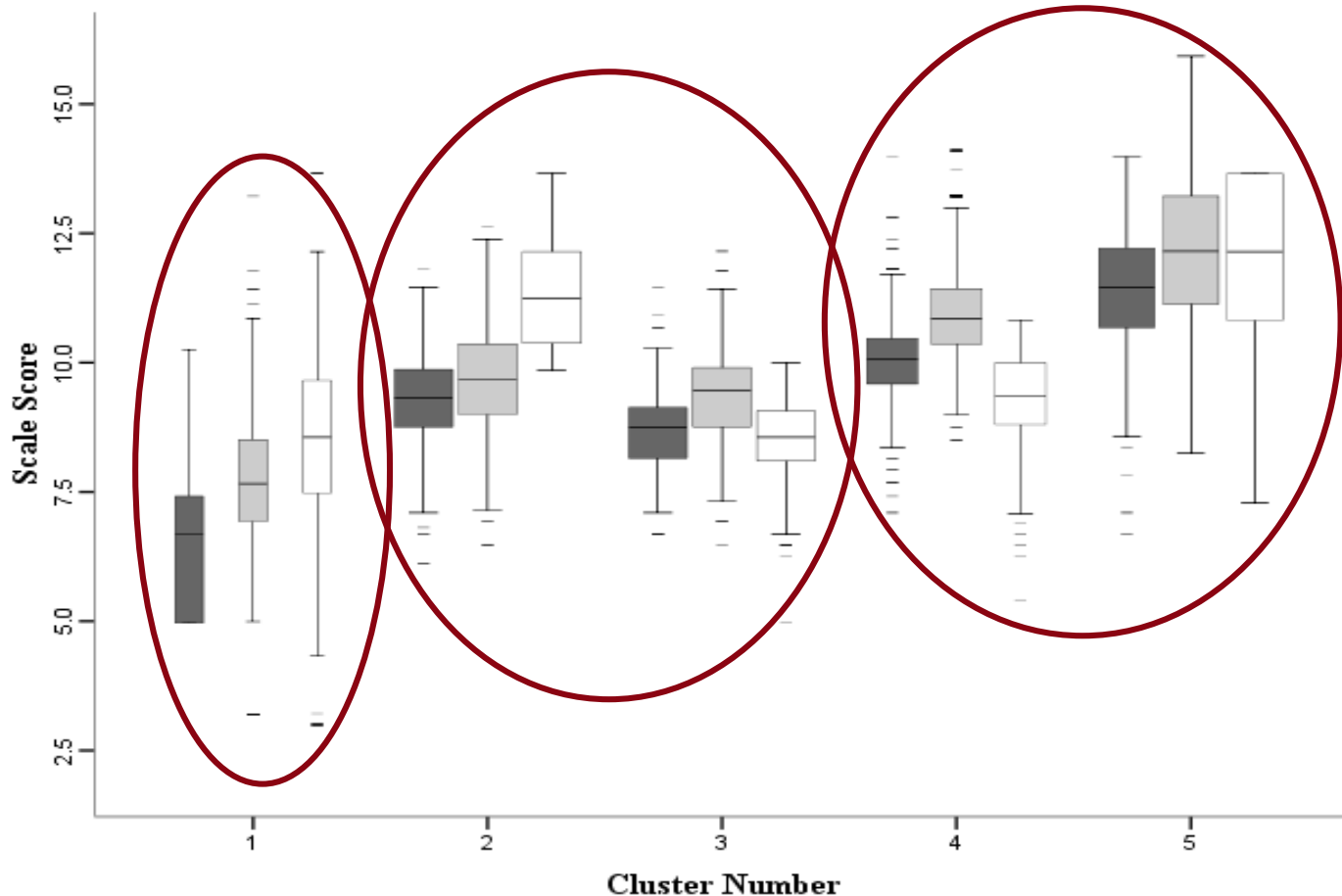
## Results – Iran (Grade 4, 2015)

Characteristics of clusters	Very High in Confidence, High in Like	Consistently High	High in Confidence, Low in Like	Consistently Low	Consistently Very Low
Size in %	13.5%	24.5%	28.1%	26.4%	7.5%
Mean achievement (plausible value)	<b>463.2<sup>d</sup></b>	440.8 <sup>c,d</sup>	435.4 <sup>b,c</sup>	<b>386.1<sup>a</sup></b>	398.6 <sup>a,b</sup>
% female*	<b>52.4</b>	49.2	48.1	49.5	<b>44.3</b>
Mean home resources for learning	8.5 <sup>a,b</sup>	8.3 <sup>a,b</sup>	8.3 <sup>a,b</sup>	8.1 <sup>b</sup>	8.7 <sup>a</sup>

Chi-square test of independence of Gender x Cluster not significant ( $\chi^2(4) = 5.239, p = 0.264$ ).

## Boxplots – England (Grade 8, 2015)

(**Dark grey: Enjoyment**, Light grey: Confidence, White: Value)



- Clusters 4, 5: high achievement, not sign. different despite differences in motivational distributions
- Clusters 2, 3: moderate achievement, not sign. different despite difference in “value”
- Cluster 1: lowest mean achievement

## England – Cluster statistics

<i>Cluster characteristics</i>	<i>Cluster</i>				
	<i>Consistently high</i>	2	3	4	<i>Consistently low</i>
Size (% of total number of students)	22.1	20.3	23.1	23.3	11.2
Mean plausible value	556.7 <sup>a</sup>	549.6 <sup>a</sup>	501.5 <sup>b</sup>	502.8 <sup>b</sup>	466.8 <sup>c</sup>
Female students in cluster (%)*	36.3	47.5	59.2	50.0	66.9
Students spending > 45 minutes per week on homework (%)	33.7	26.6	22.7	27.2	19.1
Mean home educational resources scale score	11.2 <sup>a</sup>	11.0 <sup>a,b</sup>	10.7 <sup>c</sup>	10.8 <sup>b,c</sup>	10.7 <sup>c</sup>

\*Chi-square test of independence of gender × cluster was significant ( $\chi^2(4) = 176.879, p < 0.001$ ). UNIVERSITY of NICOSIA

## Relative importance of Confidence / Enjoyment with achievement

Jurisdiction	Grade 4			Grade 8		
	1995	2007	2015	1995	2007	2015
<b>Australia</b>	E	C	C	E	C	C
<b>Ontario</b>	C	C	C	C	C	C
<b>Quebec</b>	E	C	C	C	C	C
<b>England</b>	E	C	C	E	C	E
<b>Hong Kong</b>	E	C	C	E	C	E
<b>Hungary</b>	E	C	C	E	C	C
<b>Iran</b>	E	C	C	E	C	C
<b>Japan</b>	C	C	E	C	C	E
<b>Norway</b>	-	C	C	-	C	C
<b>Singapore</b>	E	C	C	E	C	C
<b>Slovenia</b>	C	C	C	C	C	C
<b>USA</b>	C	C	C	C	C	C

**C:** Confidence more important than Enjoyment in the association with achievement,  
**E:** Confidence equally or less important

## Trends in the alignment of the Valuing Mathematics with achievement (Grade 8 only)

Jurisdiction	1995	2007	2015
Australia	x	x	x
Ontario	x	x	x
Quebec	x	x	x
England	x	x	x
Hong Kong	x	x	✓
Hungary	x	x	x
Iran	x	x	x
Japan	x	x	x
Norway	-	x	x
Singapore	x	x	x
Slovenia	x	x	x
USA	x	x	x

x: Value distributions not associated with achievement across all clusters

✓: Value distributions aligned with achievement in all clusters

# Trends in gender composition of clusters

Jurisdiction	Grade 4			Grade 8		
	1995	2007	2015	1995	2007	2015
Australia	✓	✓	✓	✓	✓	✓
Ontario	x	✓	✓	✓	✓	✓
Quebec	✓	✓	✓	✓	✓	✓
England	✓*	✓	✓	✓	✓	✓
Hong Kong	✓	✓	✓	✓	✓	✓
Hungary	✓	✓	✓	x	✓	✓
Iran	✓*	✓^	x	x	x	✓^
Japan	✓	✓	✓	✓	✓	✓
Norway	-	✓	✓	-	✓	✓
Singapore	✓	✓	✓	✓	✓	✓
Slovenia	✓	✓	✓	x	✓	✓
USA	✓	✓	✓	✓	✓	✓

✓: Chi-square test (gender by cluster) significant at .05, x: Chi-square test not significant, \*: more girls in high and more boys in low motivation and achievement clusters, ^: about equal numbers of boys and girls in the top performing group.

## Conclusions: Consistent Profiles

Most of the clusters in all jurisdictions were consistent

Students in the consistently high motivational cluster also had:

The highest levels of achievement

More males in the high cluster and more females in the low cluster

- With the exception of Iran

Significantly higher scores on the home educational resources variable.



## Conclusions: Inconsistent profiles



Found in all twelve samples, except Hong Kong



Most usual inconsistent finding:

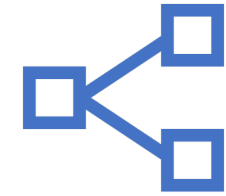
students valuing mathematics but who had lower self-confidence and lower enjoyment of mathematics



In these cases, it was self-confidence that was associated with mean achievement (proxy for achievement)

# Implications

- Value, as an external type of motivation:
  - When aligned with self-confidence and enjoyment, then relates to achievement (as hypothesized)
- When self-confidence and enjoyment did not overlap, self-confidence was more closely aligned with mean achievement
- In inconsistent clusters with similar levels of Confidence, higher Enjoyment was linked to lower achievement



## Final points

- Students with higher confidence rightly believed they could do the mathematics in the TIMSS tests
  - They achieved higher scores than those who prioritized value or enjoyment, but lacked strong beliefs in their capabilities
- Implications for teaching:

The challenge is to move away from making students interested in mathematics or knowing its value, to one in which teachers focus on helping students become competent in mathematics;

→ In turn, this competence can lead them to intrinsic interest in mathematics(Murphy & Alexander 2002).