

## TECHNICAL ANNEX to final report: The impact of human spaceflight on young people's attitudes to STEM subjects

### Technical Annex 1: Detailed statistics

#### Principal Components Analysis factors: individual item loadings

Principal Components Analysis was used to probe the structure of the data, investigating underlying concepts.

Parameters: OBLIMIN rotation; missing values are replaced with the variable mean (parameter MEANSUB); 7 factors extracted.

#### Primary school data

##### Phase 1 Factor 1: attitudes to learning about space and science

In Phase 2 the following variables also load onto factor 1: PPD8, PSD2, PPD13, PPD12, PPD16, PSD5 and PPD14. It is then a much broader 'attitudes to space and science' factor. These variables are added here.

In Phase 3 PPD15 is also included in this factor. This means factor 1 is strictly related to attitudes to space at that point.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PPD3	0.682	0.730	0.746
PPD1	0.681	0.752	0.744
PPD4	0.540	0.658	0.677
PSD14	0.520	0.586	
PSD3	0.511	0.617	
PPD2	0.505	0.745	0.634
PPD5	0.397	0.603	0.647
PSD1	0.394	0.450	
PSD13	<0.3	0.419	
PPD8		0.481	0.419
PSD2		0.481	
PPD13		0.448	0.570
PPD12		0.413	0.609
PPD16		0.370	0.571
PSD5		0.364	
PPD14		0.314	0.317
PPD15			0.409

##### Phase 1 Factor 2: attitudes to mathematics

In Phase 2 this is factor 3. Variables PMD4 and PMD12 load onto factor 7; PMD11, PMD7 and PMD10 load onto factor 5 in Phase 2.

In Phase 3 PMD8 also loads onto this factor, and it is once again factor 2.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PMD2	0.795	0.764	0.805
PMD3	0.794	0.760	0.780
PMD14	0.689	0.726	0.730
PMD15	0.612	0.537	0.600
PMD6	0.574	0.541	0.607
PMD4	0.546	Factor 7	0.603
PMD12	0.436	Factor 7	0.520
PMD13	0.421	0.519	0.568
PMD11	0.371	Factor 5	0.410
PMD7	0.367	Factor 5	0.544
PMD1	0.325	0.338	0.387
PMD10	<0.3	Factor 5	0.374
PMD8			0.406

### **Phase 1 Factor 3: the need for cleverness, and STEM jobs are well-paid**

In Phase 2 this is factor 2.

In Phase 3 this is once again factor 3. PTED22ph3 also loads here (0.389), but it also loads suitably onto Phase 3 factor 4 which is where it is included as before.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PMD16	0.749	0.712	0.645
PPD17	0.626	0.637	0.584
PTED21ph1	0.493		
PTED23ph2ph3		0.635	0.636
PTED24ph2ph3		0.587	0.656
PMD9	0.452	0.458	0.538
PTED13ph1	0.393	Is PTED15 at Phase 2	
PTED15ph2ph3	Was PTED13 at Phase 1	0.499	0.556
PSD8	0.383	0.466	0.436

### **Phase 1 Factor 4: attitudes to technology and engineering ('designing and making')**

Variables were added for Phase 2 (and Phase 3) so numbering is out of sync. See Annex 2.

In Phase 3 this is factor 5, effectively swapped in importance with the one directly below.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PTED10	-0.576	-0.586	0.691
PTED11ph2ph3		0.550	
PTED17ph1	-0.552		
PTED12ph1	-0.508	See factor 5	
PTED5	-0.495	See alternative factor 7	0.552
PTED18ph1	-0.480	See alternative factor 6	
PTED3	-0.467	-0.335	0.554
PTED2	-0.458	-0.485	
PTED11ph1	-0.454	Is PTED12 at Phase 2	
PTED12ph2ph3	Was PTED11 at Phase 1	-0.431	0.476

PTED16ph1	-0.444	See factor 5	
PTED14ph1	-0.416	See factor 5	
PTED7	-0.415	-0.427	0.492
PTED6	-0.411	-0.338	0.448
PTED19ph1	-0.395	Is PTED21 at Phase 2	
PTED21ph2ph3	Was PTED19 at Phase 1	-0.329	0.447
PTED15ph1	-0.394	See factor 5	
PTED20ph1	-0.383	See factor 5	
PTED8	-0.352	-0.405	See factor 5 below
PTED1	Smaller than -0.3	See factor 5	0.389
PTED13ph2ph3		-0.441	See factor 5 below
PTED19ph2ph3			0.551
PTED20ph2ph3			0.475

**Phase 1 Factor 5: utility of science and mathematics (weak factor, only three variables loading onto it in Phase 1)**

In Phase 2 this factor includes a variety of utility of space-, technology- and engineering-related items, which are added here.

In Phase 3 this is factor 4, although not all variables are included. PTED22ph2ph3 also loads onto factor 3 (see above). PTED8 and PTED13ph2ph3 have loadings here, rather than on the factor directly above here, but with weak loadings.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PSD11	-0.541	-0.453	-0.494
PMD8	-0.431	-0.490	
PTED14ph2ph3	Was PTED12 at Phase 1	-0.557	-0.614
PTED18ph2ph3	Was PTED16 at Phase 1	-0.541	-0.636
PTED17ph2ph3	Was PTED15 at Phase 1	-0.521	-0.485
PTED16ph2ph3	Was PTED14 at Phase 1	-0.434	-0.476
PTED22ph2ph3	Was PTED20 at Phase 1	-0.387	-0.307
PMD7	See factor 2	-0.368	
PMD10	See factor 2	-0.365	
PMD11	See factor 2	-0.346	
PTED1	See factor 4	Smaller than -0.3	
PPD15	See factor 7	-0.411	
PTED8			-0.367
PTED13ph2ph3			-0.347

**Phase 1 Factor 6: attitudes to science and informal (space) science learning**

In Phase 3 this factor re-appears as factor 6, with the exception of variable PPD18 included (loading weakly) rather than PPD8.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PSD2	-0.564		-0.645
PSD9	-0.558		-0.645
PSD15	-0.475		-0.590
PSD12	-0.403		-0.484

PSD4	-0.379		-0.479
PSD5	-0.372		-0.421
PPD8	-0.368	Onto factor 1	
PPD18			-0.332

Phase 2 Alternative Factor 6 is a rather different collection of five variables which do not form a very coherent concept. The factor loadings are weak:

Item	Loading		
	Phase 1	Phase 2	Phase 3
PSD7		-0.495	
PSD9		-0.474	
PSD15		-0.364	
PTED20ph2	Was PTED18 in Phase 1	-0.360	
PPD18		-0.303	

### Phase 1 Factor 7: utility of space for science, jobs and travel

PPD13 also loads less strongly (-0.402) onto factor 6 in Phase 1.

Item	Loading		
	Phase 1	Phase 2	Phase 3
PPD14	-0.523		
PPD13	-0.499		
PPD15	-0.499	See factor 5	
PPD18	-0.486		
PPD16	-0.472		

### Phase 2 Alternative Factor 7: influence of family on attitudes to STEM

This forms a new strong coherent factor in Phase 2.

This factor disappears again in Phase 3 – variables included in factors representing attitudes to individual subjects.

Item	Loading		
	Phase 1	Phase 2	Phase 3
PTED4		0.669	
PSD4		0.600	
PTED5		0.599	
PTED19ph2ph3		0.579	
PSD12		0.557	
PMD4		0.511	
PMD12		0.457	

### Phase 3 Alternative Factor 7:

This is not a strong factor (only four and fairly weak loadings), and can be thought of as representing 'interest in learning science in school'.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
PSD3			0.489
PSD1			0.445
PSD13			0.381

### Secondary school data

#### Phase 1 Factor 1: attitudes to space

In Phase 2 this is also factor 1. It is highly stable, with strong loadings and no 'floating' variables. In Phase 3 this is factor 2. STD5 loads 0.356 onto this factor, but also -0.303 onto factor 6, where it is included for conceptual reasons.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
SPD1	0.797	0.803	0.840
SPD2	0.765	0.825	0.847
SPD4	0.727	0.777	0.767
SPD13	0.692	0.630	0.688
SPD12	0.684	0.668	0.638
SPD5	0.667	0.686	0.679
SPD8	0.646	0.641	0.729
SPD16	0.626	0.696	0.688
SPD15	0.586	0.656	0.655
SPD14	0.550	0.714	0.694
SPD18	0.520	0.425	0.355

#### Phase 1 Factor 2: attitudes to science

In Phase 2 this is also factor 2. SSD10 is not loading onto factor 2 in Phase 2. In Phase 3 this is factor 5. It is largely stable with high loadings and very few 'floating' variables.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
SSD3	0.742	0.707	-0.723
SSD14	0.720	0.647	-0.586
SSD1	0.696	0.690	-0.636
SSD4	0.611	0.596	-0.583
SSD12	0.582	0.585	
SSD7	0.582	0.633	-0.621
SSD15	0.566	0.645	-0.630
SSD13	0.552	0.426	-0.414
SSD9	0.546	0.633	-0.688
SSD10	0.432		-0.401
SSD5	0.382	0.342	-0.361
SSD11			-0.394

### Phase 1 Factor 3: attitudes to mathematics

In Phase 2 this is factor 4, a very stable factor with many high loadings.

In Phase 3 this is factor 4, very similar to Phases 1 and 2.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
SMD3	0.846	0.836	0.833
SMD14	0.744	0.751	0.754
SMD6	0.702	0.671	0.734
SMD13	0.673	0.626	0.746
SMD4	0.667	0.645	0.656
SMD15	0.603	0.559	0.476
SMD12	0.601	0.643	0.611
SMD1	0.563	0.578	0.574
SMD10	0.558	0.568	0.649
SMD8	0.534	0.501	0.552
SMD11	0.488	0.466	0.573
SMD7	0.482	0.422	0.442
SMD9	0.466	0.450	

### Phase 1 Factor 4: utility of science, technology and engineering

In Phase 2 this is factor 3. It is not a stable factor.

In Phase 3 this is factor 3. It is stronger at that point, with only technology- and engineering-related variables.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
STD10	0.563	See factor 5	0.602
STD13	0.528	0.437	0.671
STD12	0.515	See factor 5	0.587
SED9	0.500	0.532	0.754
STD6	0.441	See factor 5	0.425
SSD11	0.435	0.477	
STD11	0.361		0.445
SED1	0.321		0.532
SED12		0.557	0.778
SSD10		0.422	
SED11			0.739
SED17			0.594
SED10			0.577
STD18			0.525
SED13			0.389

### Phase 1 Factor 5: attitudes to technology

In Phase 2 this is also factor 5. It is largely stable, with a few 'floating' variables. STD12, for example, loads almost as strongly onto factor 3, which is another technology-related factor.

In Phase 3 this is factor 6. It is highly stable, covering the same variables as in Phase 1.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
STD2	-0.710	-0.664	-0.756
STD17	-0.647	-0.700	-0.637
STD4	-0.606	-0.602	-0.666
STD8	-0.573	-0.566	-0.657
STD1	-0.517	-0.589	-0.611
STD16	-0.512	-0.580	-0.499
STD9	-0.432	-0.517	-0.502
STD5	-0.431	-0.437	-0.303
STD15	-0.355	-0.513	-0.391
STD6		-0.520	
STD10		-0.447	
STD18		-0.428	
STD12		-0.394	

### **Phase 1 Factor 6: attitudes to engineering**

In Phase 2 this is also factor 6. It is largely stable, with high loadings and few 'floating' variables.

In Phase 3 this is factor 1. It is largely stable, but less so than in Phases 1 and 2.

<i>Item</i>	<i>Loading</i>		
	<i>Phase 1</i>	<i>Phase 2</i>	<i>Phase 3</i>
SED7	0.753	-0.738	0.673
SED3	0.708	-0.675	0.571
SED13	0.693	-0.667	
SED4	0.689	-0.646	0.500
SED8	0.653	-0.591	0.584
SED2	0.637	-0.638	0.627
SED14	0.620	-0.630	0.473
SED15	0.616	-0.610	0.560
SED5	0.587	-0.644	0.518
SED16	0.558	-0.618	0.572
SED11	0.508	-0.523	
SED10	0.491	-0.492	
SED12	0.476	See factor 3	
SED17	0.408	-0.422	
SED1		-0.357	
SED18			0.444

### **Phase 1 Factor 7: the need for cleverness, and STEM jobs are well-paid**

In Phase 2 this is also factor 7. It is not a very strong factor, and there are a few 'floating' variables.

In Phase 3 this is also factor 7. It is not a very strong factor, but consistently present and recognisable as a stable concept.

Item	Loading		
	Phase 1	Phase 2	Phase 3
SSD16	0.657	0.690	0.654
SMD16	0.639	0.695	0.642
SPD17	0.552	0.551	0.582
SED18	0.550	0.444	
STD19	0.533	0.488	0.306
STD18	0.330	See factor 5	
SSD8	0.329	0.389	0.527
STD11		0.463	
SMD9			0.451

### Timeline data: factor scores over three phases

#### Primary school data

ANOVA over three phases, looking at attitude scores; Bonferroni correction applied. These calculations provide information about the significant differences in the overall timeline patterns as shown in Technical Annex 2.

#### Attitudes to science

PA	Sphericity assumed	Not sig (p=0.057)	-
PB	Sphericity assumed	Not sig (p=0.564)	-
PC	Sphericity assumed	Not sig (p=0.573)	-
PE	Sphericity assumed	F(2,120)=6.739, p=0.002	1&3 and 2&3
PF	Sphericity assumed	Not sig (p=0.287)	-
PG	Sphericity assumed	Not sig (p=0.464)	-
PH	HF	F(2,81)=4.407, p=0.019	-
PI	Sphericity assumed	Not sig (p=0.497)	-
PJ	Sphericity assumed	F(2,44)=4.016, p=0.025	1&2
PK	HF	Not sig (p=0.928)	-
PL	Sphericity assumed	Not sig (p=0.215)	-
PM	Sphericity assumed	Not sig (p=0.656)	-
PN	Sphericity assumed	Not sig (p=0.153)	-
PP	Sphericity assumed	F(2,86)=14.139, p=0.000	1&2 and 2&3
PR	Sphericity assumed	F(2,60)=4.141, p=0.021	-

#### Attitudes to mathematics

PA	Sphericity assumed	Not sig (p=0.894)	-
PB	Sphericity assumed	F(2,120)=9.761, p=0.000	1&3 and 2&3
PC	Sphericity assumed	F(2,124)=8.369, p=0.000	1&2 and 2&3
PE	Sphericity assumed	Not sig (p=0.899)	-
PF	Sphericity assumed	Not sig (p=0.064)	-
PG	Sphericity assumed	F(2,42)=5.787, p=0.006	1&2 and 1&3
PH	Sphericity assumed	F(2,92)=3.262, p=0.043	1&3
PI	Sphericity assumed	Not sig (p=0.151)	-



PJ	Sphericity assumed	F(2,44)=4.932, p=0.012	1&3
PK	HF	Not sig (p=0.862)	-
PL	HF	Not sig (p=0.372)	-
PM	Sphericity assumed	Not sig (p=0.742)	-
PN	Sphericity assumed	Not sig (p=0.171)	-
PP	Sphericity assumed	Not sig (p=0.294)	-
PR	GG	Not sig (p=0.329)	-

### Attitudes to space

PA	HF	F(2,147)=7.311, p=0.002	1&2 and 2&3
PB	GG	Not sig (p=0.518)	-
PC	HF	Not sig (p=0.457)	-
PE	HF	F(2,100)=4.859, p=0.014	1&2
PF	GG	Not sig (p=0.471)	-
PG	Sphericity assumed	Not sig (p=0.186)	-
PH	HF	F(2,77)=3.766, p=0.035	-
PI	HF	Not sig (p=0.879)	-
PJ	Sphericity assumed	Not sig (p=0.500)	-
PK	Sphericity assumed	F(2,228)=3.541, p=0.031	1&3
PL	Sphericity assumed	Not sig (p=0.698)	-
PM	Sphericity assumed	Not sig (p=0.556)	-
PN	Sphericity assumed	F(2,62)=6.108, p=0.004	1&3
PP	HF	Not sig (p=0.127)	-
PR	GG	Not sig (p=0.237)	-

### Attitudes to 'designing and making'

PA	Sphericity assumed	F(2,186)=27.772, p=0.000	1&3 and 2&3
PB	HF	Not sig (p=0.220)	-
PC	Sphericity assumed	F(2,124)=19.946, 0.000	1&3 and 2&3
PE	HF	Not sig (p=0.109)	-
PF	GG	Not sig (p=0.239)	-
PG	Sphericity assumed	Not sig (p=0.705)	-
PH	HF	Not sig (p=0.944)	-
PI	HF	F(2,162)=5.556, p=0.006	1&3
PJ	GG	Not sig (p=0.780)	-
PK	Sphericity assumed	Not sig (p=0.286)	-
PL	Sphericity assumed	Not sig (p=0.070)	-
PM	Sphericity assumed	Not sig (p=0.547)	-
PN	HF	Not sig (p=0.611)	-
PP	Sphericity assumed	F(2,86)=9.614, p=0.000	1&3 and 2&3
PR	Sphericity assumed	Not sig (p=0.104)	-

### Attitudes to STEM

PA	Sphericity assumed	F(2,186)=18.575, p=0.000	1&3 and 2&3
PB	HF	F(2,105)=6.620, p=0.003	2&3
PC	Sphericity assumed	F(2,124)=12.034, p=0.000	1&3 and 2&3

PE	Sphericity assumed	Not sig (p=0.717)	-
PF	Sphericity assumed	Not sig (p=0.435)	-
PG	Sphericity assumed	Not sig (p=0.835)	-
PH	Sphericity assumed	Not sig (p=0.110)	-
PI	Sphericity assumed	F(2,178)=3.363, p=0.037	-
PJ	Sphericity assumed	Not sig (p=0.099)	-
PK	HF	Not sig (p=0.565)	-
PL	Sphericity assumed	Not sig (p=0.291)	-
PM	Sphericity assumed	Not sig (p=0.951)	-
PN	Sphericity assumed	Not sig (p=0.094)	-
PP	Sphericity assumed	F(2,86)=6.199, p=0.003	1&2 and 1&3
PR	Sphericity assumed	F(2,60)=6.725, p=0.002	2&3

### Attitudes to STEM-and-space

PA	HF	F(2,162)=8.590, p=0.001	1&3 and 2&3
PB	Sphericity assumed	F(2,120)=5.810, p=0.004	2&3
PC	Sphericity assumed	F(2,124)=14.431, p=0.000	1&3 and 2&3
PE	HF	Not sig (p=0.192)	-
PF	Sphericity assumed	Not sig (p=0.406)	-
PG	Sphericity assumed	Not sig (p=0.366)	-
PH	Sphericity assumed	Not sig (p=0.072)	-
PI	Sphericity assumed	Not sig (p=0.224)	-
PJ	Sphericity assumed	Not sig (p=0.592)	-
PK	Sphericity assumed	Not sig (p=0.638)	-
PL	Sphericity assumed	Not sig (p=0.269)	-
PM	Sphericity assumed	Not sig (p=0.800)	-
PN	Sphericity assumed	Not sig (p=0.772)	-
PP	Sphericity assumed	F(2,86)=8.024, p=0.001	1&2 and 1&3
PR	Sphericity assumed	F(2,60)=3.757, p=0.029	2&3

### Cleverness/well-paid jobs

PA	HF	F(2,174)=7.942, p=0.001	1&2 and 2&3
PB	HF	Not sig (p=0.271)	-
PC	Sphericity assumed	F(2,124)=3.158, p=0.046	-
PE	Sphericity assumed	Not sig (p=0.367)	-
PF	Sphericity assumed	Not sig (p=0.626)	-
PG	Sphericity assumed	Not sig (p=0.991)	-
PH	Sphericity assumed	F(2,92)=3.595, p=0.031	-
PI	Sphericity assumed	Not sig (p=0.052)	-
PJ	Sphericity assumed	Not sig (p=0.985)	-
PK	Sphericity assumed	Not sig (p=0.756)	-
PL	Sphericity assumed	Not sig (p=0.213)	-
PM	Sphericity assumed	Not sig (p=0.144)	-
PN	HF	Not sig (p=0.534)	-
PP	Sphericity assumed	Not sig (p=0.555)	-
PR	Sphericity assumed	Not sig (p=0.620)	-

## Secondary school data

These calculations provide information about the significant differences in the overall timeline patterns as shown in Technical Annex 3.

### Attitudes to Science, ANOVA on factor scores over three phases

<i>School</i>	<i>Relevant parameters</i>	<i>Statistical numbers</i>	<i>Pairwise sig diff</i>
SY	Sphericity assumed	Not sig ( $p=0.121$ )	-
SX	HF correction	$F(2,292)=7.077$ , $p=0.003$	1&3 and 2&3
SW	GG	$F(1,129)=7.387$ , $p=0.003$	1&2 and 1&3
SV	HF	$F(2,310)=8.105$ , $p=0.001$	1&3 and 2&3
SU	HF	$F(2,120)=10.164$ , $p=0.000$	1&3 and 2&3
ST	HF	$F(2,177)=32.706$ , $p=0.000$	1&2 and 1&3
SR	HF	$F(2,215)=12.647$ , $p=0.000$	1&3 and 2&3
SP	GG	$F(1,314)=8.153$ , $p=0.002$	1&3 and 2&3
SN	HF	Not sig ( $p=0.148$ )	-
SM	GG	$F(1,73)=4.567$ , $p=0.023$	1&3
SL	HF	$F(2,76)=34.181$ , $p=0.000$	all
SK	HF	$F(2,277)=4.885$ , $p=0.014$	1&3

### Attitudes to Mathematics, ANOVA, over three phases

<i>School</i>	<i>Relevant parameters</i>	<i>Stats number</i>	<i>Differences</i>
SY	Sphericity assumed	Not sig ( $p=0.718$ )	
SX	Sphericity assumed	$F(2,382)=5.118$ , $p=0.006$	1&2 and 1&3
SW	Sphericity assumed	Not sig ( $p=0.337$ )	
SV	HF	$F(2,306)=3.339$ , $p=0.041$	1&2
SU	Sphericity assumed	Not sig ( $p=0.434$ )	
ST	HF	$F(2,179)=4.493$ , $p=0.017$	1&2
SR	Sphericity assumed	$F(2,256)=3.232$ , $p=0.041$	-
SP	HF	$F(2,419)=3.962$ , $p=0.022$	1&3
SN	Sphericity assumed	Not sig ( $p=0.069$ )	
SM	Sphericity assumed	Not sig ( $p=0.069$ )	
SL	Sphericity assumed	$F(2,96)=15.945$ , $p=0.000$	1&2 and 1&3
SK	Sphericity assumed	$F(2,354)=8.708$ , $p=0.000$	1&3 and 2&3

### Attitudes to Space

SY	Sphericity assumed	Not sig ( $p=0.291$ )	-
SX	HF correction	Not sig ( $p=0.220$ )	-
SW	Sphericity assumed	Not sig ( $p=0.288$ )	-
SV	HF	$F(2,294)=4.573$ , $p=0.014$	2&3
SU	Sphericity assumed	Not sig ( $p=0.184$ )	-
ST	HF	$F(2,191)=3.685$ , $p=0.030$	1&2
SR	Sphericity assumed	Not sig ( $p=0.268$ )	-
SP	HF	Not sig ( $p=0.226$ )	-
SN	Sphericity assumed	Not sig ( $p=0.940$ )	-

SM	Sphericity assumed	F(2,102)=4.284, p=0.016	2&3
SL	GG	Not sig (p=0.075)	-
SK	HF	Not sig (p=0.070)	-

### Attitudes to Technology

SY	HF	F(2,87)=6.841, p=0.003	1&2
SX	Sphericity assumed	F(2,382)=10.453, p=0.000	1&2 and 1&3
SW	Sphericity assumed	F(2,174)=3.652, p=0.028	1&2
SV	Sphericity assumed	F(2,332)=5.015, p=0.007	1&3
SU	HF	F(2,126)=13.989, p=0.000	1&3 and 2&3
ST	HF	Not sig (p=0.776)	-
SR	Sphericity assumed	F(2,256)=6.491, p=0.002	1&3 and 2&3
SP	HF	F(2,437)=10.483, p=0.000	1&3 and 2&3
SN	Sphericity assumed	F(2,254)=13.961, p=0.000	1&3 and 2&3
SM	HF	Not sig (p=0.788)	-
SL	HF	Not sig (p=0.619)	-
SK	HF	Not sig (p=0.836)	-

### Attitudes to engineering

SY	HF	Not sig (p=0.648)	-
SX	HF	Not sig (p=0.570)	-
SW	Sphericity assumed	Not sig (p=0.071)	-
SV	HF	F(2,267)=3.750, p=0.034	2&3
SU	GG	F(2,105)=7.037, p=0.003	1&2 and 2&3
ST	HF	F(2,199)=4.976, p=0.009	1&2
SR	HF	Not sig (p=0.147)	-
SP	HF	F(2,362)=3.642, p=0.036	1&3
SN	GG	Not sig (p=0.121)	-
SM	HF	Not sig (p=0.364)	-
SL	GG	Not sig (p=0.254)	-
SK	HF	F(2,325)=5.249, p=0.007	1&2

### Attitudes to STEM

SY	HF	F(2,84)=4.740, p=0.016	1&3
SX	Sphericity assumed	F(2,382)=7.053, p=0.001	1&3 and 2&3
SW	HF	F(2,157)=3.556, p=0.035	-
SV	HF	F(2,277)=7.701, p=0.001	2&3
SU	Sphericity assumed	F(2,136)=21.756, p=0.000	all
ST	HF	F(2,163)=19.699, p=0.000	1&2 and 1&3
SR	Sphericity assumed	F(2,256)=4.571, p=0.011	1&3
SP	HF	F(2,433)=4.966, p=0.008	2&3
SN	HF	F(2,234)=4.625, p=0.013	1&2 and 1&3
SM	Sphericity assumed	Not sig (p=0.445)	-
SL	HF	F(2,76)=26.283, p=0.000	1&2 and 1&3
SK	HF	Not sig (p=0.080)	1&2

### Attitudes to STEM+Space

SY	HF	Not sig ( $p=0.067$ )	-
SX	Sphericity assumed	$F(2,382)=3.768$ , $p=0.024$	2&3
SW	HF	$F(2,148)=3.945$ , $p=0.027$	1&3
SV	HF	$F(2,264)=10.775$ , $p=0.000$	1&3 and 2&3
SU	Sphericity assumed	$F(2,136)=12.849$ , $p=0.000$	1&2 and 2&3
ST	GG	$F(1,154)=21.192$ , $p=0.000$	1&2 and 1&3
SR	Sphericity assumed	$F(2,256)=5.498$ , $p=0.005$	1&3
SP	Sphericity assumed	$F(2,446)=6.053$ , $p=0.003$	2&3
SN	Sphericity assumed	$F(2,254)=3.347$ , $p=0.037$	-
SM	Sphericity assumed	Not sig ( $p=0.731$ )	-
SL	GG	$F(1,70)=18.834$ , $p=0.000$	1&2 and 1&3
SK	HF	$F(2,344)=4.057$ , $p=0.019$	1&2

### Cleverness/well-paid jobs

SY	Sphericity assumed	Not sig ( $p=0.306$ )	-
SX	Sphericity assumed	Not sig ( $p=0.521$ )	-
SW	HF	Not sig ( $p=0.761$ )	-
SV	HF	Not sig ( $p=0.093$ )	-
SU	Sphericity assumed	Not sig ( $p=0.792$ )	-
ST	HF	Not sig ( $p=0.131$ )	-
SR	HF	Not sig ( $p=0.442$ )	-
SP	HF	Not sig ( $p=0.577$ )	-
SN	HF	Not sig ( $p=0.601$ )	-
SM	Sphericity assumed	$F(2,102)=5.893$ , $p=0.004$	1&3
SL	GG	Not sig ( $p=0.454$ )	-
SK	HF	Not sig ( $p=0.805$ )	-

### Changes over time: attitudes to STEM, and the space story

#### Attitudes to STEM subjects: significance data related to changes over time (section 5.1.1)

	<i>Primary school data</i>	<i>Secondary school data</i>
Science lessons are among my favourite lessons (PSD2, SSD2)	Significant change Phase 2 to Phase 3: $t(388)=-3.496$ , $p=0.001$ (and also even larger overall change Phase 1 to 3)	No significant change over time
Scientists help make people's lives better (PSD10, SSD10)	No significant change over time	No significant change over time
I would consider a career as a scientist (PSD7, SSD7)	No significant change over time	No significant change over time
Maths lessons are among my favourite lessons (PMD2, SMD2)	No significant change over time	Significant change Phase 2 to Phase 3: $t(458)=-3.898$ , $p=0.000$ (and also even larger overall change Phase 1 to Phase 3)

Mathematicians help make people's lives better (PMD10, SMD10)	No significant change over time	No significant change over time
I would consider a career where I would do maths all the time (PMD6)/as a mathematician (SMD6)	No significant change over time	Significant change Phase 2 to Phase 3: $t(453)=-3.392$ , $p=0.001$
I would be happiest if I had only 'designing and making'/technology lessons and no other lessons at school (PTED2, STD2)	Significant change Phase 2 to 3: $t(374)=-4.072$ , $p=0.000$ (and also significant overall change Phase 1 to 3)	Significant change Phase 2 to 3: $t(445)=-2.179$ , $p=0.030$ (and also even larger overall change Phase 1 to 3)
Technology (and engineering) make(s) everything work better (PTED14/16/STD12))	No significant change over time	Significant change Phase 2 to 3: $t(430)=-2.586$ , $p=0.010$
I would consider a career in which technology is the most important part (PTED10/11/STD8)	Significant change Phase 2 to 3: $t(377)=3.270$ , $p=0.001$	No significant change over time

### The space story: significance data related to changes over time (section 5.1.2)

	<i>Primary school data</i>	<i>Secondary school data</i>
I enjoy learning about space in school lessons (PPD1, SPD1)	Significant change Phase 2 to 3: $t(378)=-5.911$ , $p=0.000$ (and also even larger overall change Phase 1 to 3)	Significant change Phase 1 to 2: $t(879)=-3.127$ , $p=0.002$ (and also even larger overall change Phase 1 to 3)
When I learn about space, I am more interested in science (PPD2, SPD2)	Significant change Phase 2 to 3: $t(384)=-3.368$ , $p=0.001$ (and also even larger overall change Phase 1 to 3)	Significant overall change Phase 1 to 3: $t(570)=-2.499$ , $p=0.013$
I am interested in what happens to humans in space (PPD4, SPD4)	Significant change Phase 2 to 3: $t(379)=-2.858$ , $p=0.004$	Significant overall change Phase 1 to 3: $t(569)=-2.974$ , $p=0.003$
It is important to send people into space to find out more about the universe (PPD15, SPD15)	No significant change over time	No significant change over time
Sending humans to space is worth the money spent (PPD16, SPD16)	Significant change Phase 1 to 2: $t(601)=3.229$ , $p=0.001$	No significant change over time
I am interested in the technology which is needed for spaceflight (PPD5, SPD5)	Significant change Phase 2 to 3: $t(379)=-4.905$ , $p=0.000$	Significant change Phase 2 to 3: $t(448)=-2.675$ , $p=0.008$ (and also even larger overall change Phase 1 to 3)
I would like to have a job related to space science or space technology (PPD13, SPD13)	Significant change Phase 2 to 3: $t(380)=-4.308$ , $p=0.000$	No significant change over time
I could work in space science or space technology if I wanted to (PPD18, SPD18)	No significant change over time	No significant change over time

You need to be clever to...

You need to be clever to...: significance data related to items PSD16/PMD16/PPD17 and SSD16/SMD16/SPD17 (section 5.1.3)

**Primary school data**

<b>Items</b>	<b>Phase 1</b>	<b>Phase 2</b>	<b>Phase 3</b>
PSD16 and PMD16	t(771)=-2.850, p=0.004	t(693)=-5.973, p=0.000	t(542)=-8.678, p=0.000
PMD16 and PPD17	t(769)=-8.750, p=0.000	t(691)=-7.717, p=0.000	t(541)=-8.171, p=0.000

Split by gender, the patterns were very similar:

<b>Items</b>	<b>Phase 1 (boys)</b>	<b>Phase 1 (girls)</b>	<b>Phase 2 (boys)</b>	<b>Phase 2 (girls)</b>	<b>Phase 3 (boys)</b>	<b>Phase 3 (girls)</b>
PSD16 and PMD16	t(201)=-2.507, p=0.013	t(204)=-2.079, p=0.039	t(189)=-2.704, p=0.007	t(190)=-3.091, p=0.002	t(264)=-6.367, p=0.000	t(277)=-5.903, p=0.000
PMD16 and PPD17	t(203)=-3.934, p=0.000	t(202)=-5.780, p=0.000	t(189)=-5.626, p=0.000	t(189)=-4.208, p=0.000	t(263)=-6.429, p=0.000	t(277)=-5.142, p=0.000

**Secondary school data**

<b>Items</b>	<b>Phase 1</b>	<b>Phase 2</b>	<b>Phase 3</b>
SSD16 and SMD16	t(1562)=-11.938, p=0.000	t(1040)=-11.011, p=0.000	t(765)=-7.191, p=0.000
SMD16 and SPD17	t(1562)=-16.345, p=0.000	t(1039)=-9.011, p=0.000	t(758)=-5.906, p=0.000

Split by gender the patterns were similar:

<b>Items</b>	<b>Phase 1 (boys)</b>	<b>Phase 1 (girls)</b>	<b>Phase 2 (boys)</b>	<b>Phase 2 (girls)</b>	<b>Phase 3 (boys)</b>	<b>Phase 3 (girls)</b>
SSD16 and SMD16	t(300)=-6.956, p=0.000	t(280)=-3.748, p=0.000	t(232)=-6.148, p=0.000	t(228)=-3.748, p=0.000	t(394)=-4.832, p=0.000	t(368)=-5.258, p=0.000
SMD16 and SPD17	t(300)=-8.807, p=0.000	t(279)=-7.572, p=0.000	t(232)=-5.752, p=0.000	t(229)=-3.144, p=0.002	t(385)=-5.408, p=0.000	t(370)=-2.811, p=0.005

## Technical Annex 2: Primary school students' quantitative data

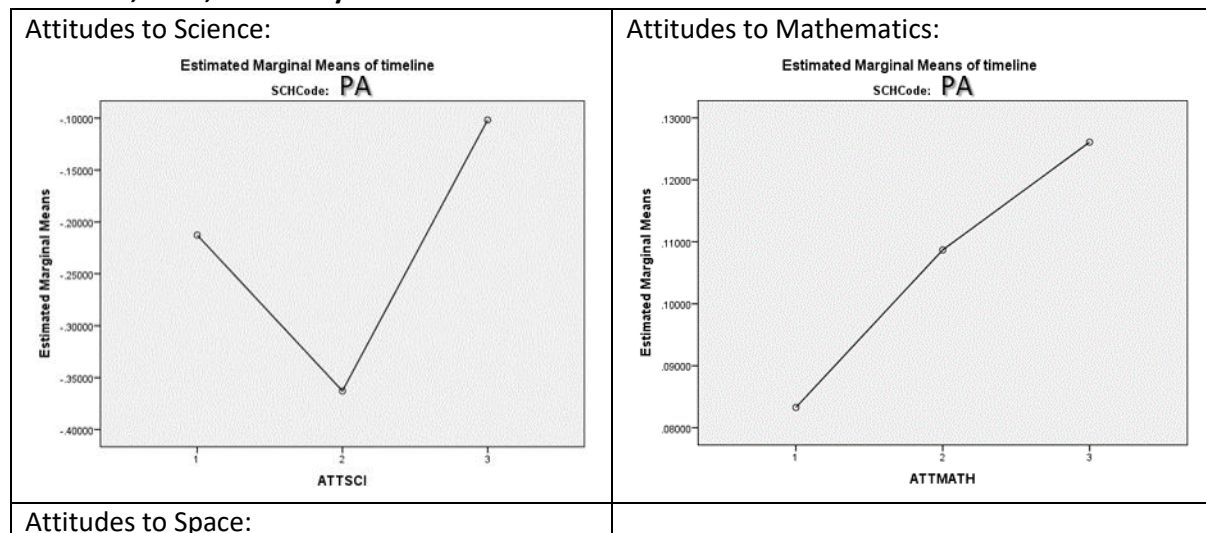
Factor scores from the Principal Components analysis were used to produce charts for individual primary schools, to be used as illustration for section 5.2. The scores are relative to the whole cohort sample, rather than absolute. So for school PA, for example, the ATTSCI attitudes to science scores were all negative compared to their whole cohort, while ATTSPACE attitudes to space were all positive. This means that the students were more negative than most about science, but more positive than most about space.

Data are presented per school, for all schools where students completed the questionnaire in all three phases (denoted by numbers 1-3 in the charts). Case study schools, who have been visited by a researcher shortly after the students completed the questionnaires, are presented first. Charts represent overall timelines: changes over time in the factor scores calculated through factor analysis (for further detail, see Technical Annex 1).

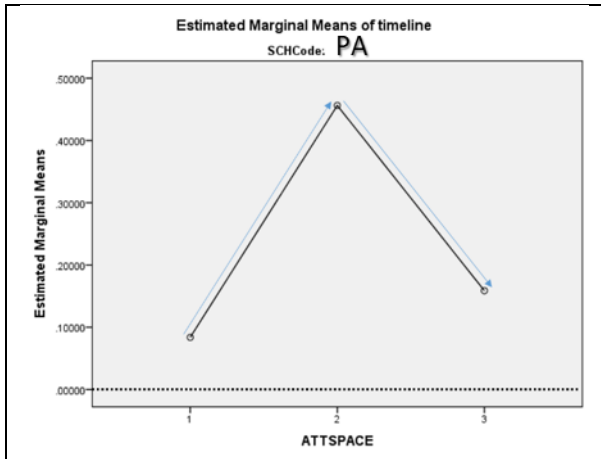
Please note that the *position* of the horizontal axis (representing a factor score of 0.00000) and the *scale* of the vertical axis are different in each chart. The horizontal axis is indicated by a dotted line, unless the scores are all negative or all positive.

Significant changes over time are indicated by single-headed arrows alongside the corresponding timeline section.

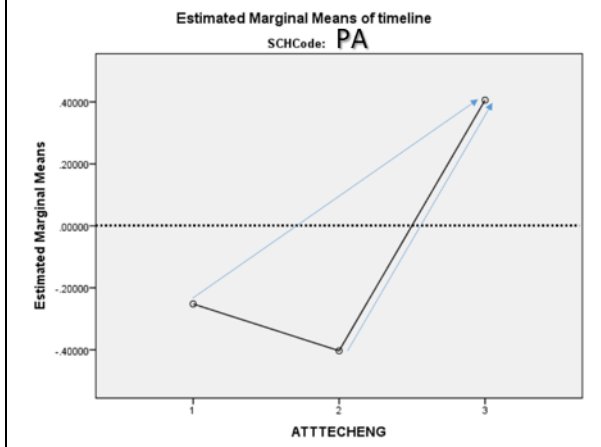
### School PA, n=94, case study school



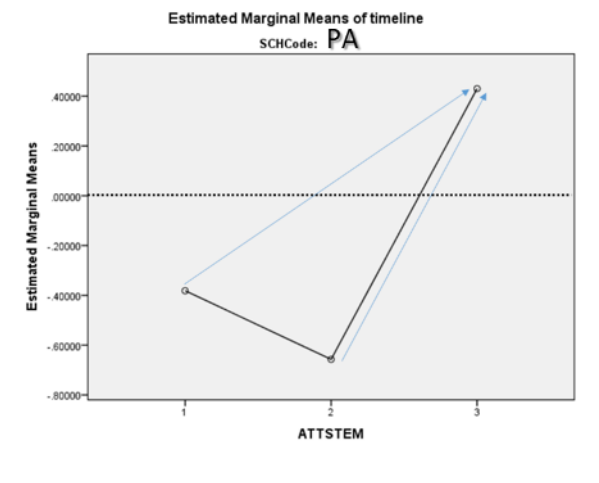




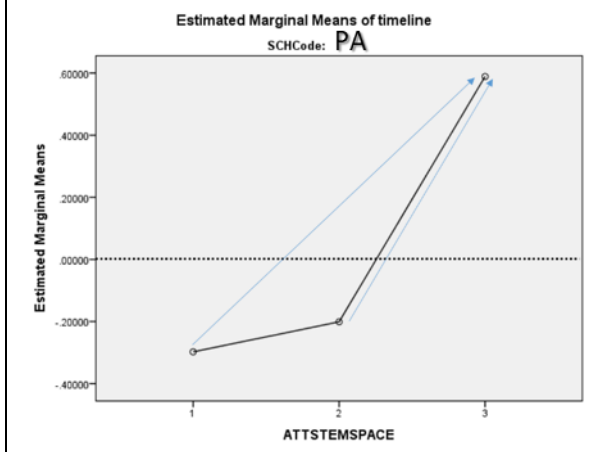
Attitudes to Technology/Engineering ('Designing and making'):



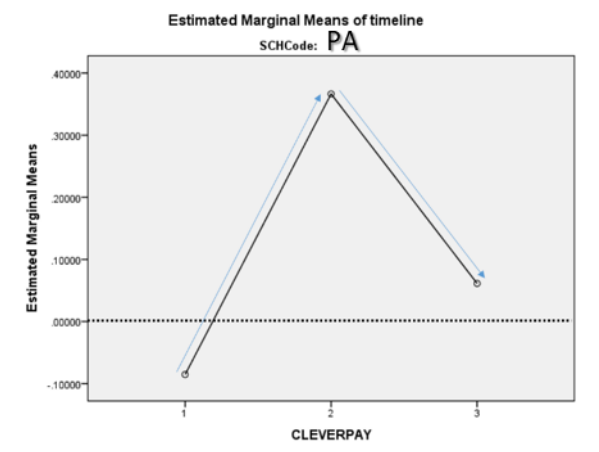
Attitudes to STEM:



Attitudes to STEM+Space:

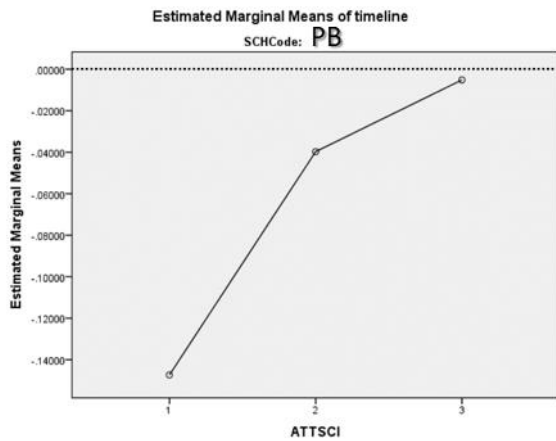


Cleverness&well-paid jobs:

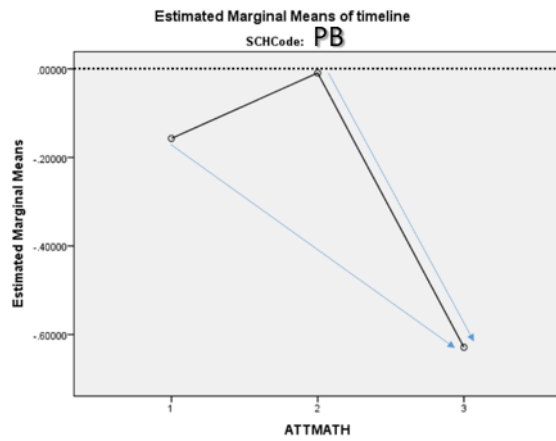


School PB, n=61, case study school

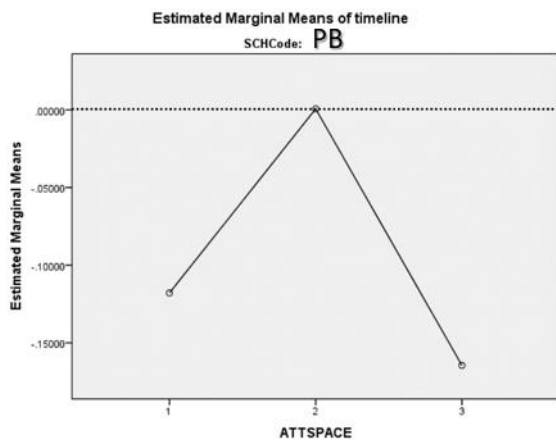
Attitudes to Science:



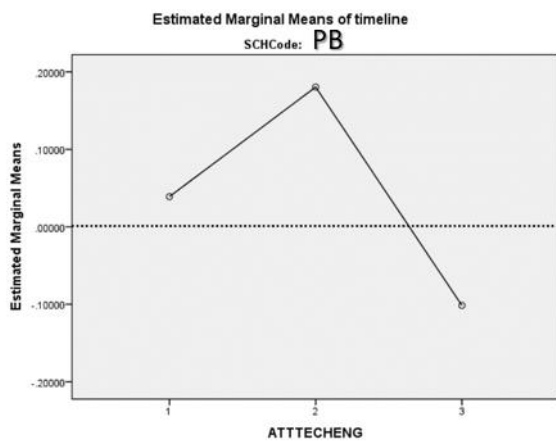
Attitudes to Mathematics:



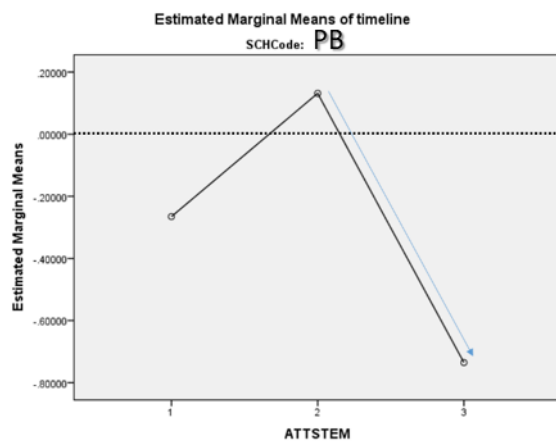
Attitudes to Space:



Attitudes to Technology/Engineering ('Designing and making'):

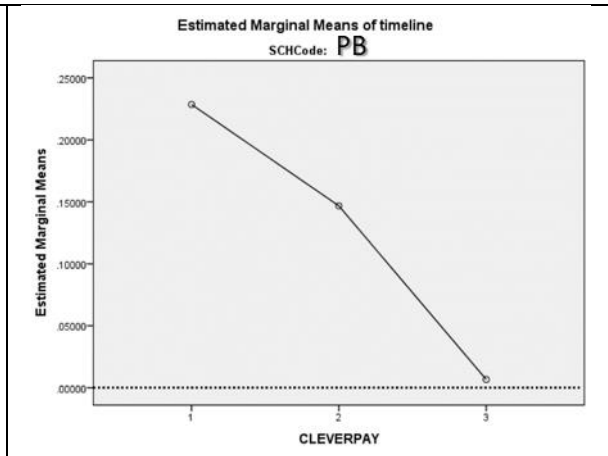
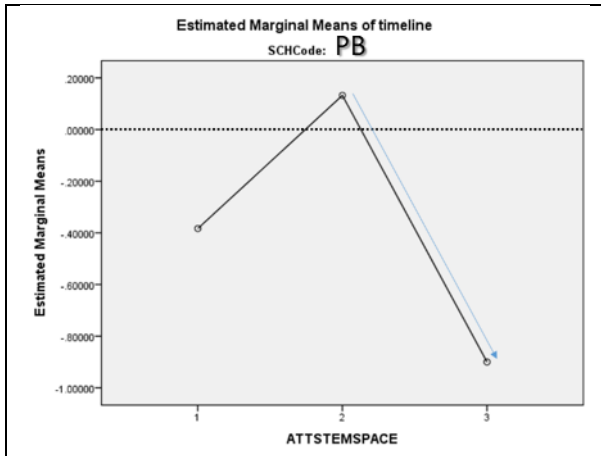


Attitudes to STEM:

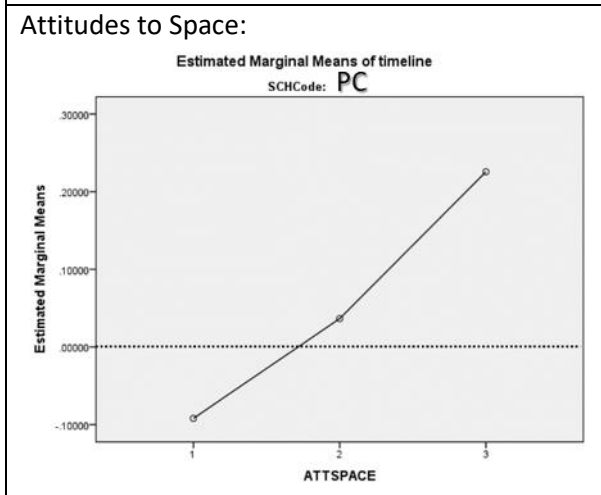
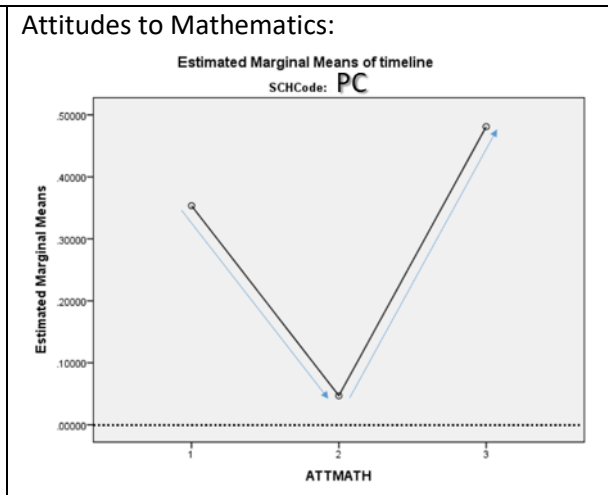
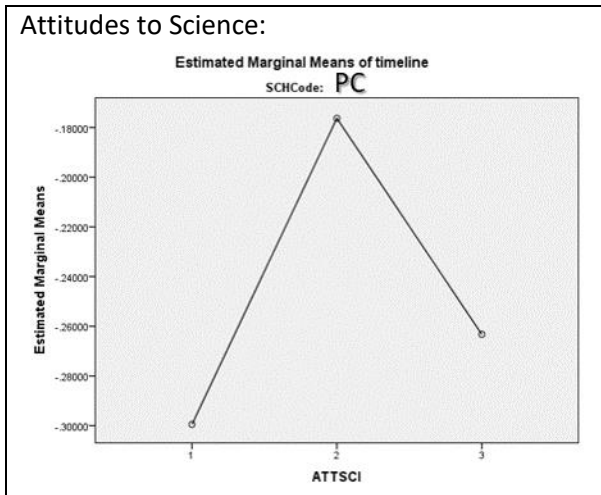


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

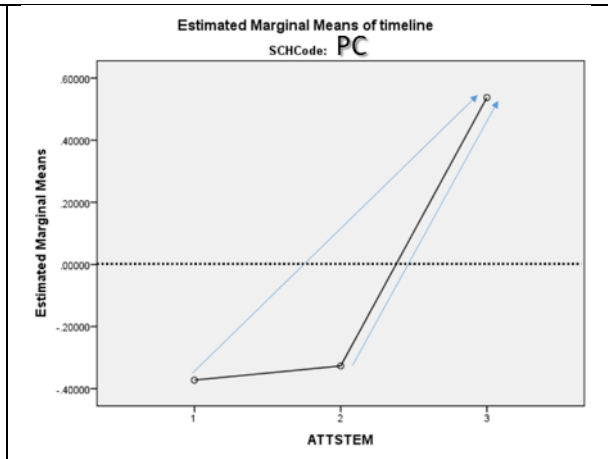
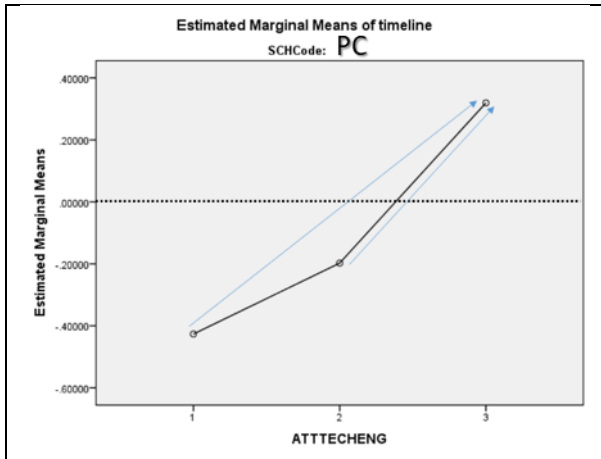


**School PC, n=63, case study school**

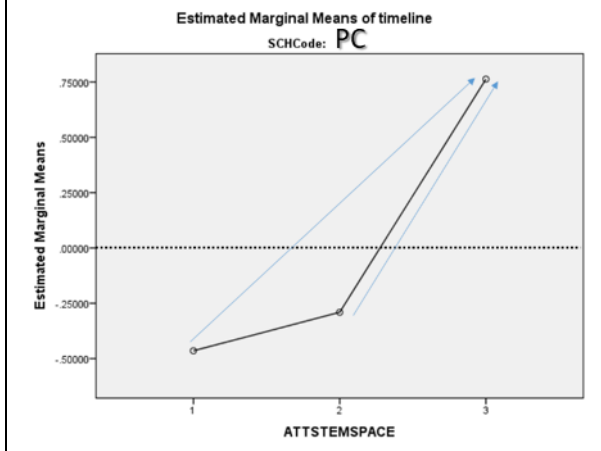


Attitudes to Technology/Engineering ('Designing and making'):

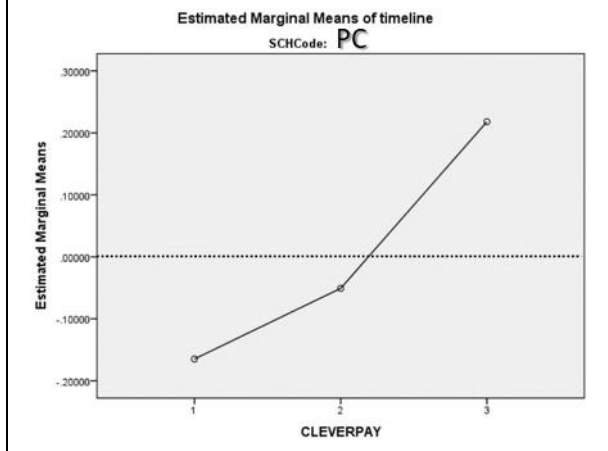
Attitudes to STEM:



Attitudes to STEM+Space:

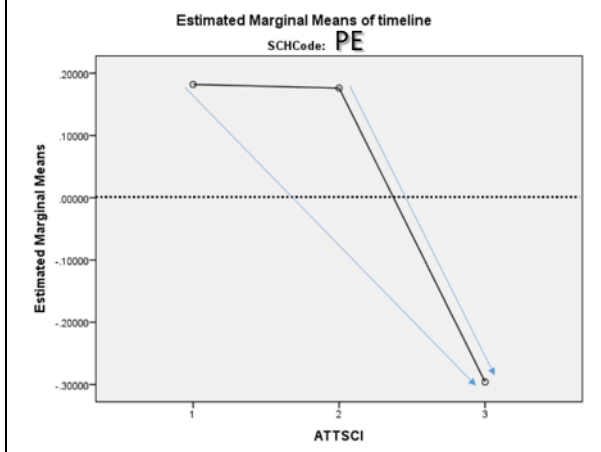


Cleverness&well-paid jobs:

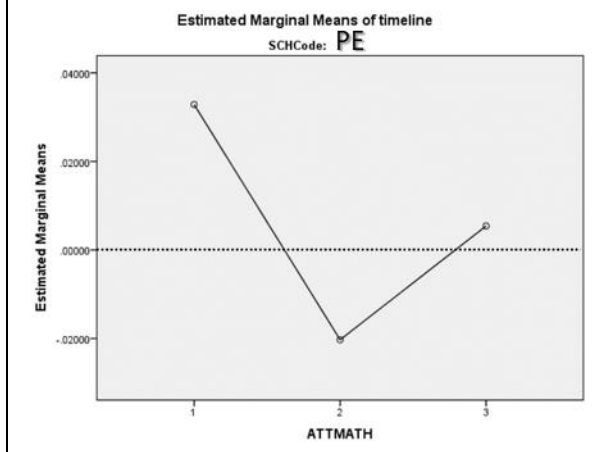


School PE, n=61, case study school

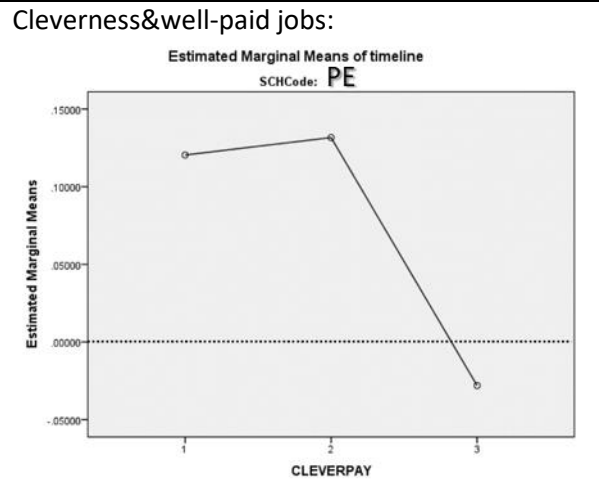
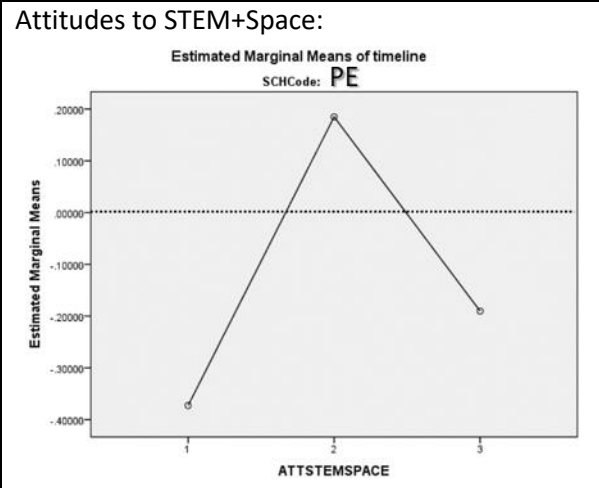
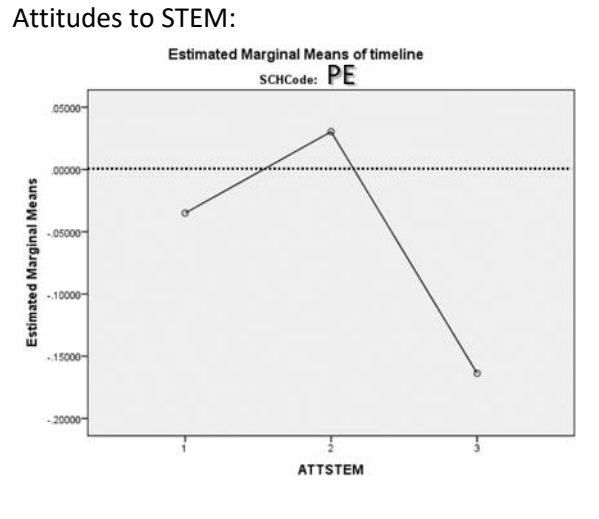
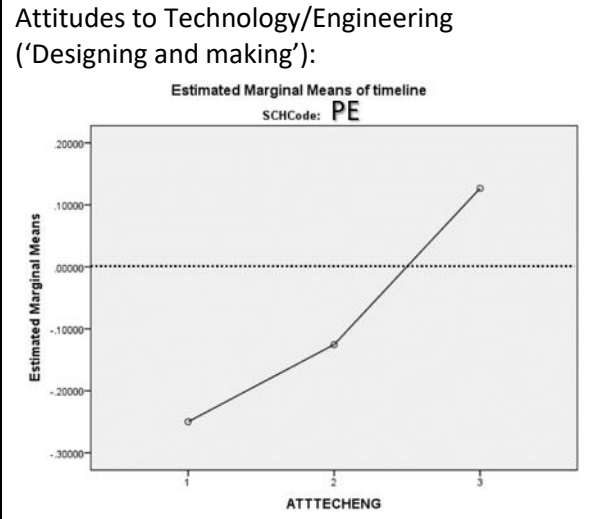
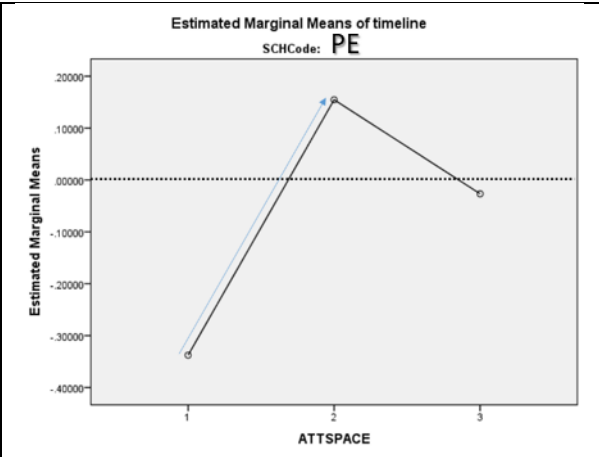
Attitudes to Science:



Attitudes to Mathematics:

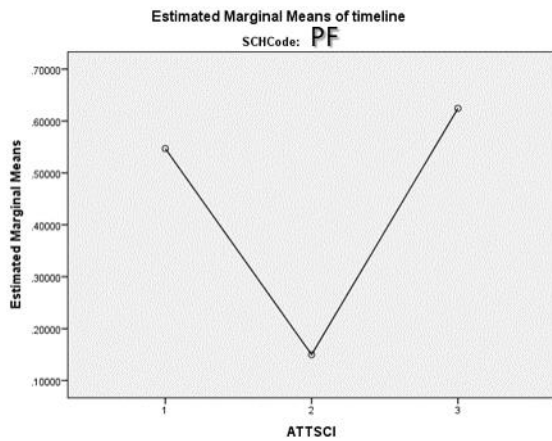


Attitudes to Space:

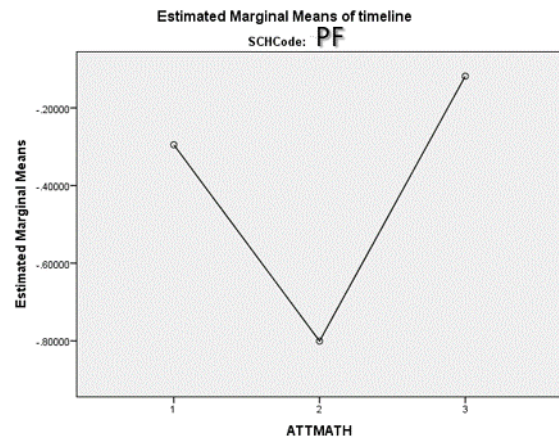


School PF, n=14, case study school

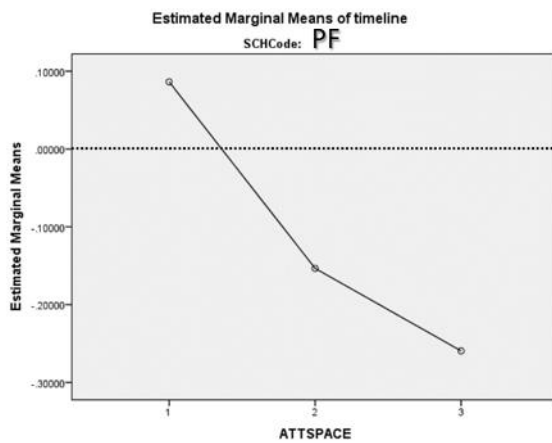
Attitudes to Science:



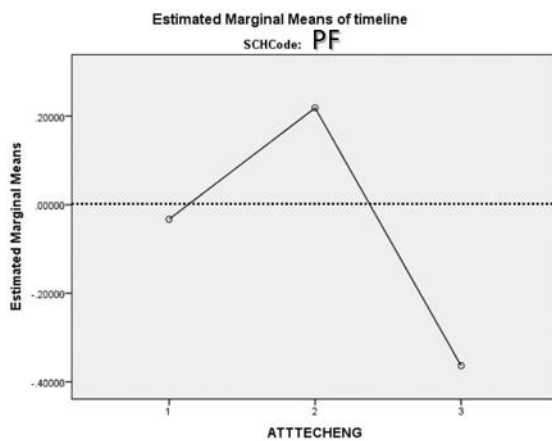
Attitudes to Mathematics:



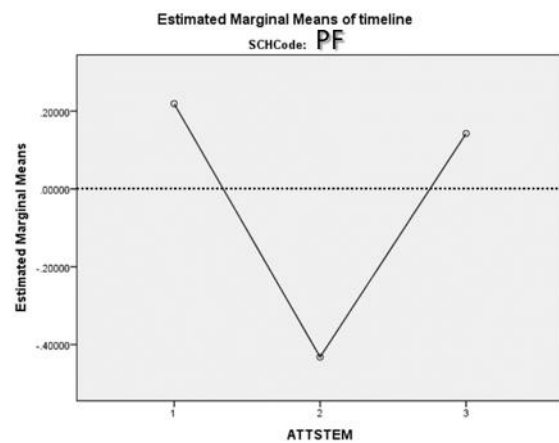
Attitudes to Space:



Attitudes to Technology/Engineering ('Designing and making'):

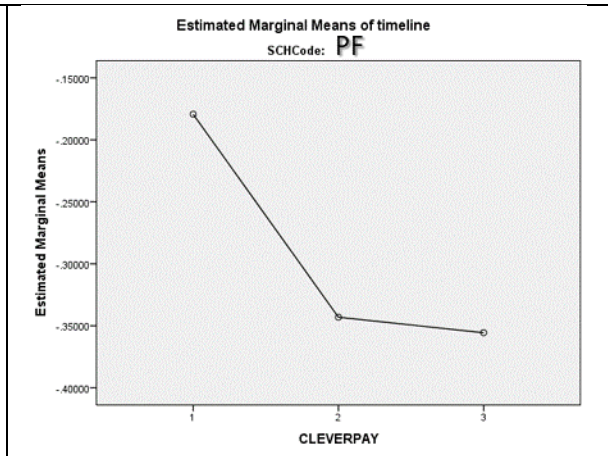
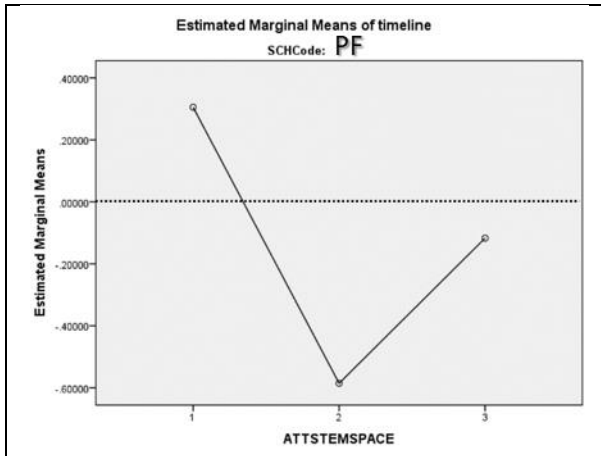


Attitudes to STEM:

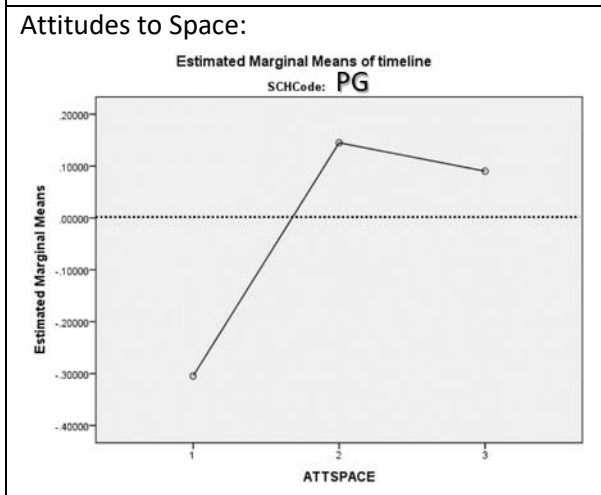
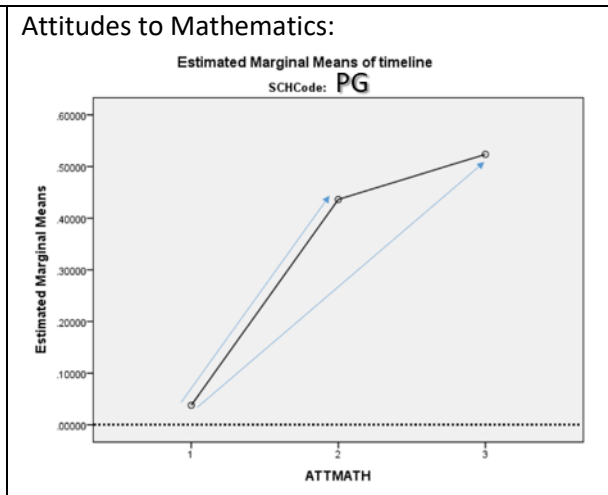
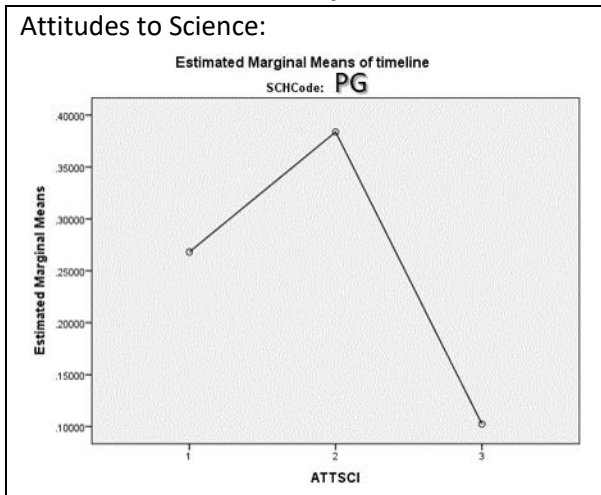


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

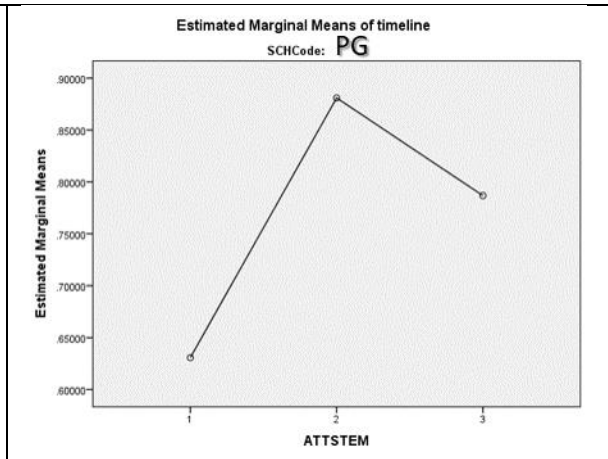
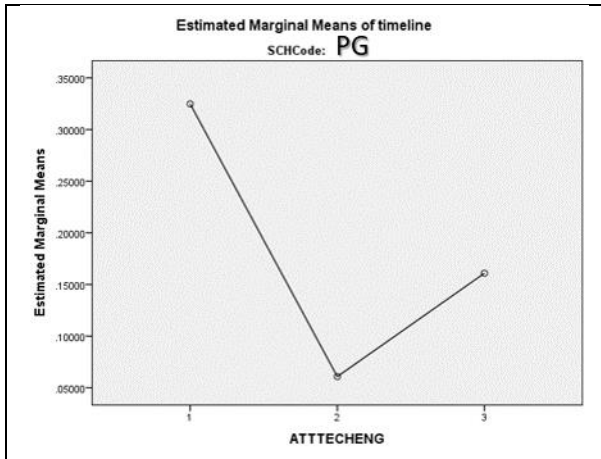


**School PG, n=22, case study school**

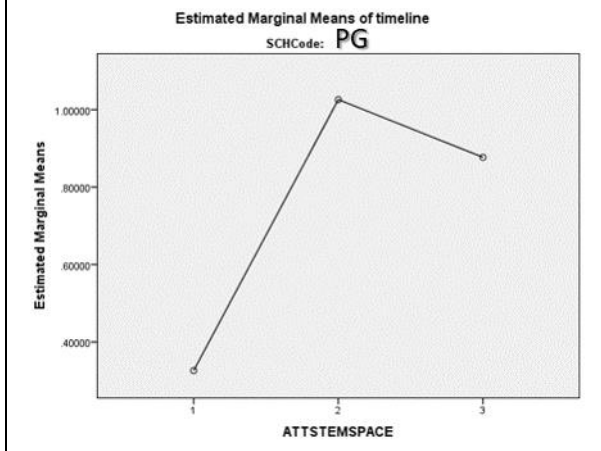


Attitudes to Technology/Engineering ('Designing and making'):

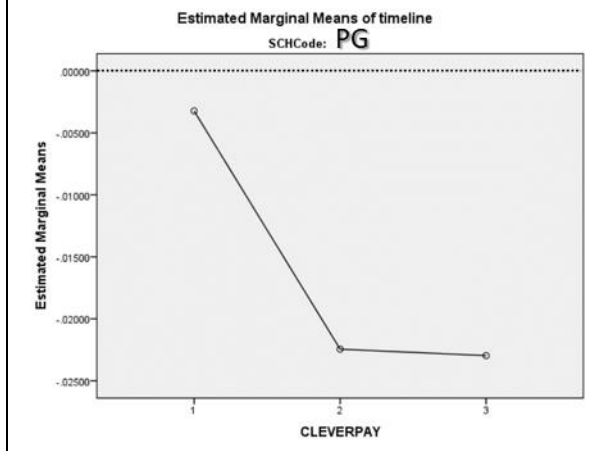
Attitudes to STEM:



Attitudes to STEM+Space:

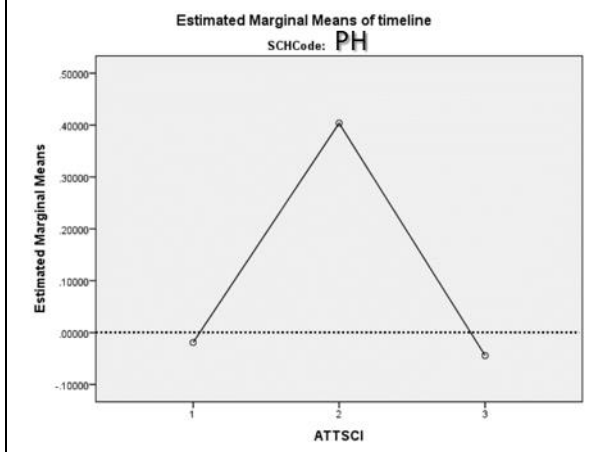


Cleverness&well-paid jobs:

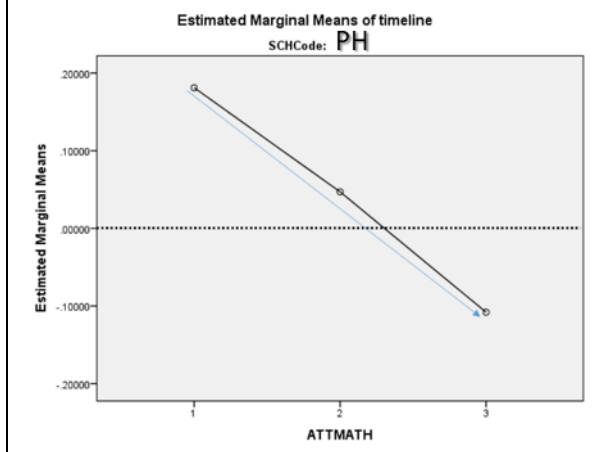


School PH, n=47, case study school

Attitudes to Science:

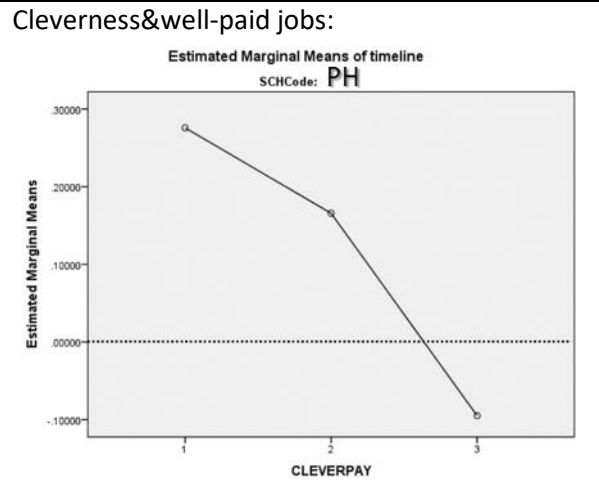
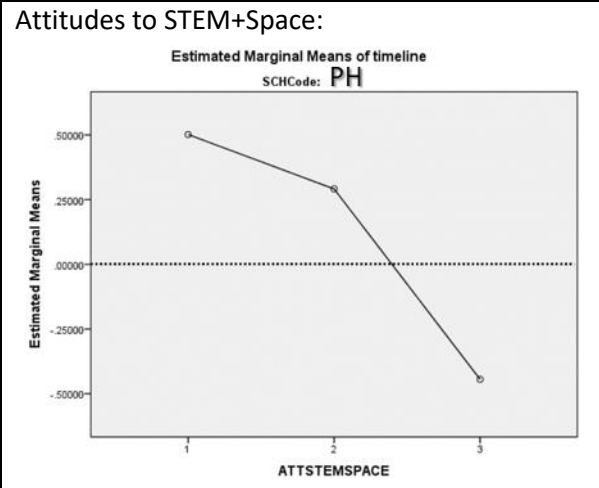
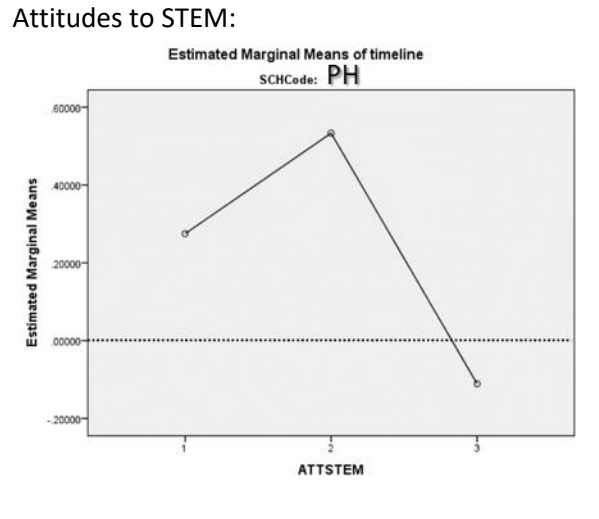
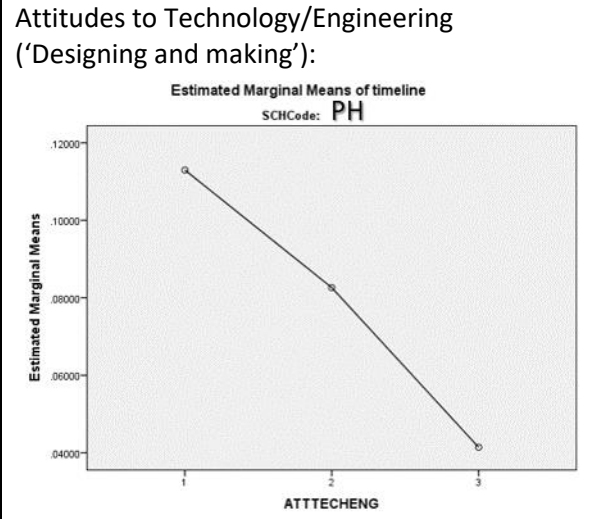
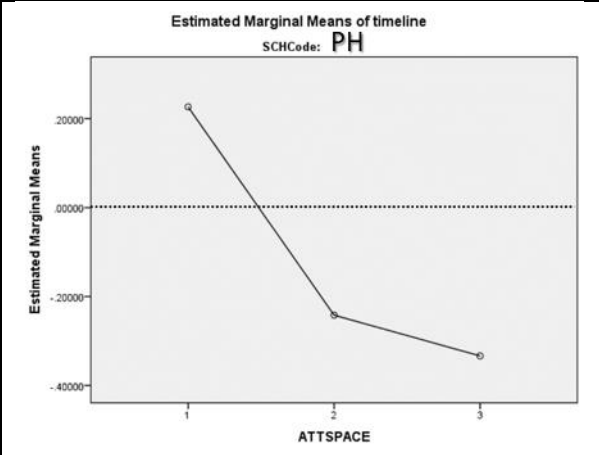


Attitudes to Mathematics:



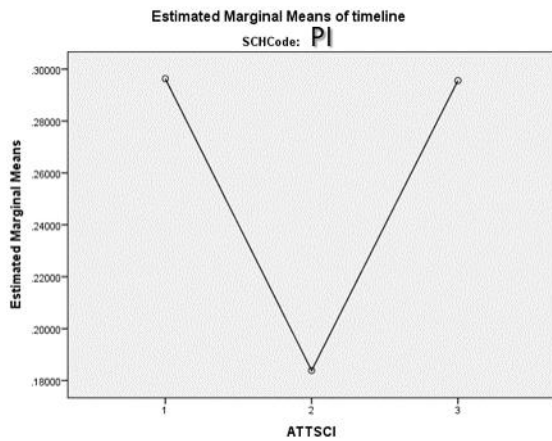
Attitudes to Space:



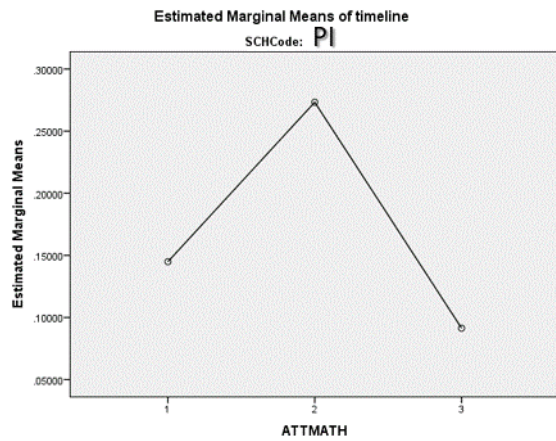


School PI, n=90, case study school

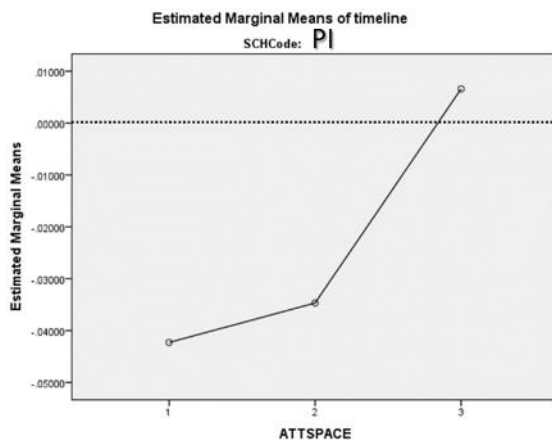
Attitudes to Science:



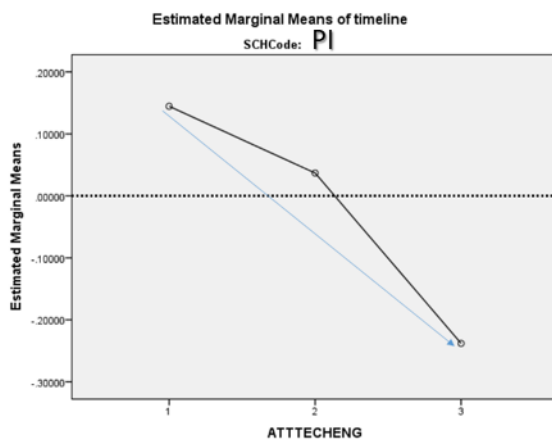
Attitudes to Mathematics:



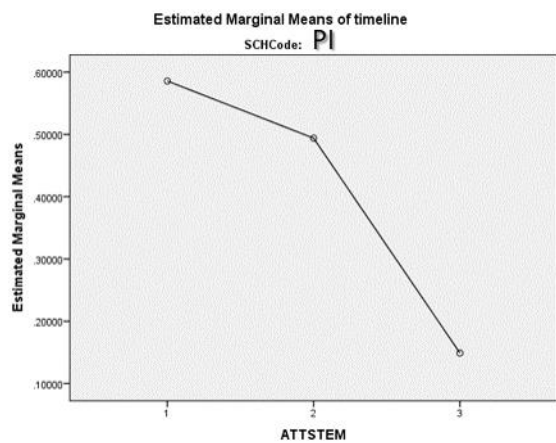
Attitudes to Space:



Attitudes to Technology/Engineering ('Designing and making'):

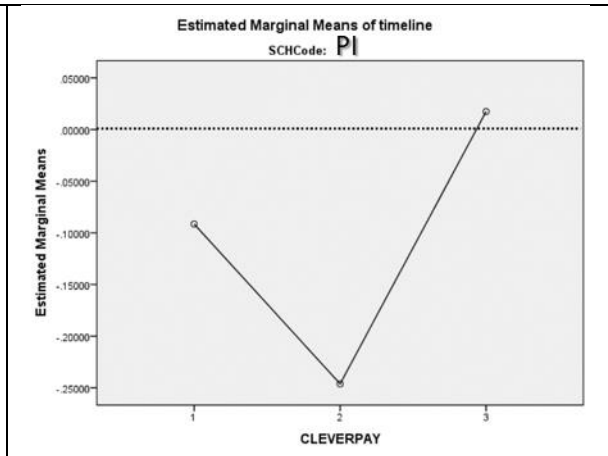
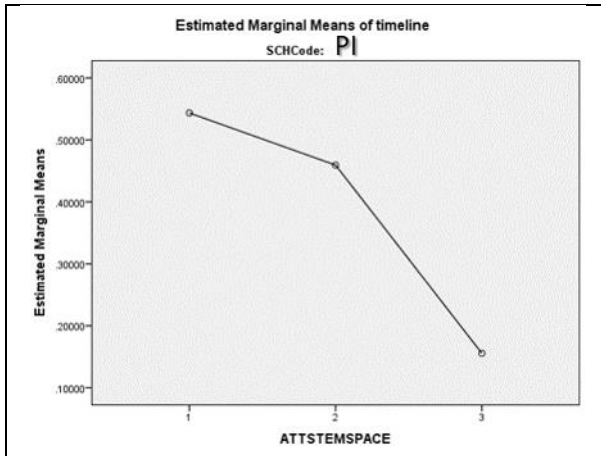


Attitudes to STEM:

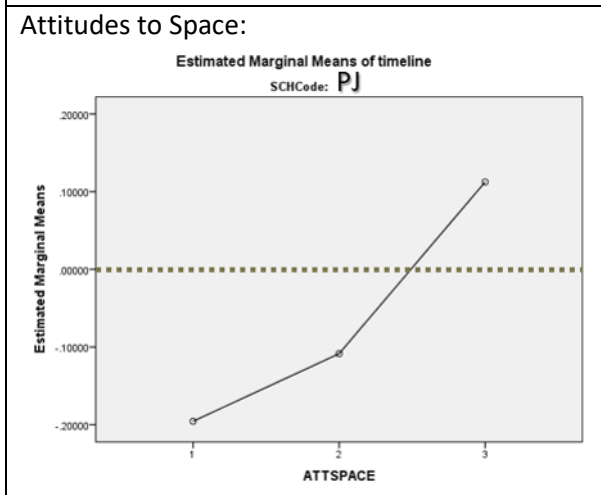
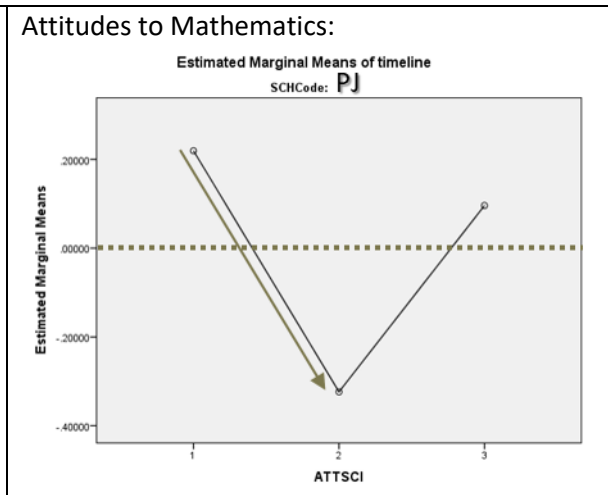
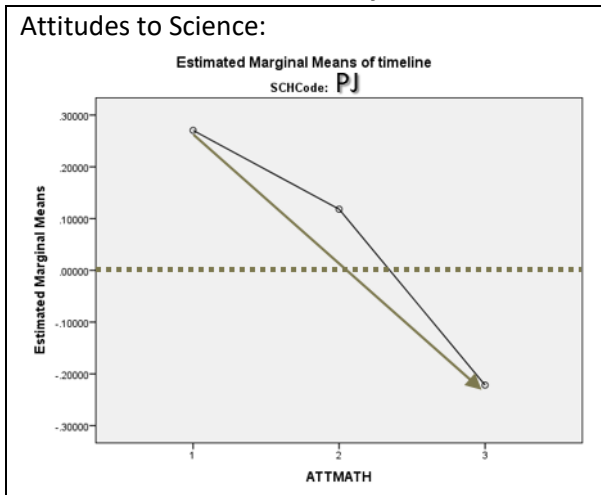


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

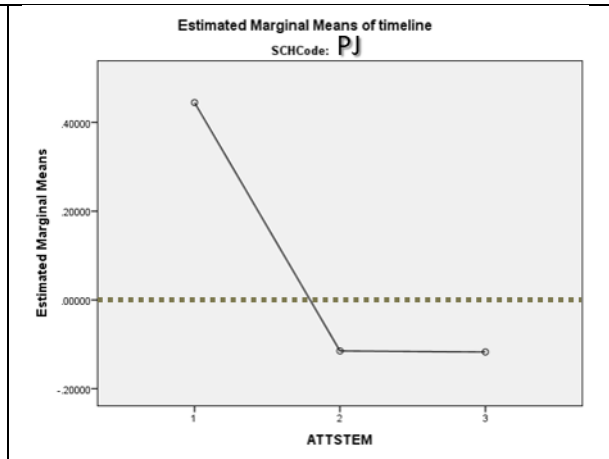
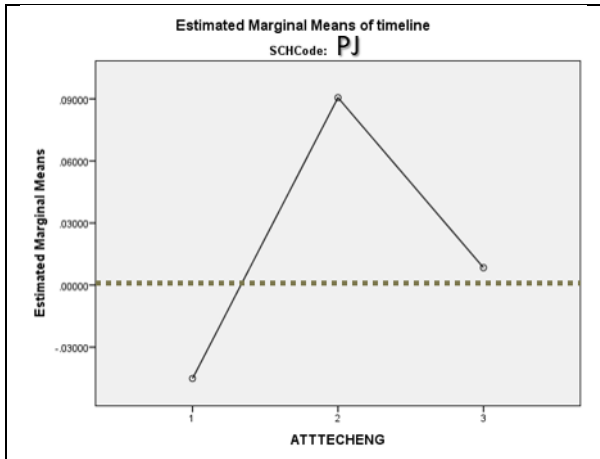


**School PJ, n=23, not case study school**

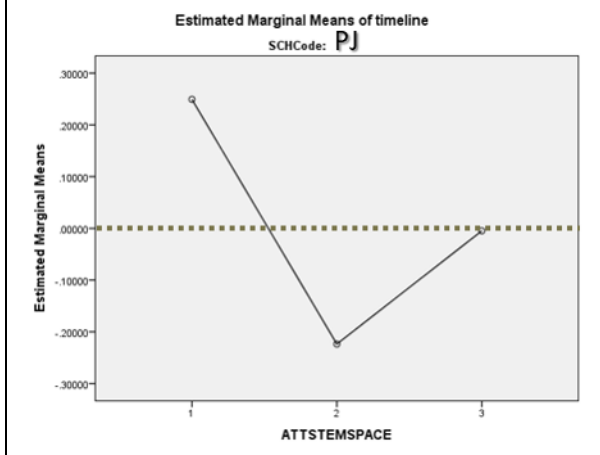


Attitudes to Technology/Engineering ('Designing and making'):

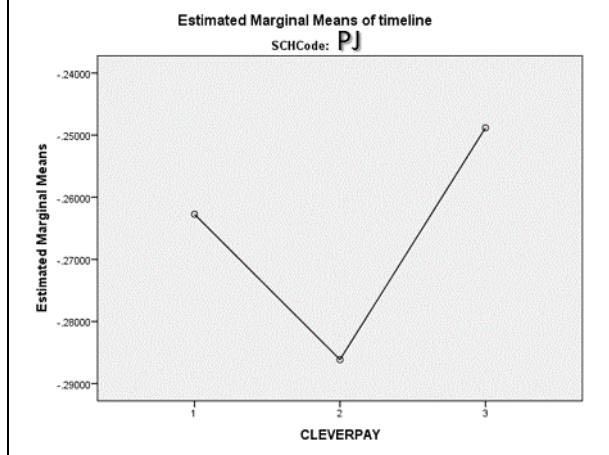
Attitudes to STEM:



Attitudes to STEM+Space:

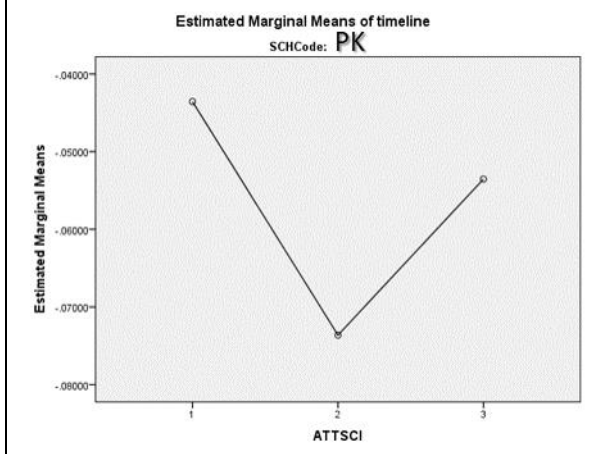


Cleverness&well-paid jobs:

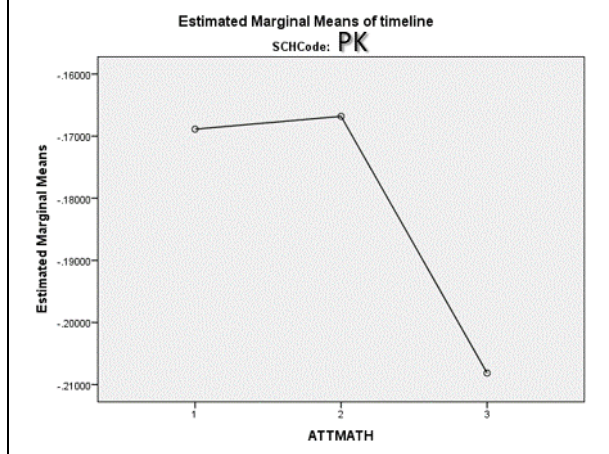


School PK, n=115, not case study school

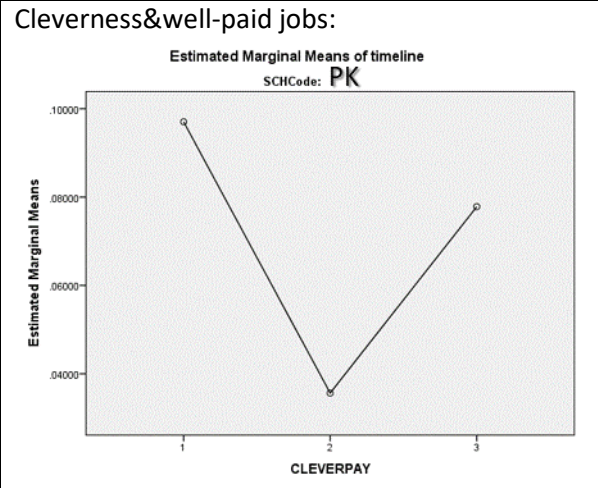
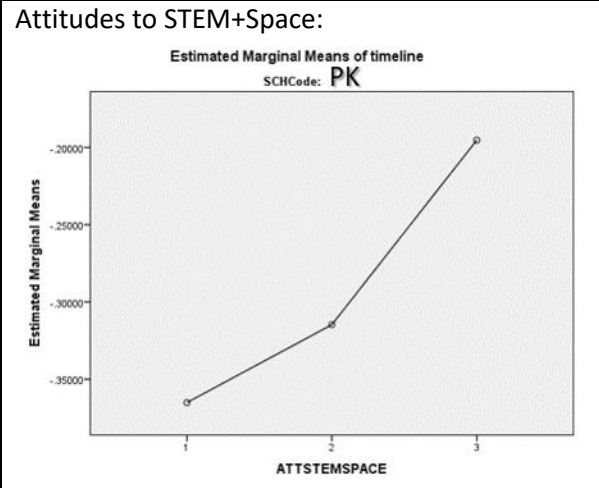
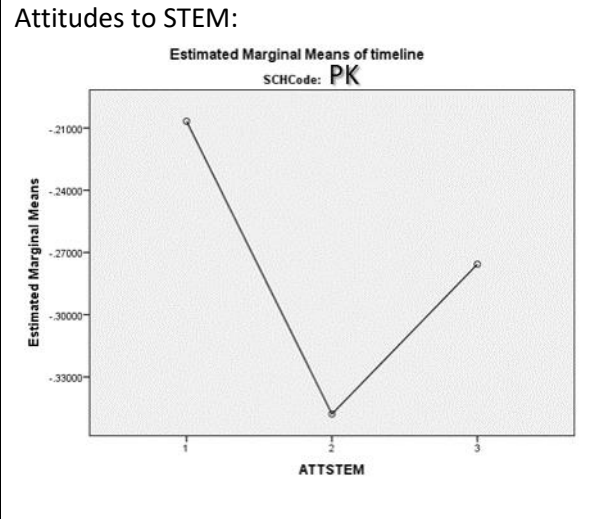
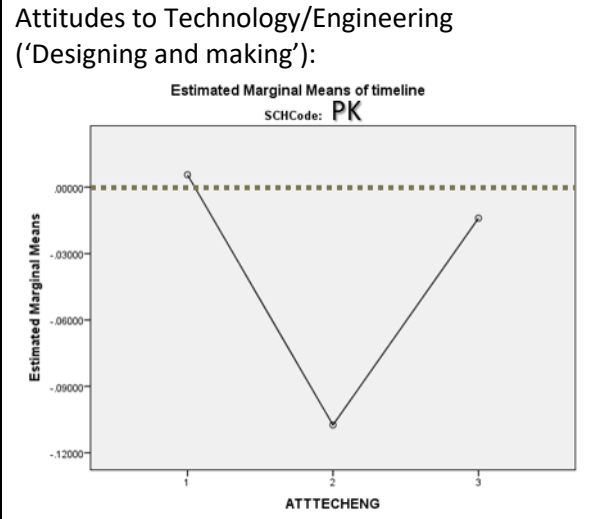
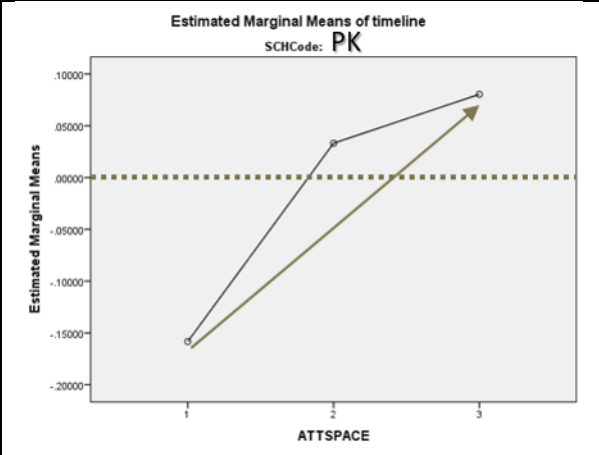
Attitudes to Science:



Attitudes to Mathematics:

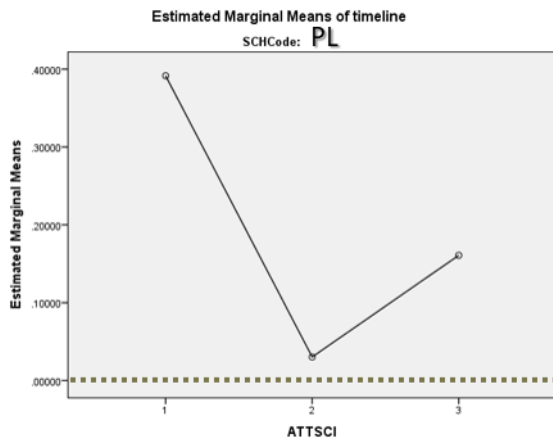


Attitudes to Space:

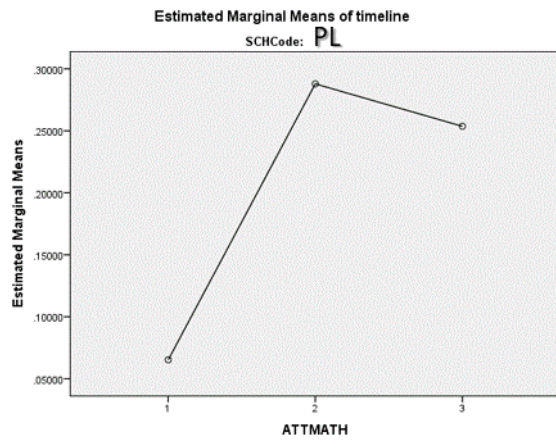


School PL, n=30, not case study school

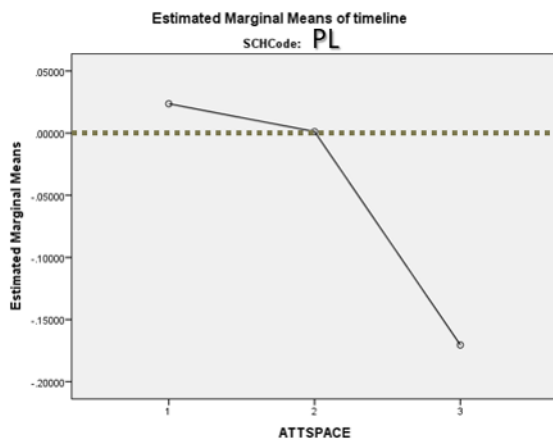
Attitudes to Science:



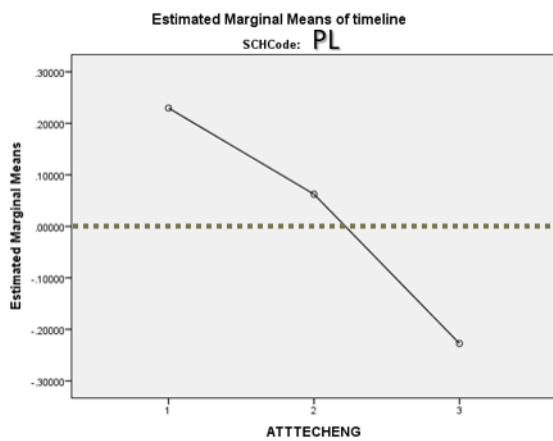
Attitudes to Mathematics:



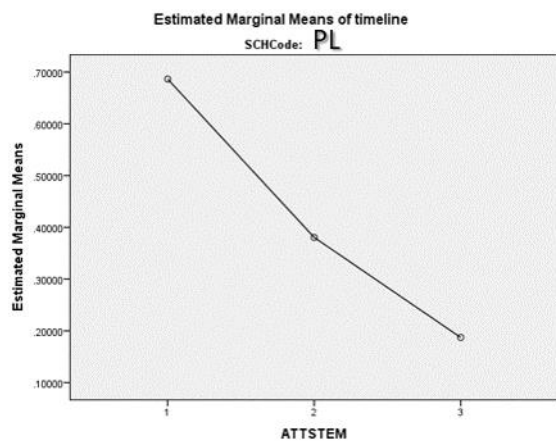
Attitudes to Space:



Attitudes to Technology/Engineering ('Designing and making'):

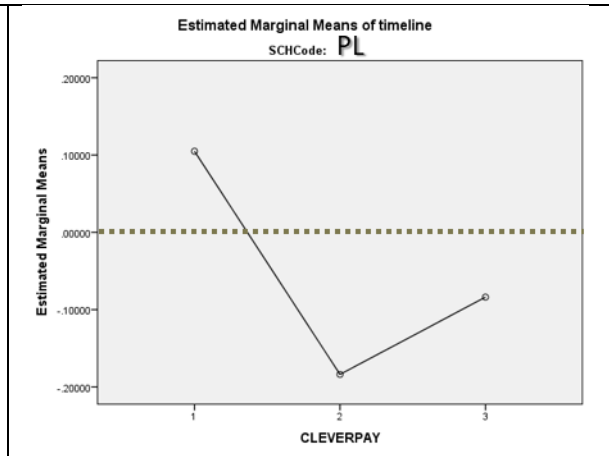
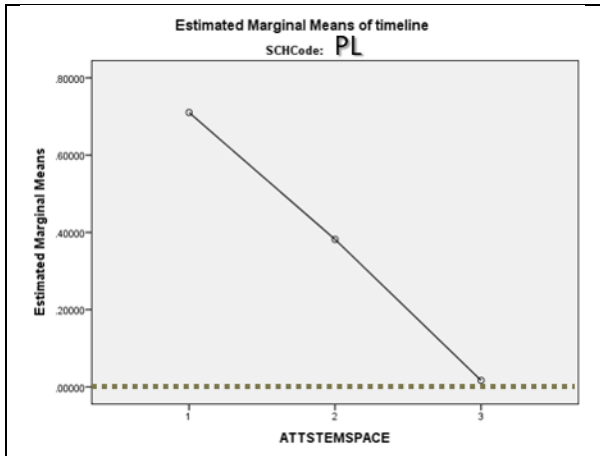


Attitudes to STEM:

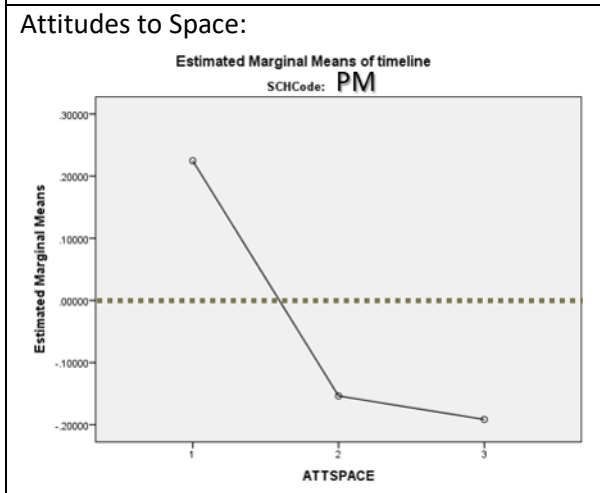
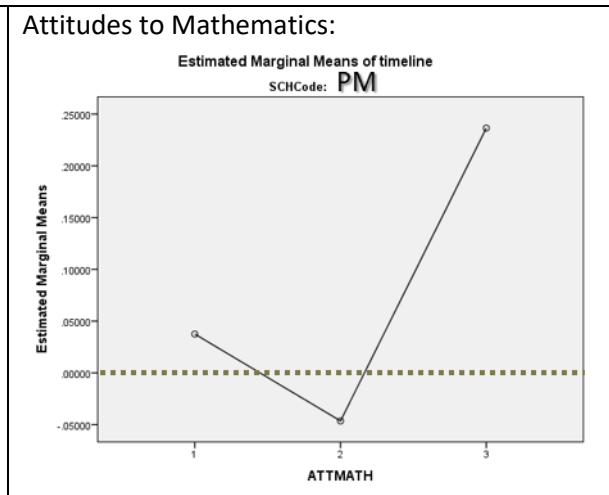
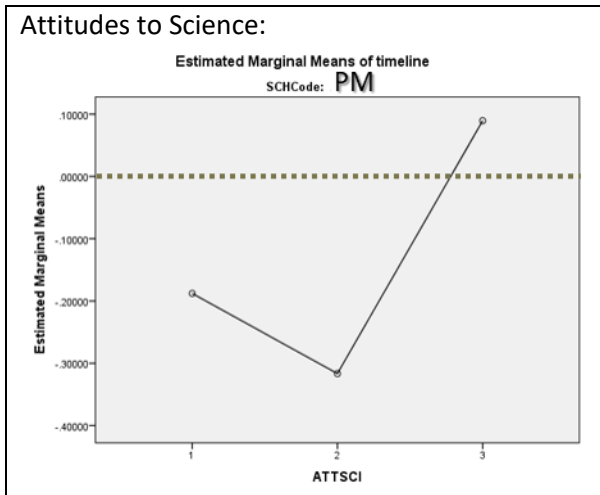


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

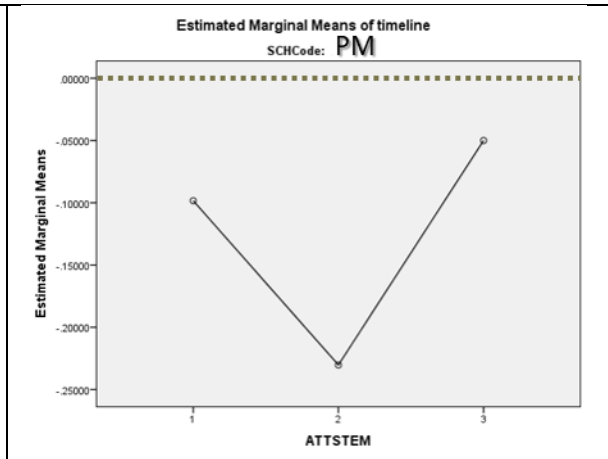
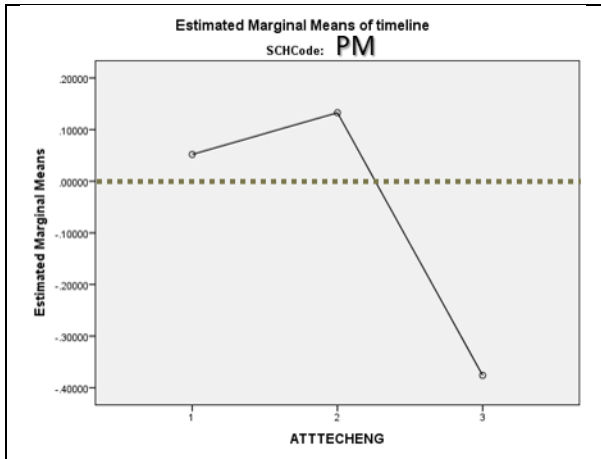


**School PM, n=8, not case study school**

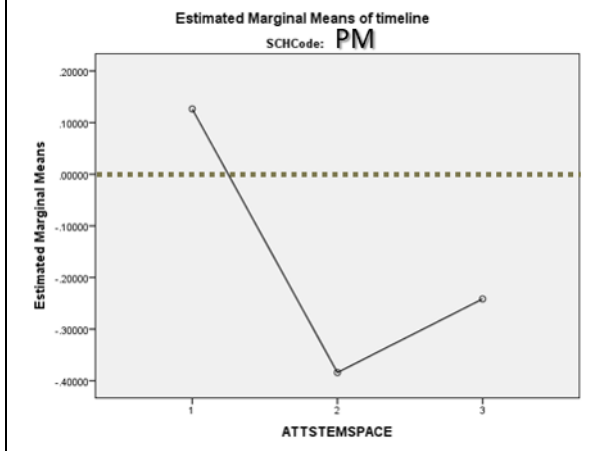


Attitudes to Technology/Engineering ('Designing and making'):

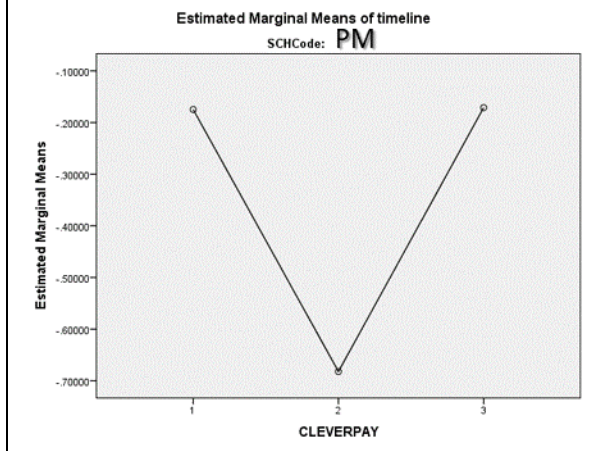
Attitudes to STEM:



Attitudes to STEM+Space:

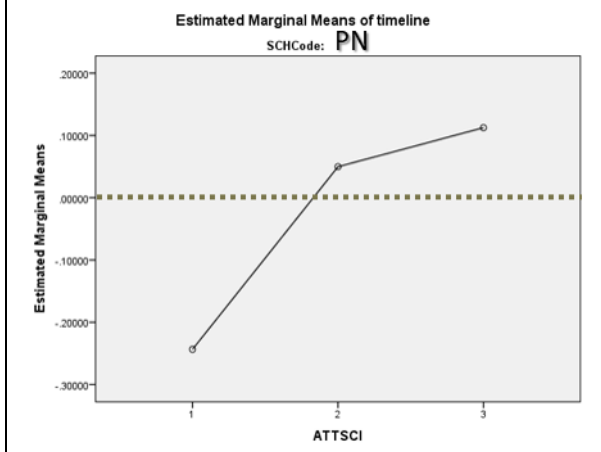


Cleverness&well-paid jobs:

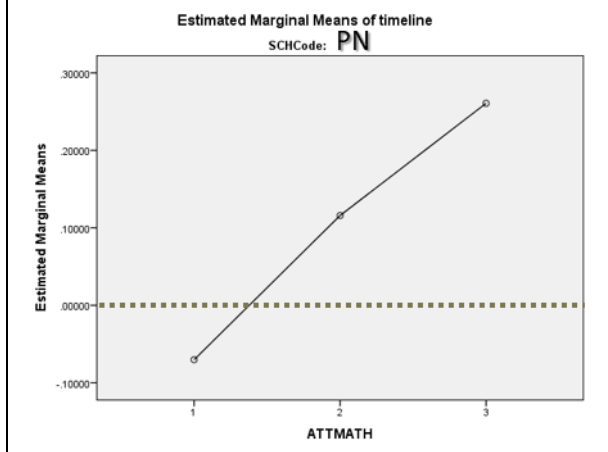


School PN, n=32, not case study school

Attitudes to Science:

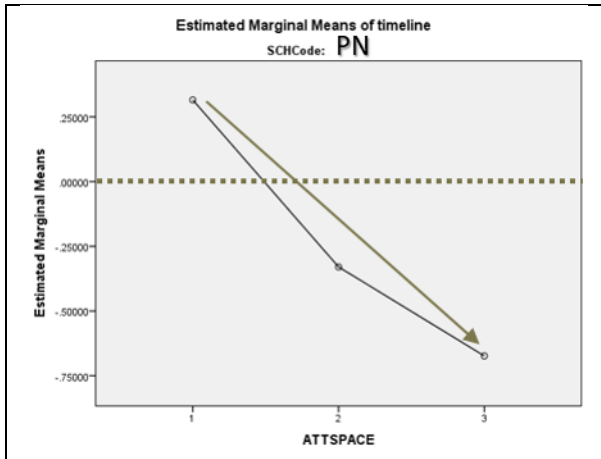


Attitudes to Mathematics:

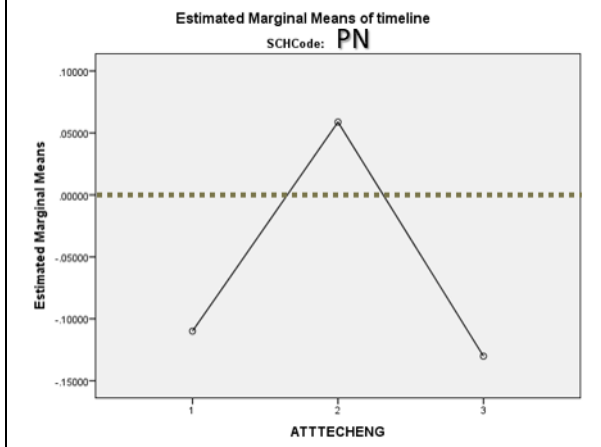


Attitudes to Space:

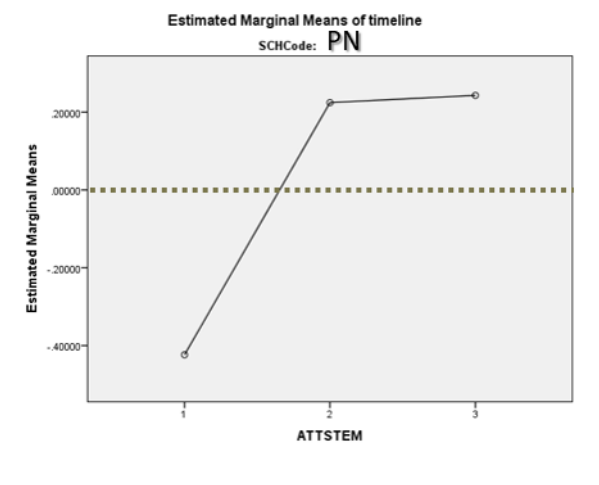




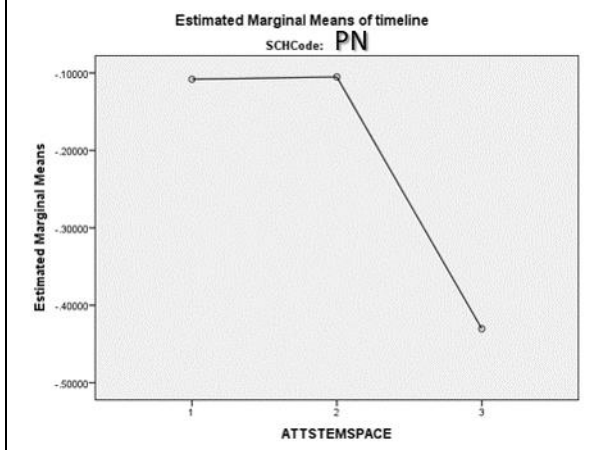
Attitudes to Technology/Engineering ('Designing and making'):



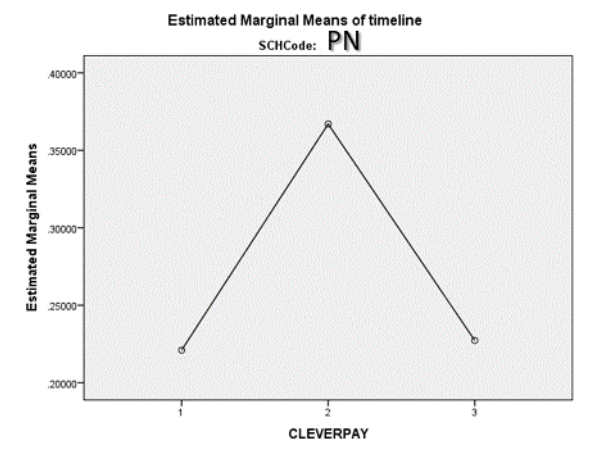
Attitudes to STEM:



Attitudes to STEM+Space:

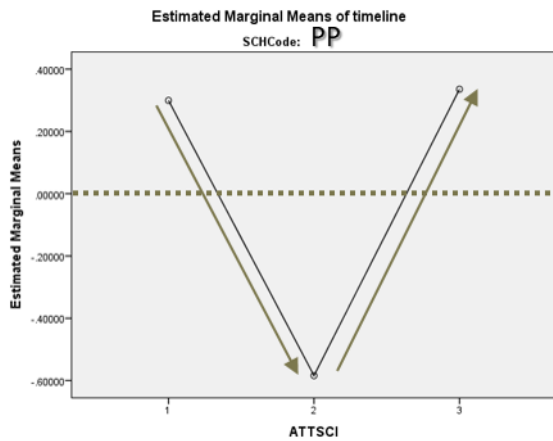


Cleverness&well-paid jobs:

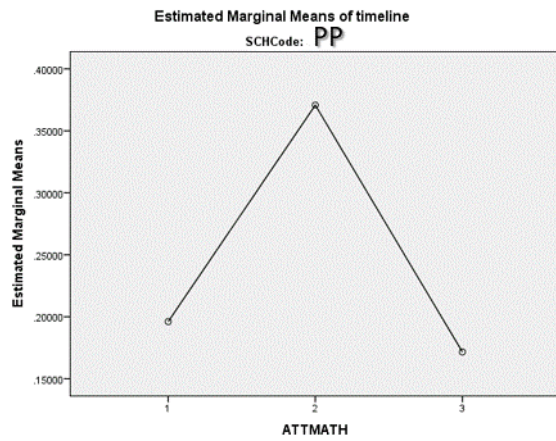


School PP, n=44, not case study school

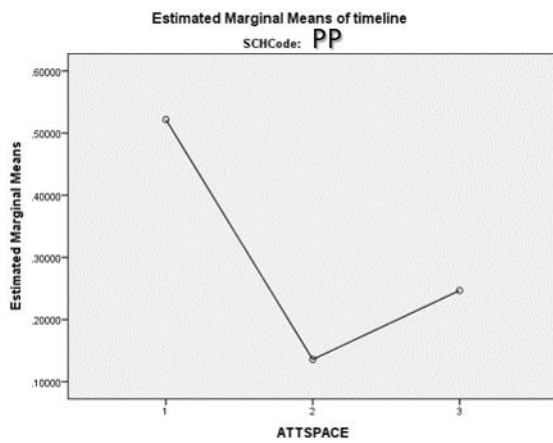
Attitudes to Science:



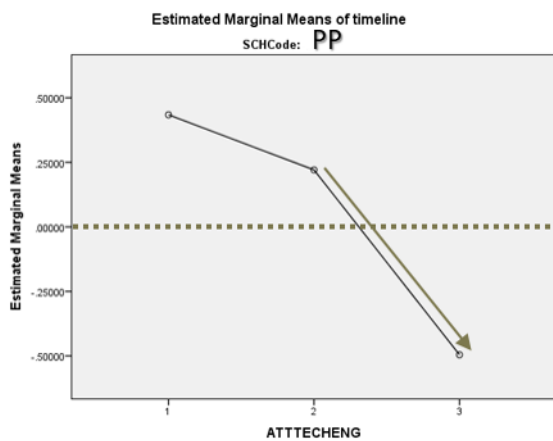
Attitudes to Mathematics:



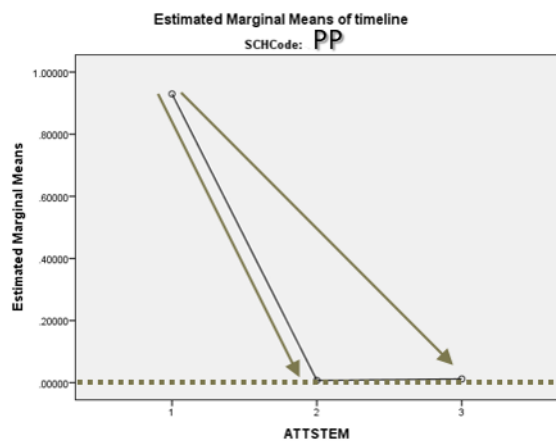
Attitudes to Space:



Attitudes to Technology/Engineering ('Designing and making'):

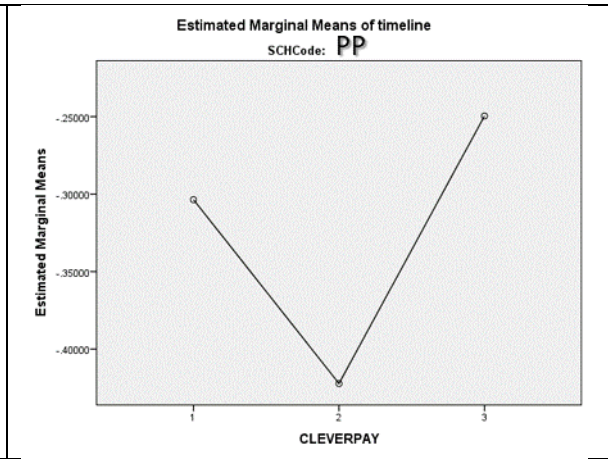
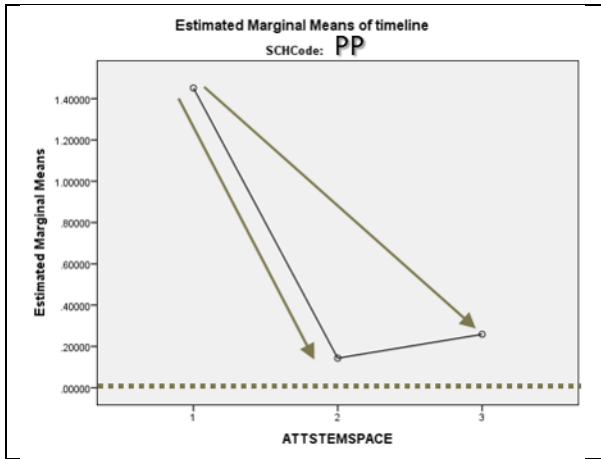


Attitudes to STEM:

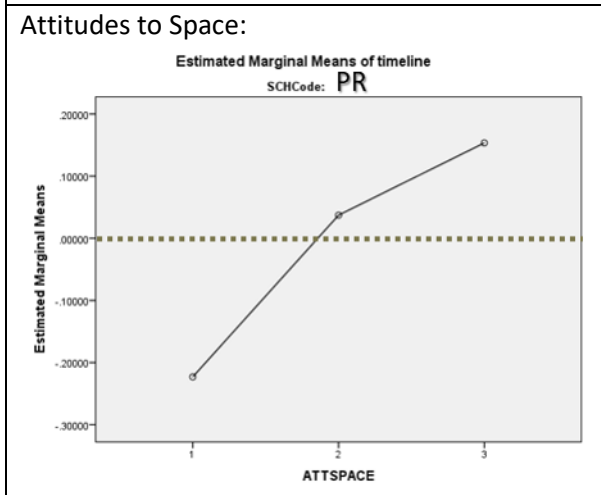
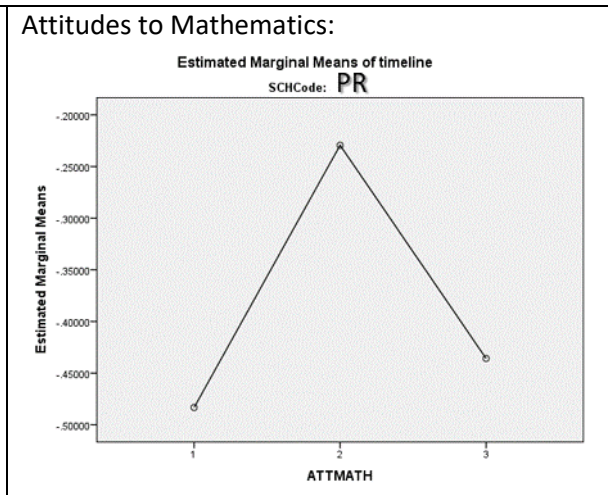
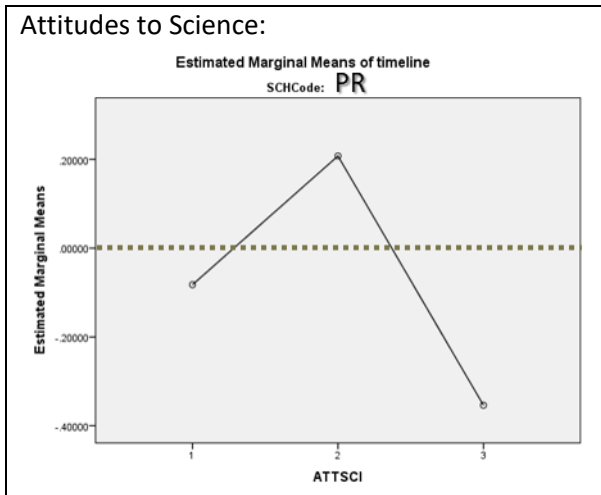


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

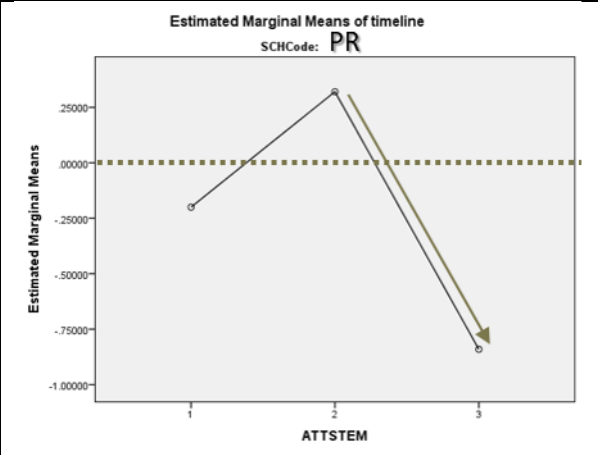
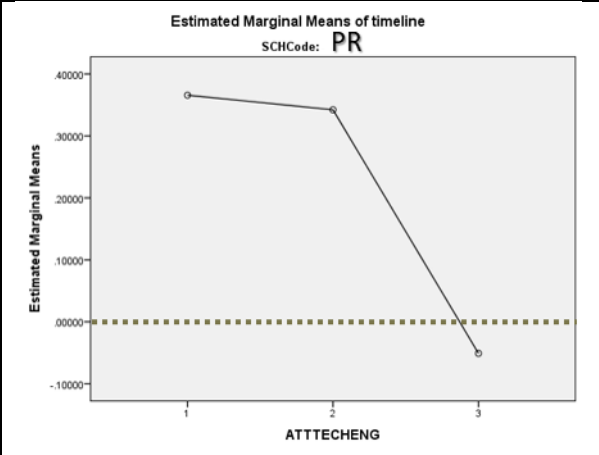


School PR, n=31, not case study school

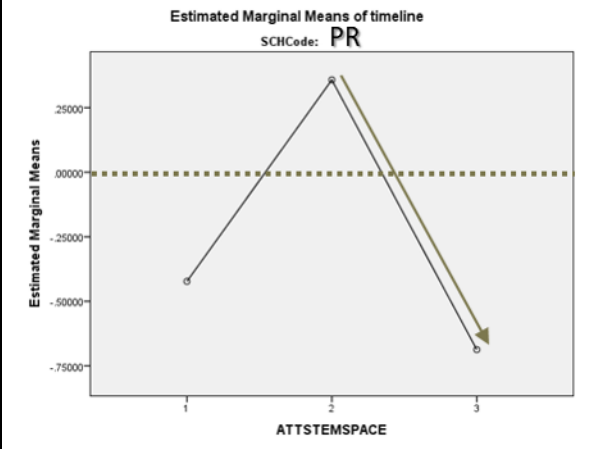


Attitudes to Technology/Engineering ('Designing and making'):

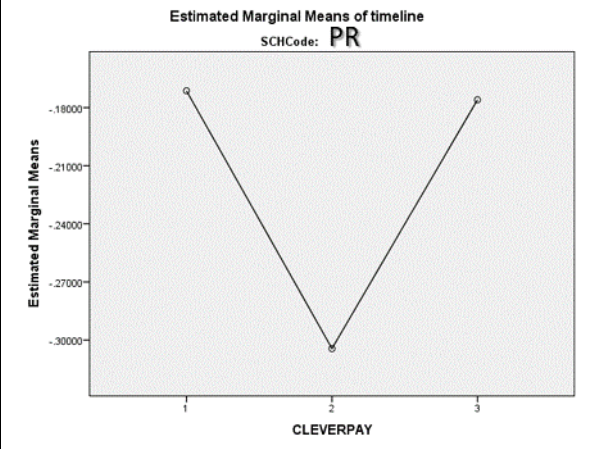
Attitudes to STEM:



Attitudes to STEM+Space:



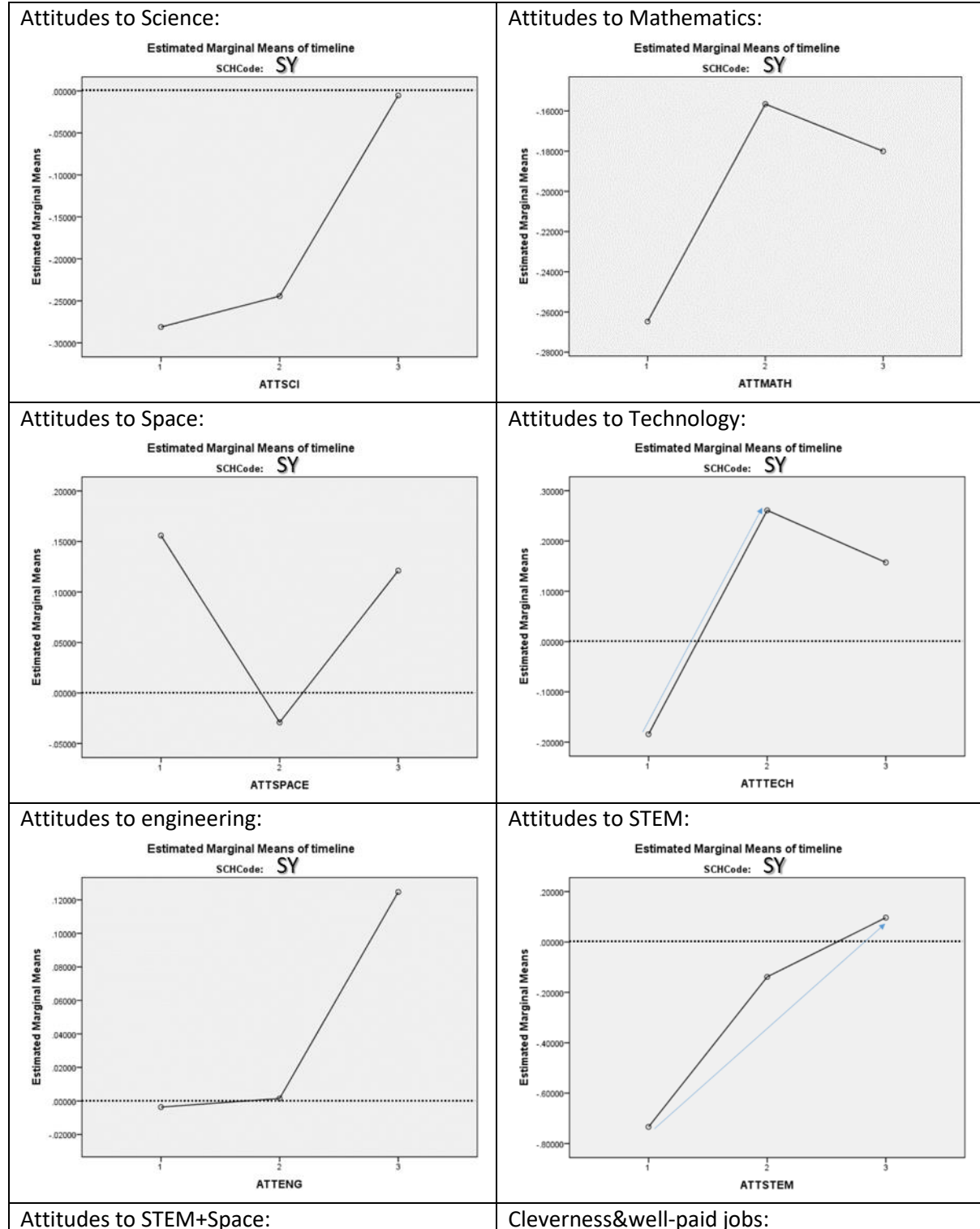
Cleverness&well-paid jobs:

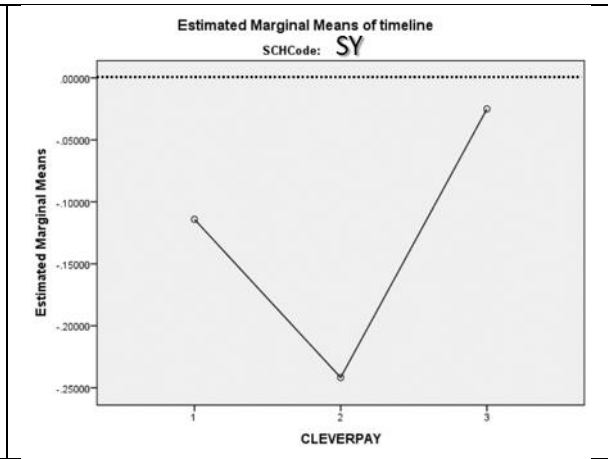
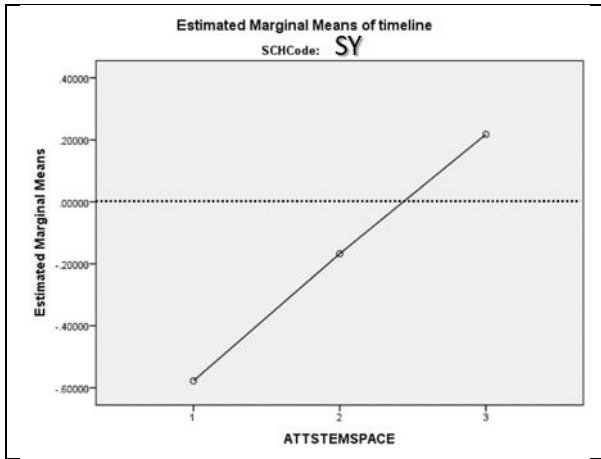


### Technical Annex 3: Secondary school students' quantitative data

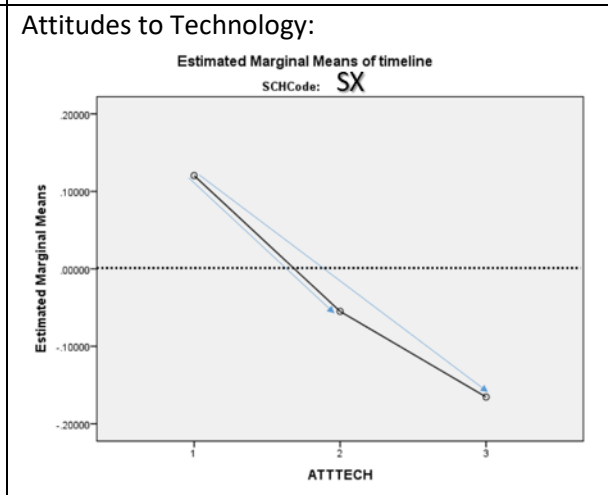
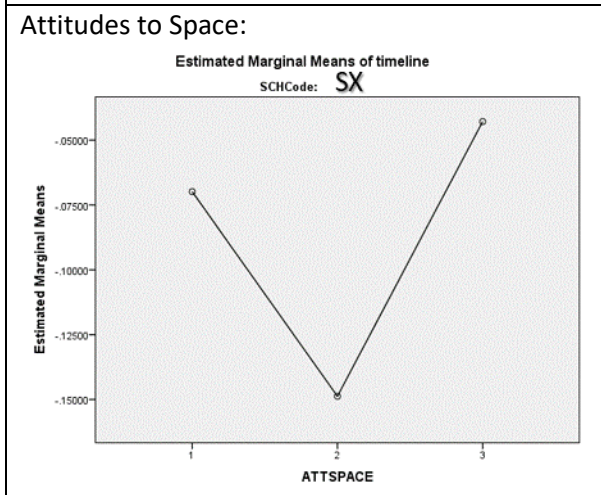
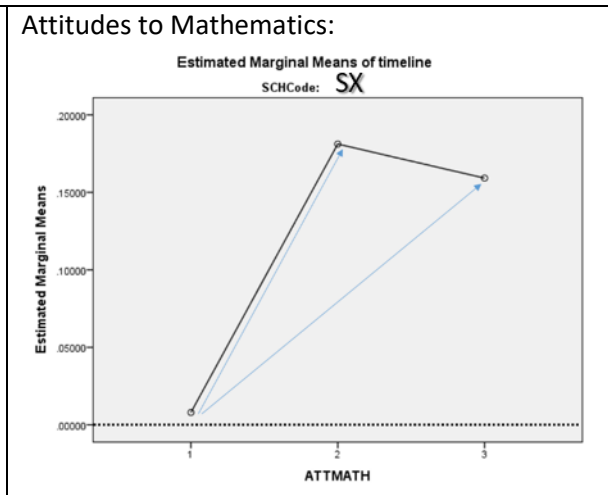
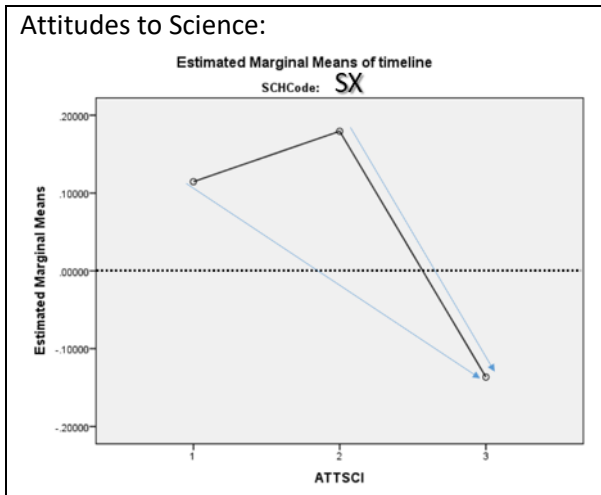
Presented here are the data related to secondary school students, to be used in conjunction with section 5.3: Differences across the phases – secondary school students.

#### Case study school SY; n=52



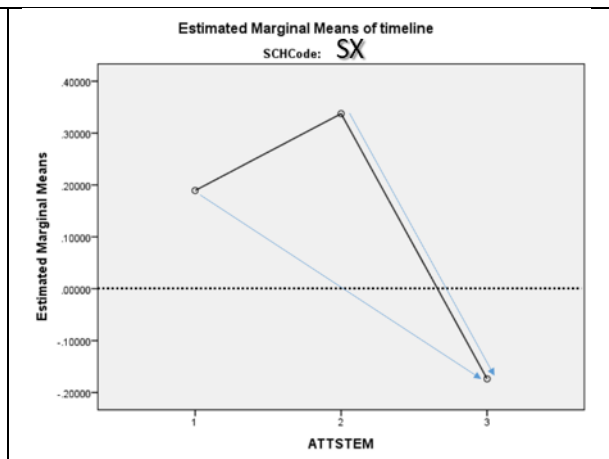
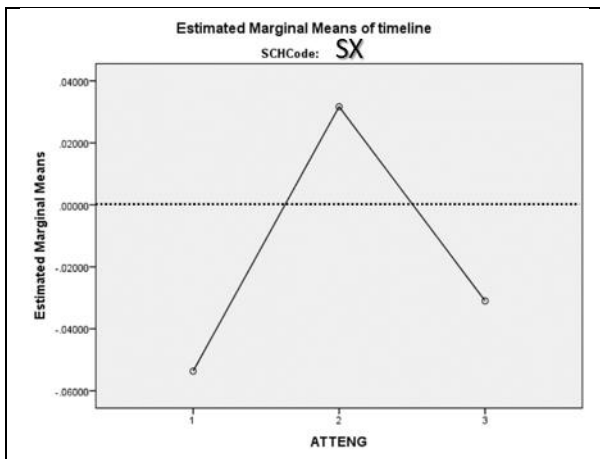


**Case study school SX; n=192**

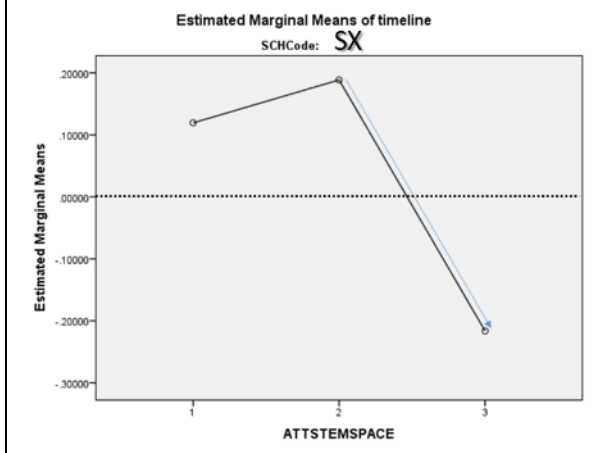


Attitudes to engineering:

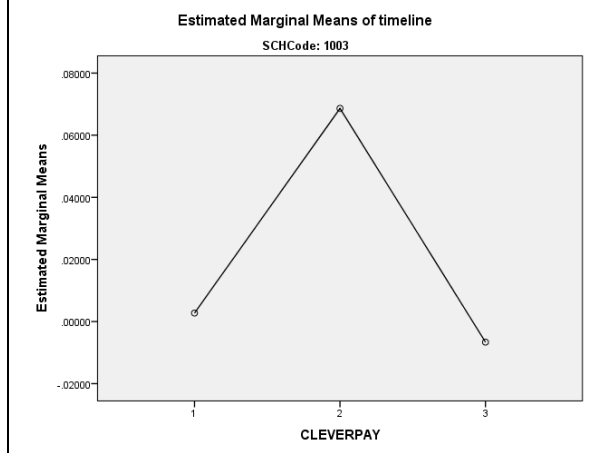
Attitudes to STEM:



Attitudes to STEM+Space:

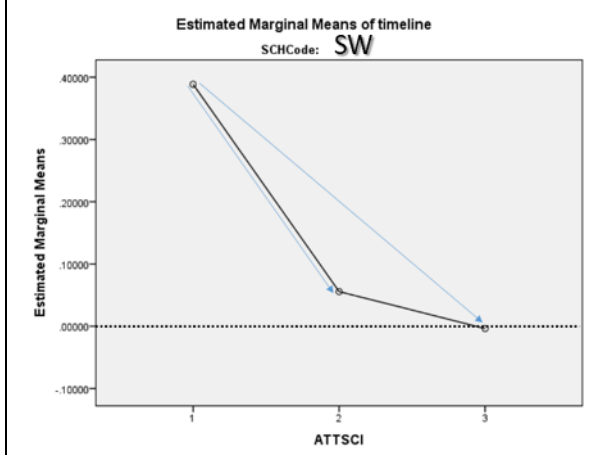


Cleverness&well-paid jobs:

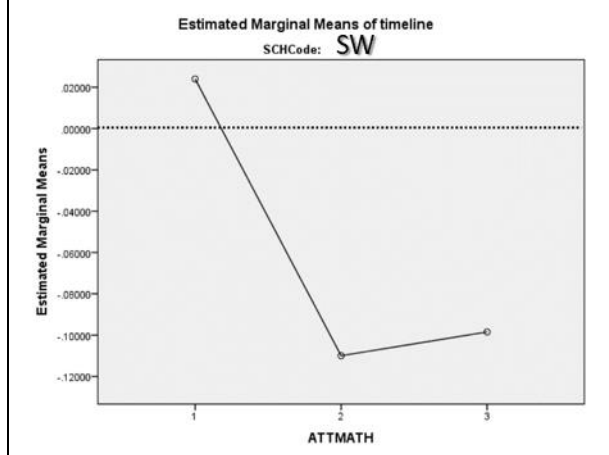


Case study school SW; n=88

Attitudes to Science:

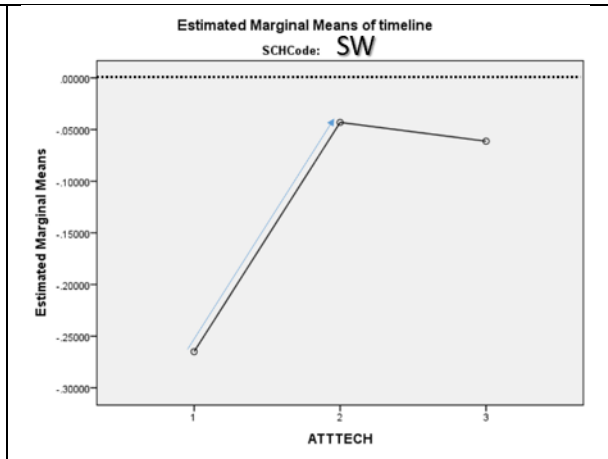
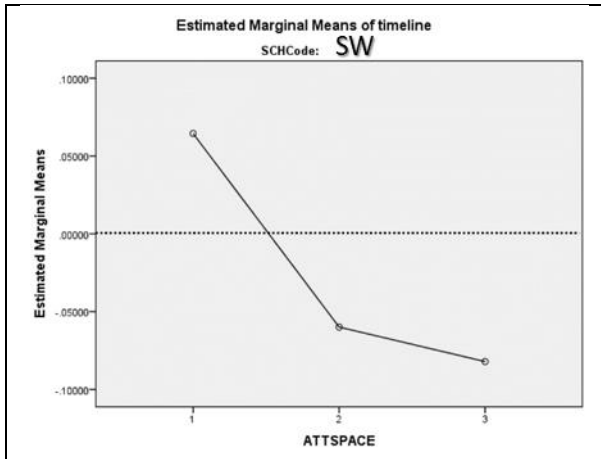


Attitudes to Mathematics:

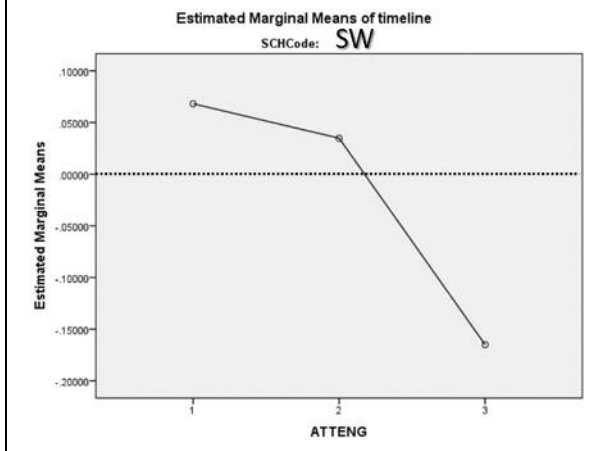


Attitudes to Space:

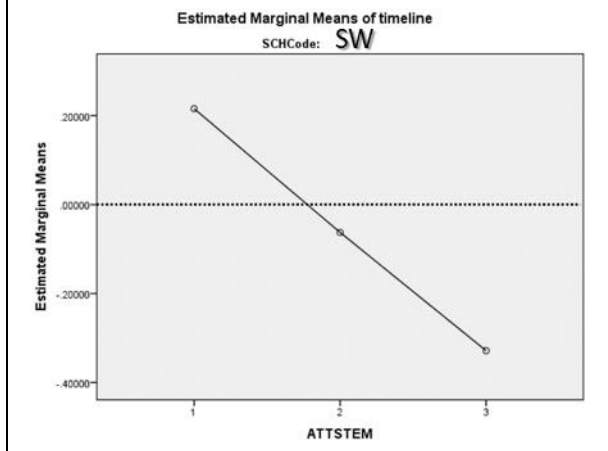
Attitudes to Technology:



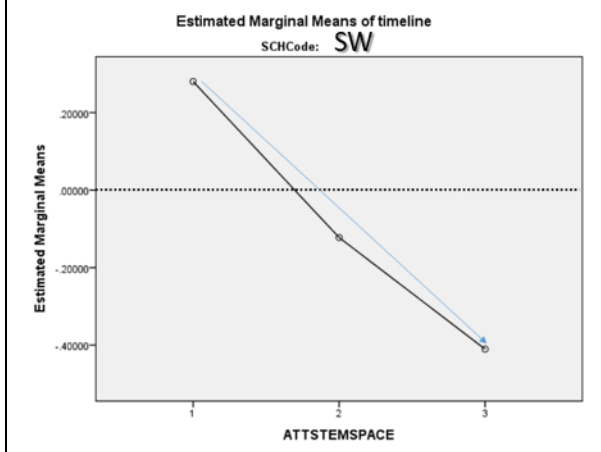
Attitudes to engineering:



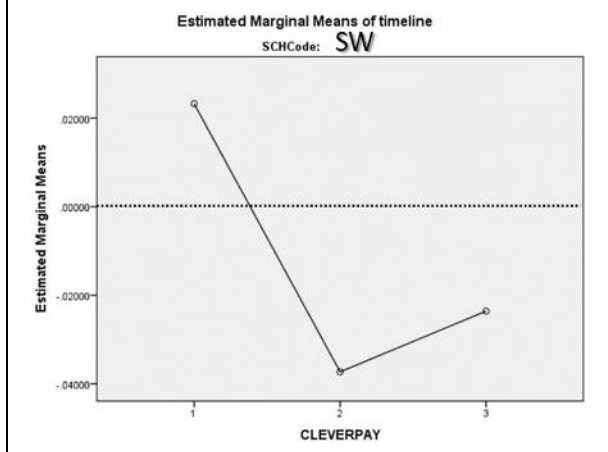
Attitudes to STEM:



Attitudes to STEM+Space:



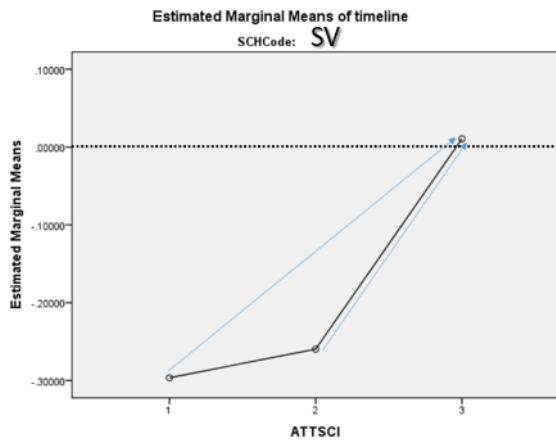
Cleverness&well-paid jobs:



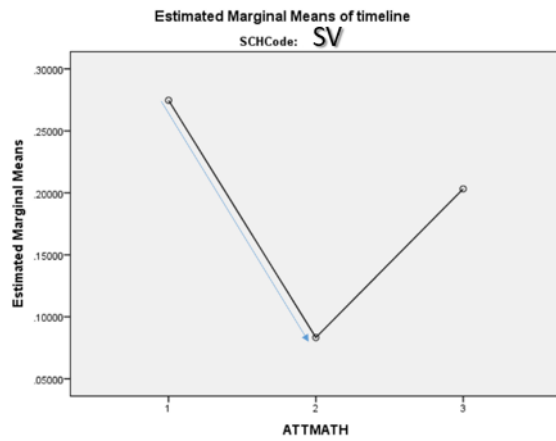


Case study school SV; n=167

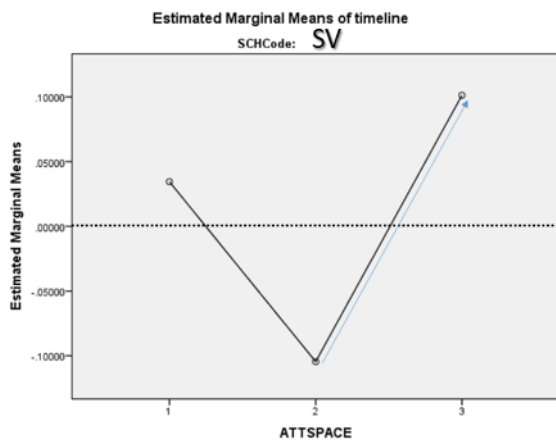
Attitudes to Science:



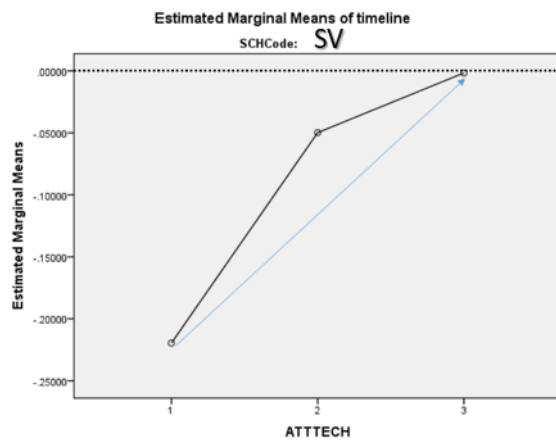
Attitudes to Mathematics:



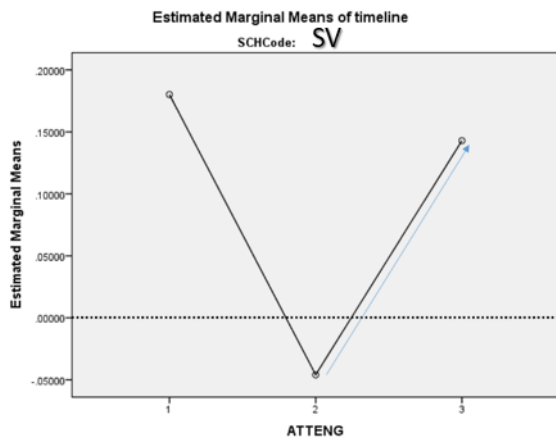
Attitudes to Space:



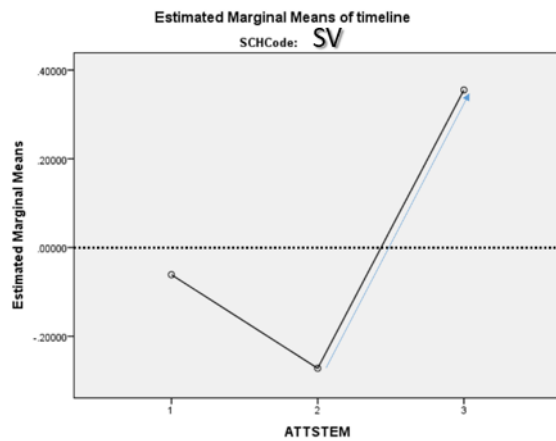
Attitudes to Technology:



Attitudes to engineering:

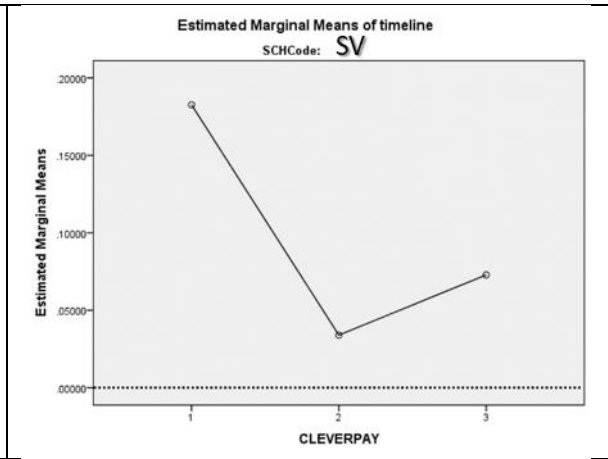
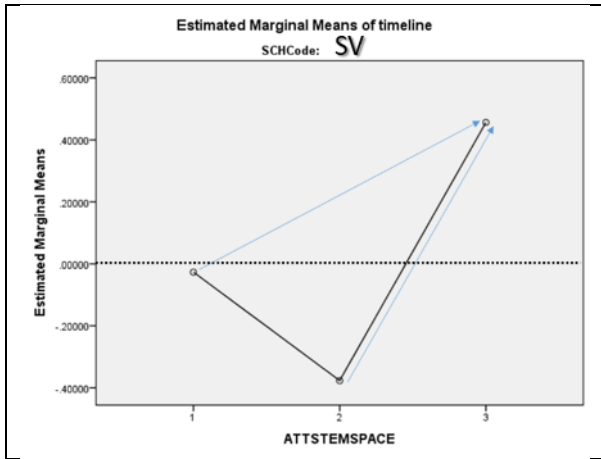


Attitudes to STEM:

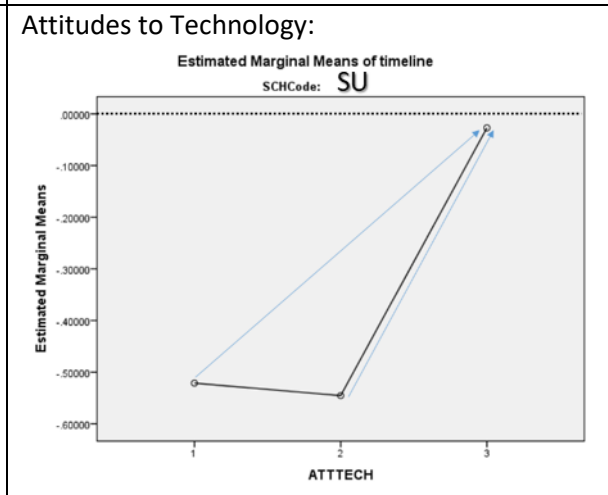
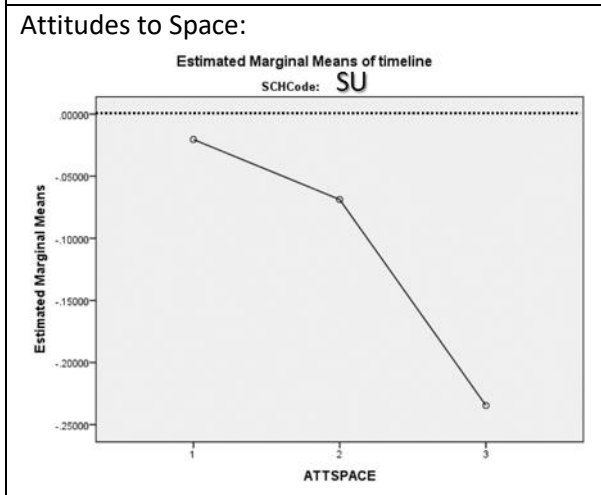
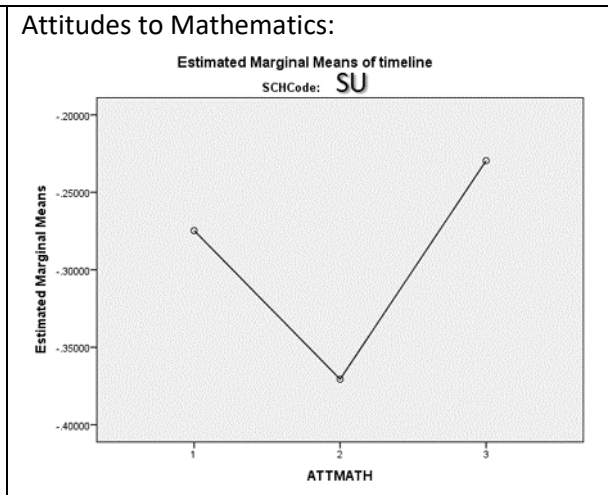
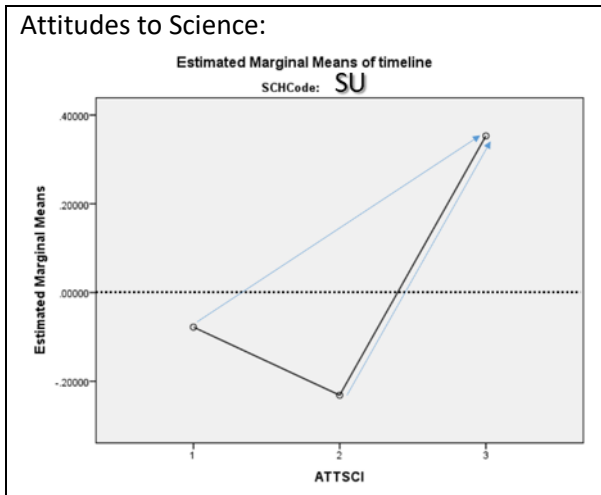


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

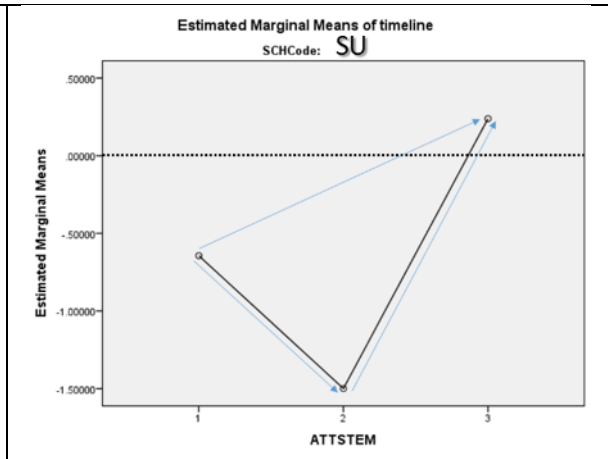
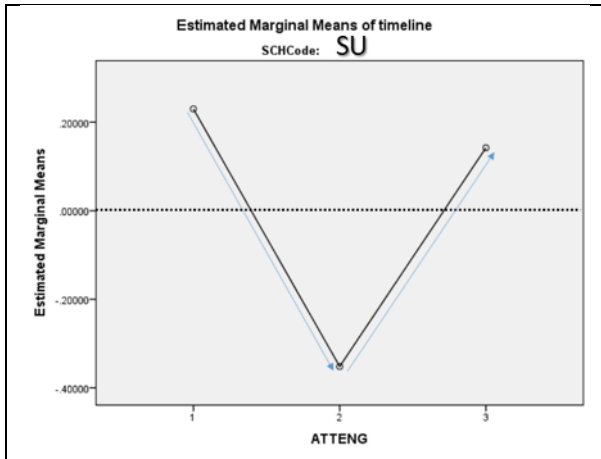


Case study school SU; n=69

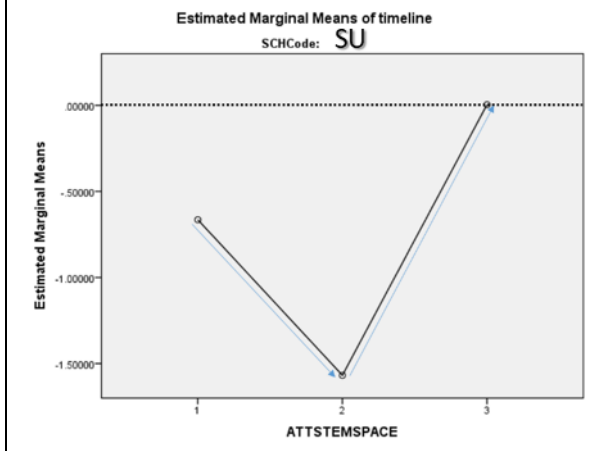


Attitudes to engineering:

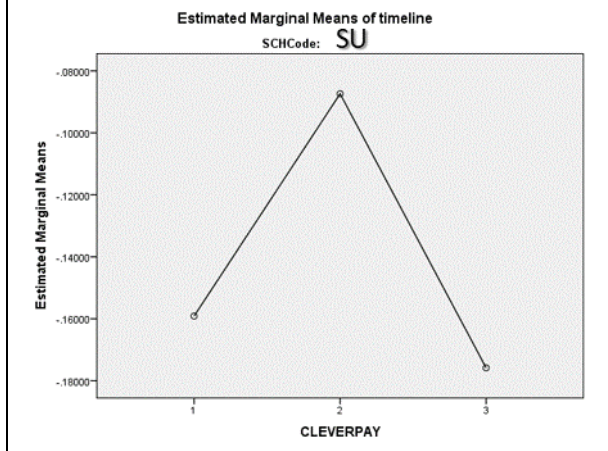
Attitudes to STEM:



Attitudes to STEM+Space:

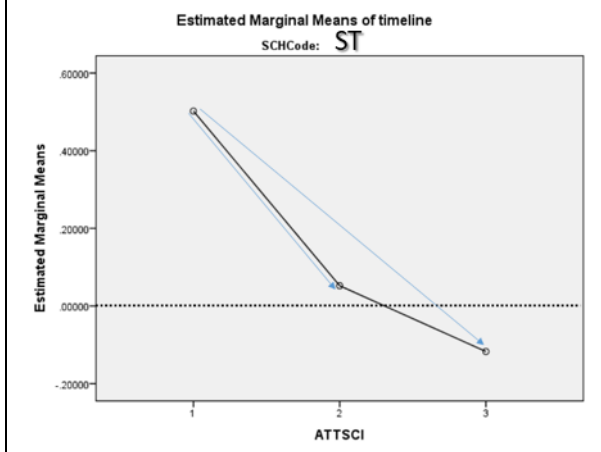


Cleverness&well-paid jobs:

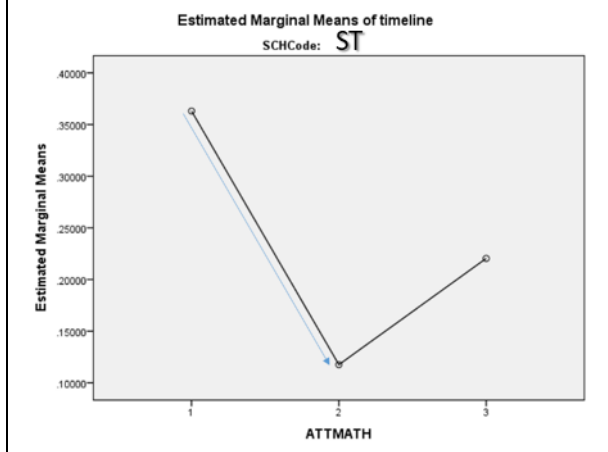


Case study school ST; n=105

Attitudes to Science:

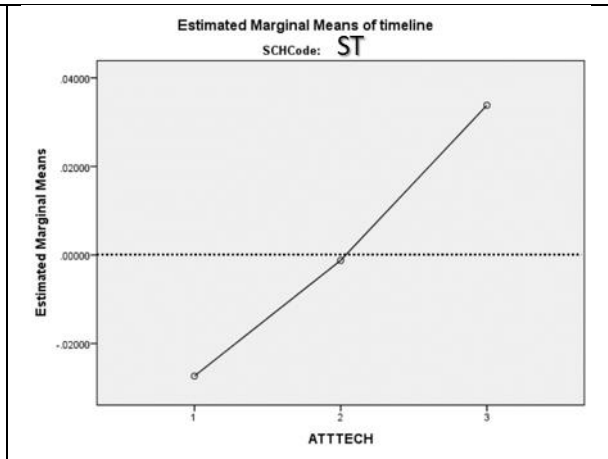
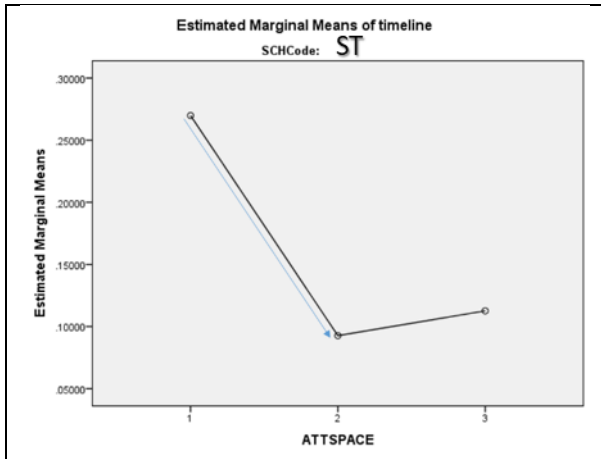


Attitudes to Mathematics:

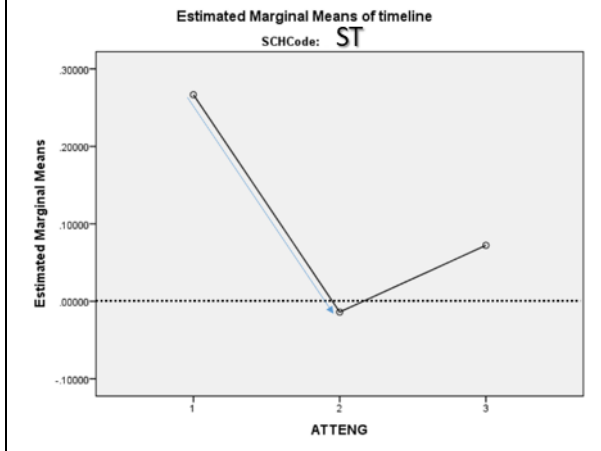


Attitudes to Space:

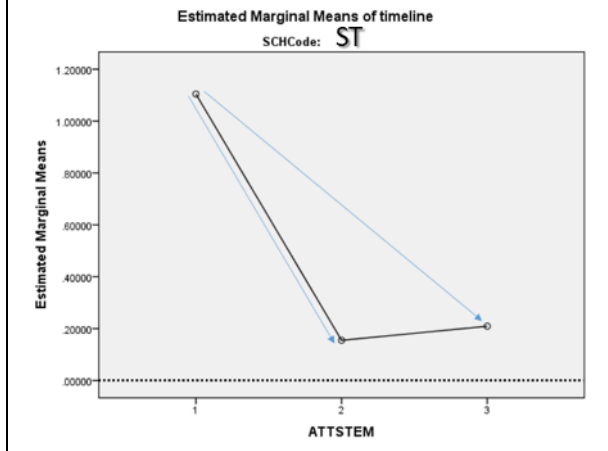
Attitudes to Technology:



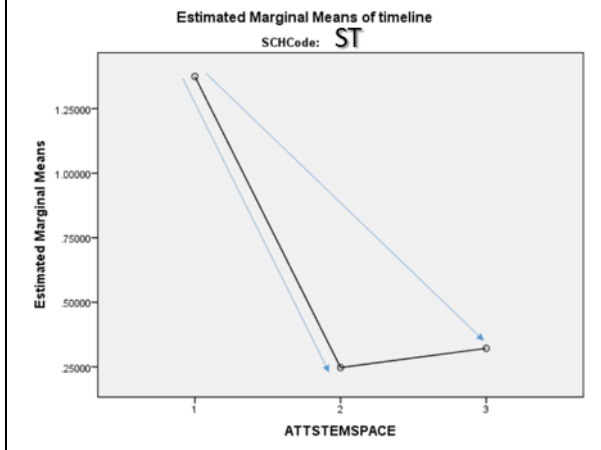
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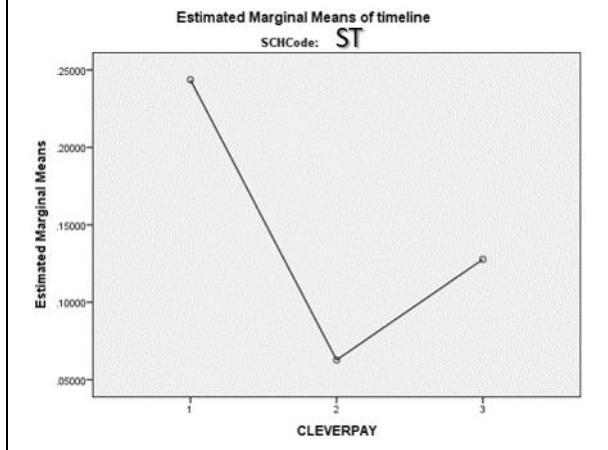
Attitudes to STEM:



Attitudes to STEM+Space:

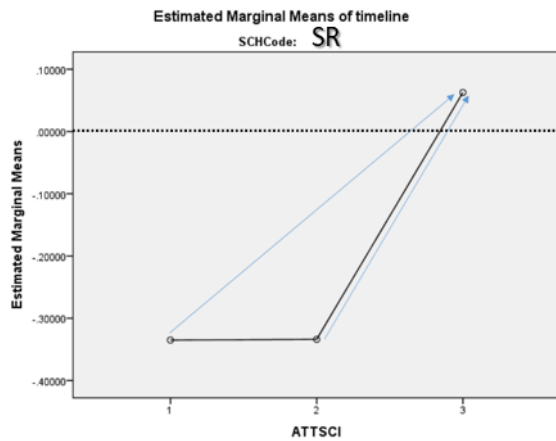


Cleverness&well-paid jobs:

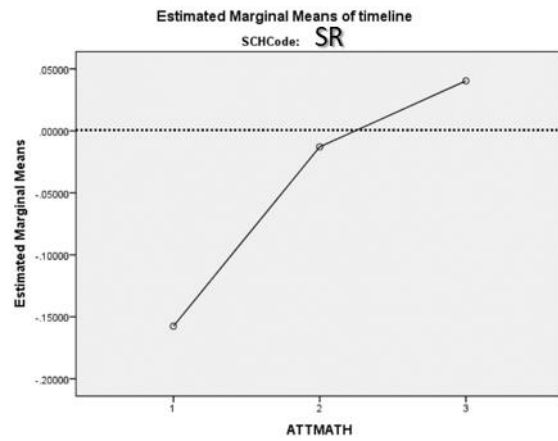


Case study school SR; n=129

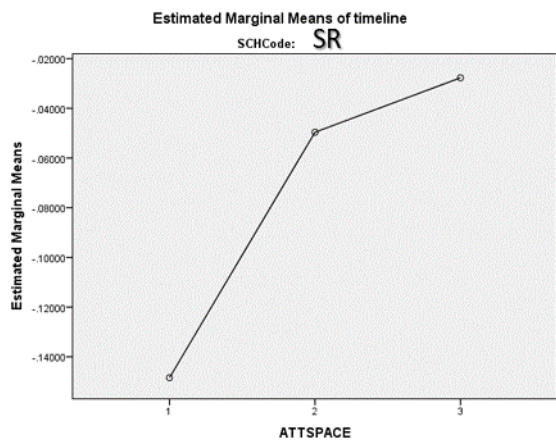
Attitudes to Science:



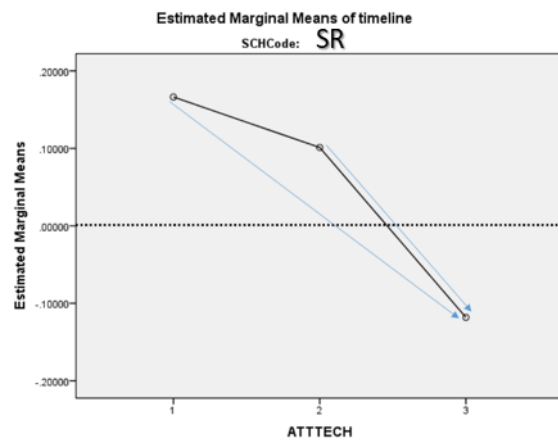
Attitudes to Mathematics:



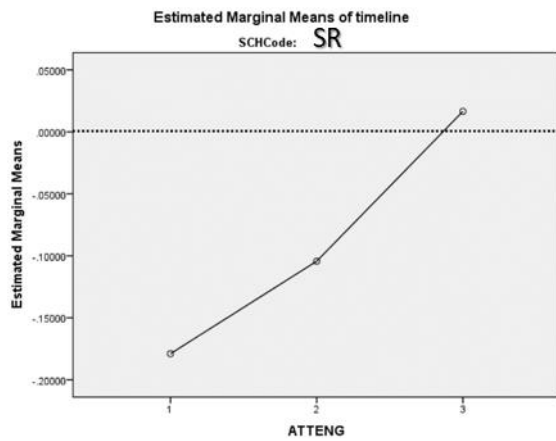
Attitudes to Space:



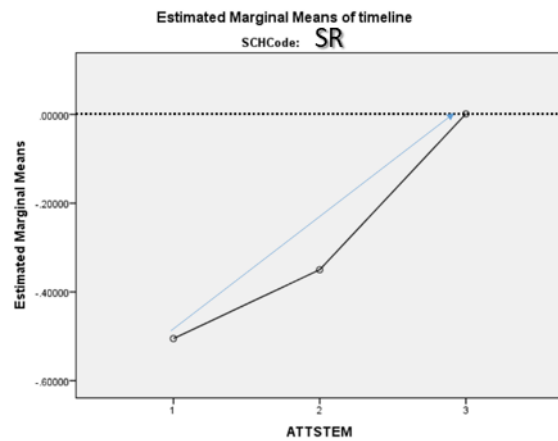
Attitudes to Technology:



Attitudes to engineering:

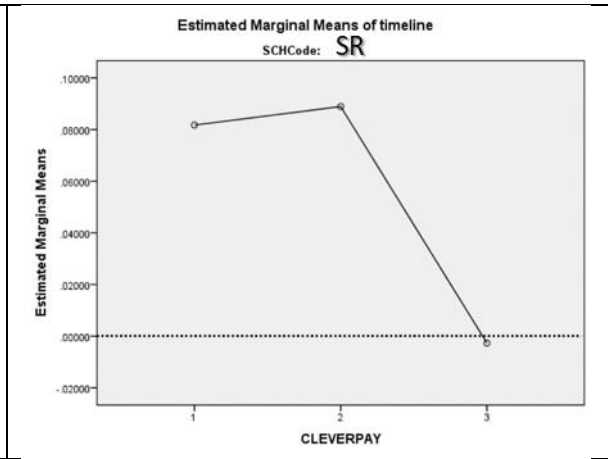
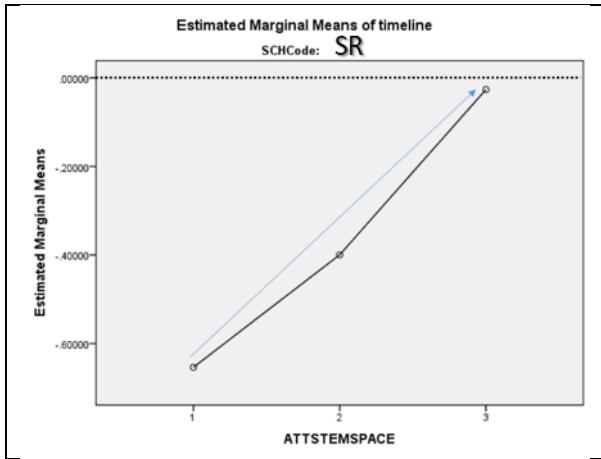


Attitudes to STEM:

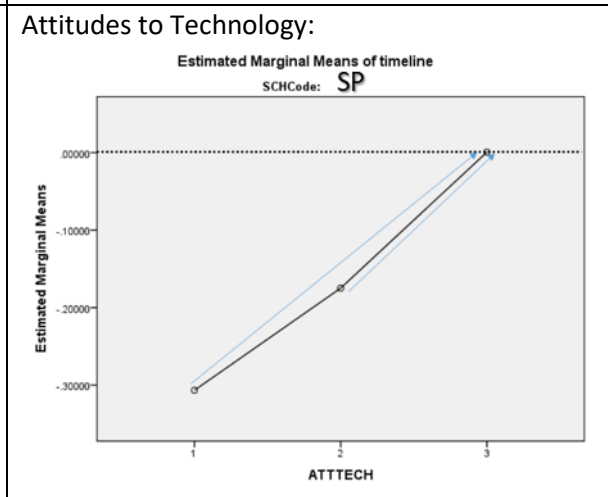
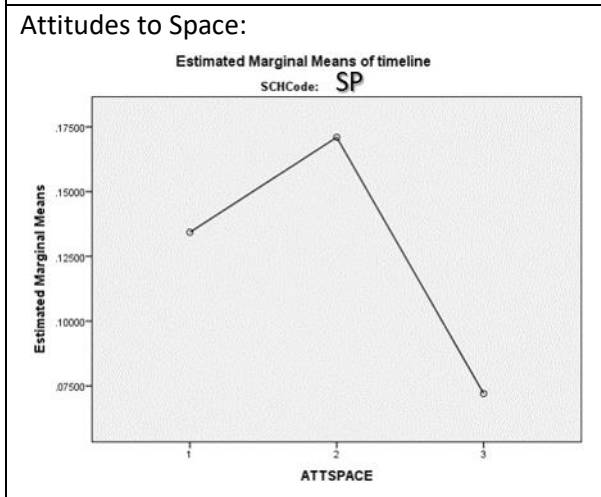
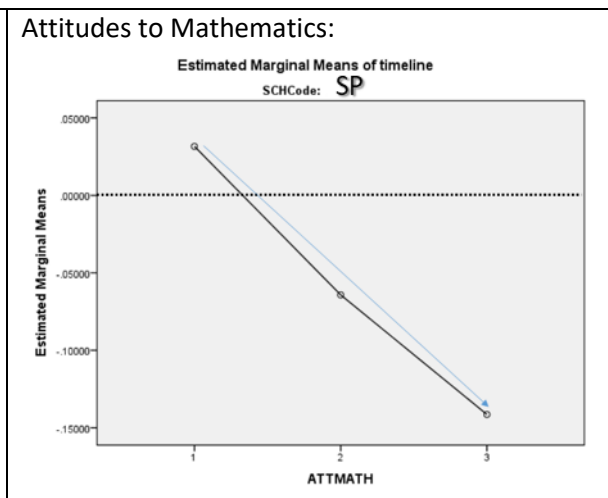
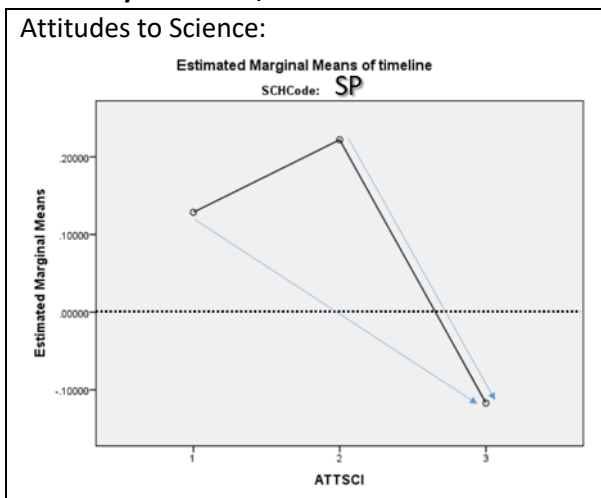


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

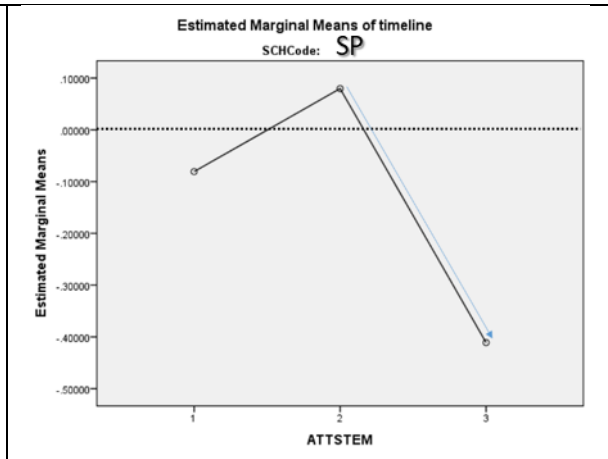
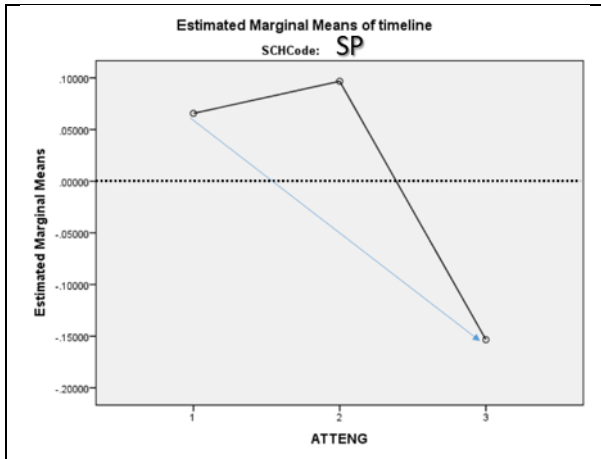


Case study school SP; n=224

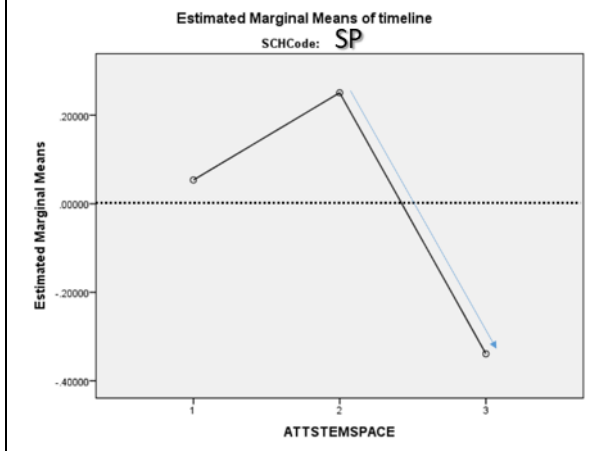


Attitudes to engineering:

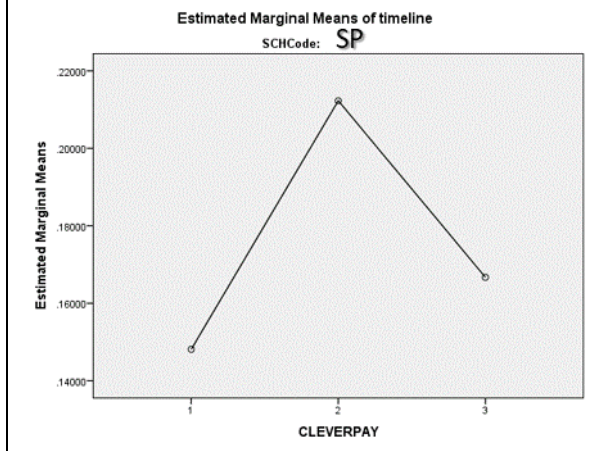
Attitudes to STEM:



Attitudes to STEM+Space:

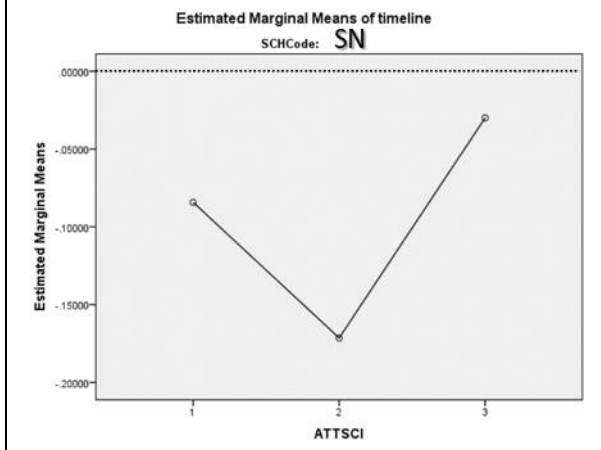


Cleverness&well-paid jobs:

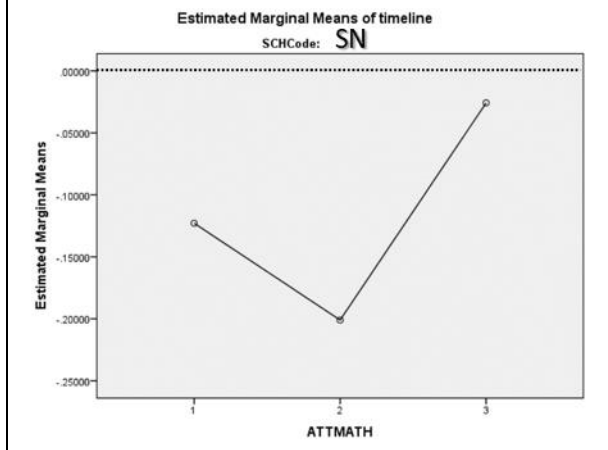


School SN – not a case study school; n=128

Attitudes to Science:

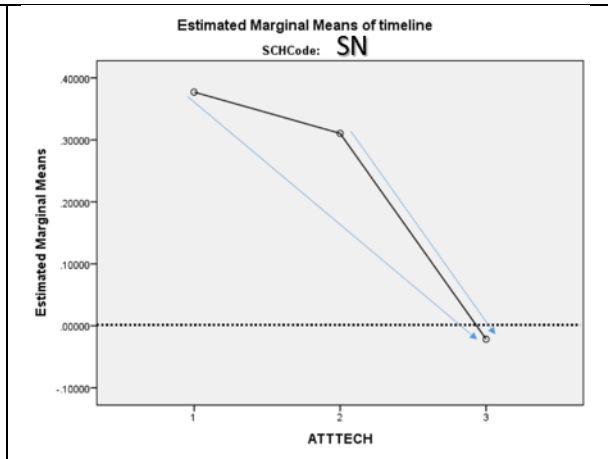
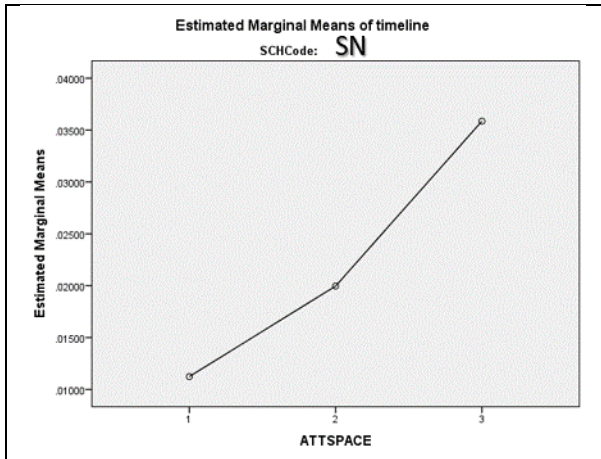


Attitudes to Mathematics:

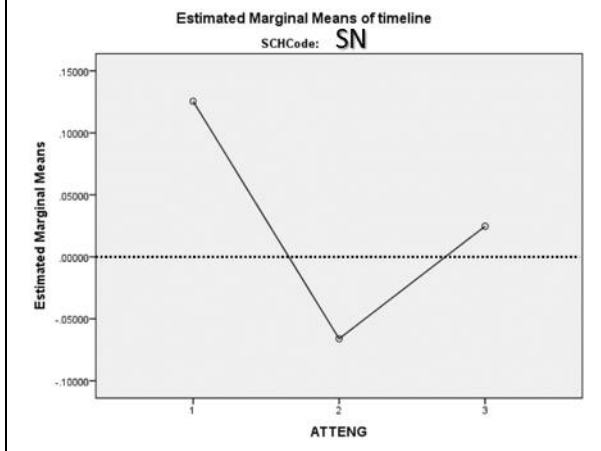


Attitudes to Space:

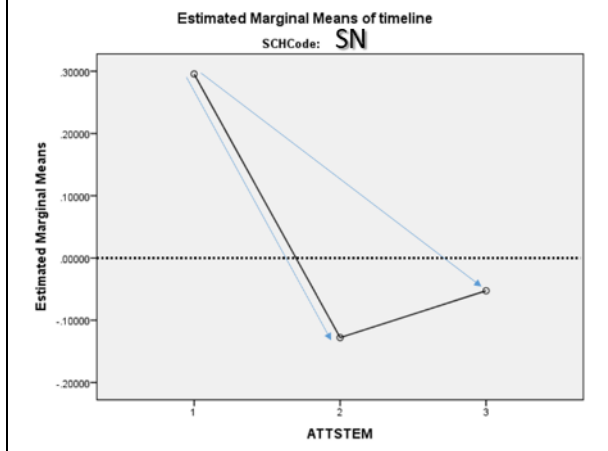
Attitudes to Technology:



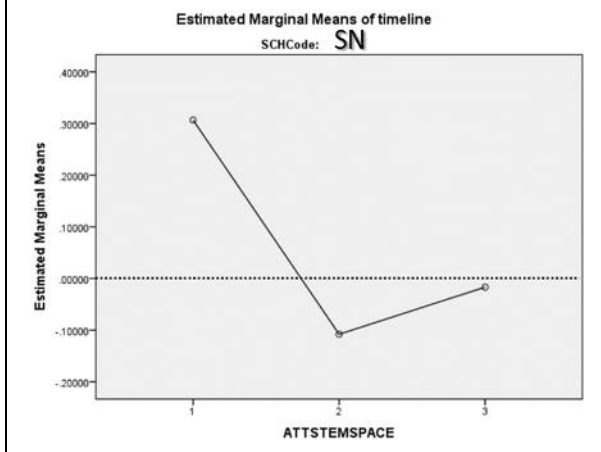
Attitudes to engineering:



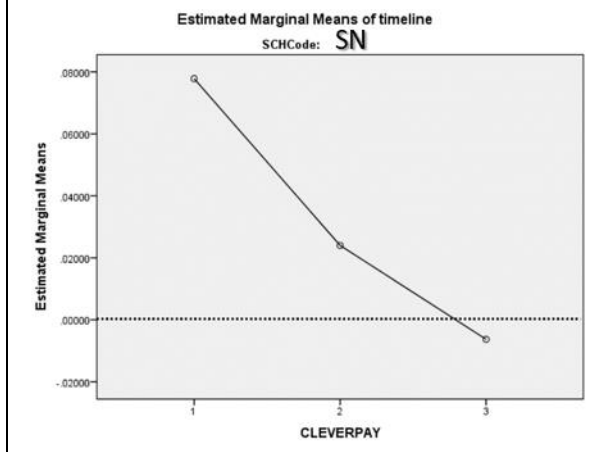
Attitudes to STEM:



Attitudes to STEM+Space:



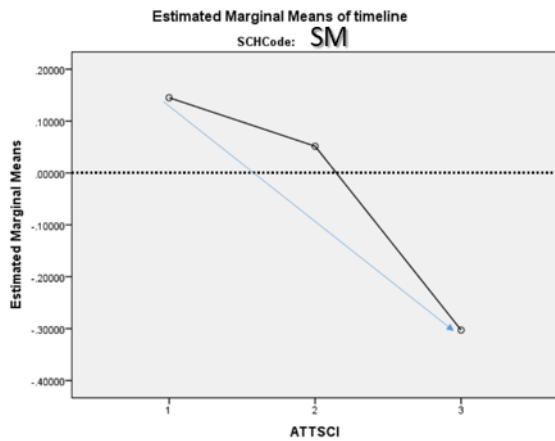
Cleverness&well-paid jobs:



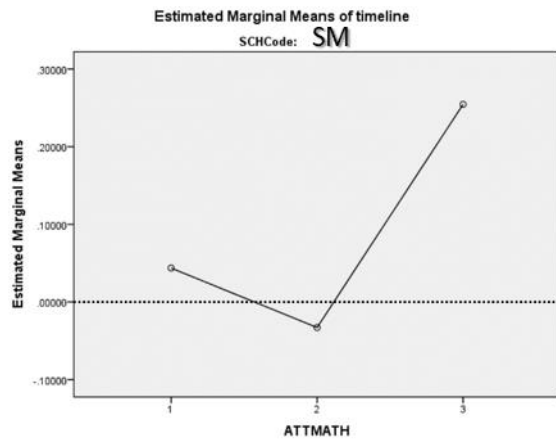


School SM – not a case study school; n=52

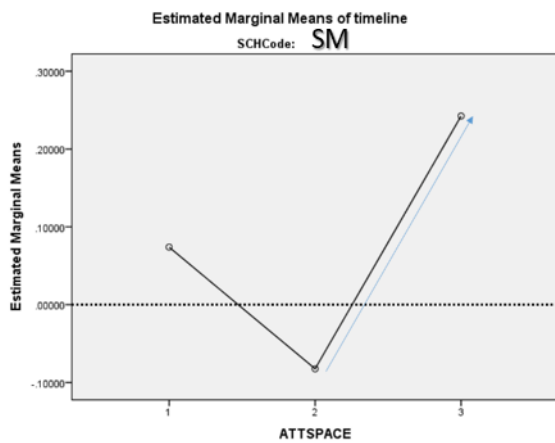
Attitudes to Science:



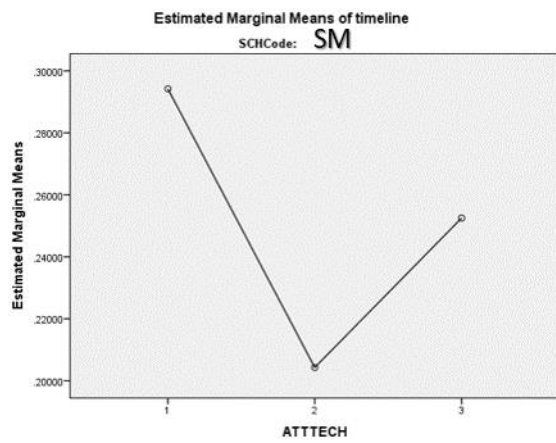
Attitudes to Mathematics:



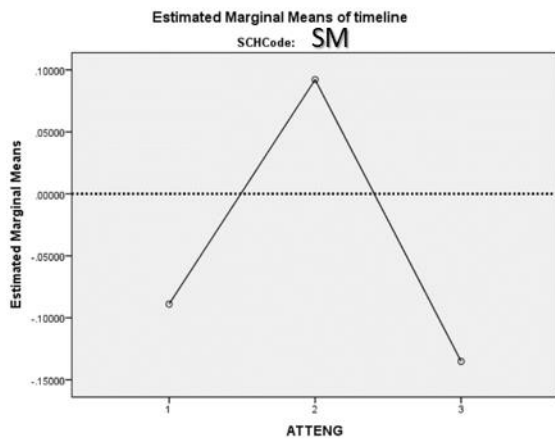
Attitudes to Space:



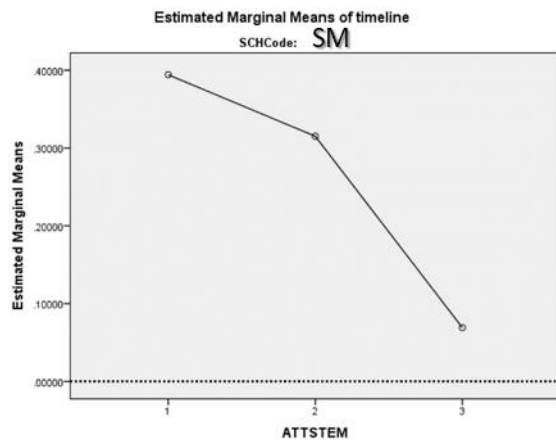
Attitudes to Technology:



Attitudes to engineering:

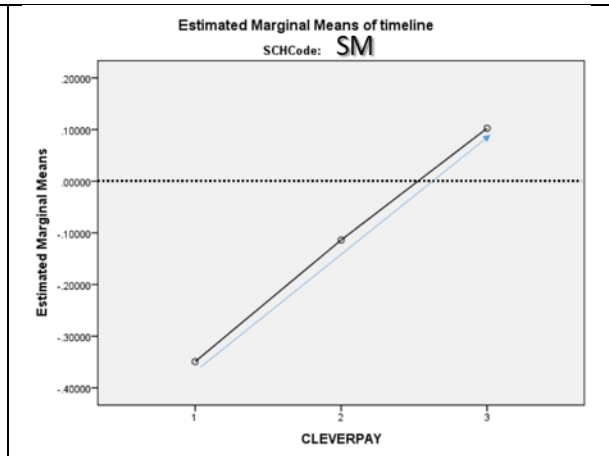
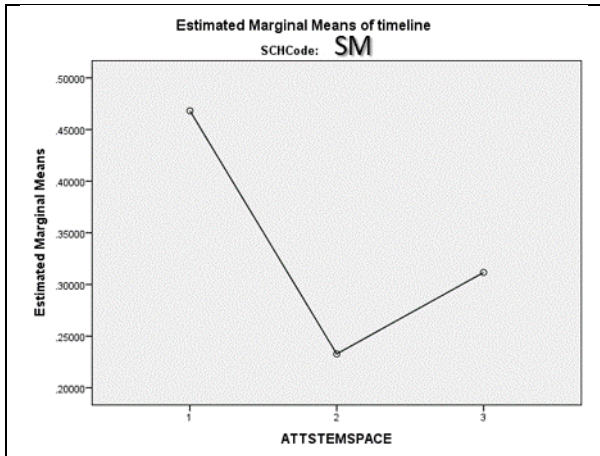


Attitudes to STEM:

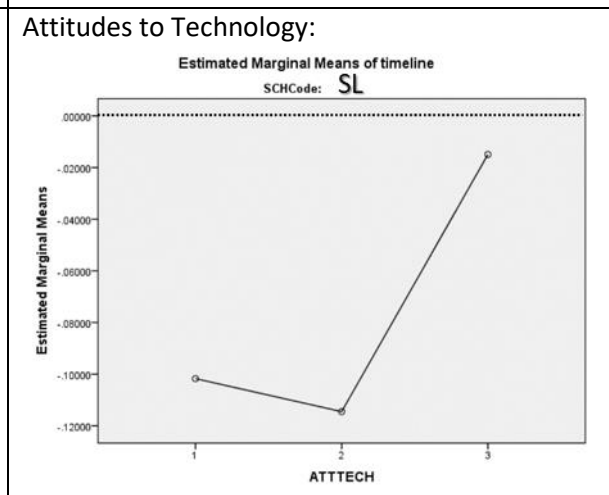
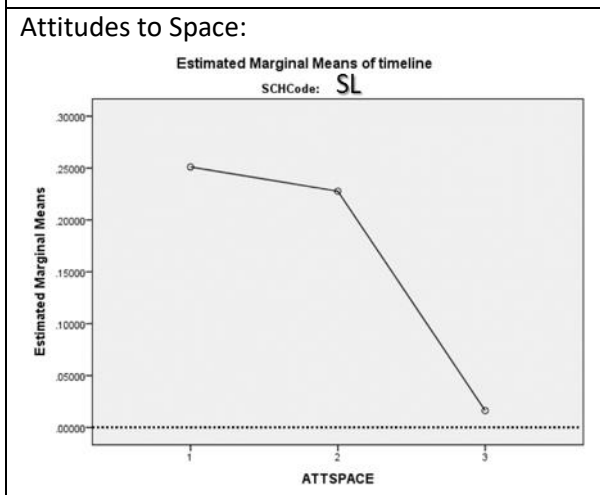
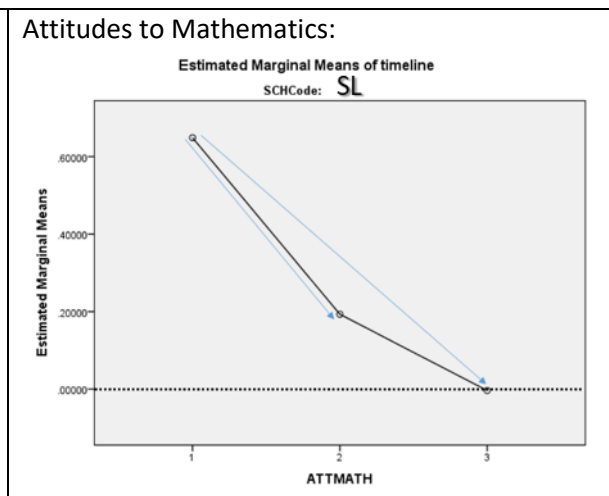
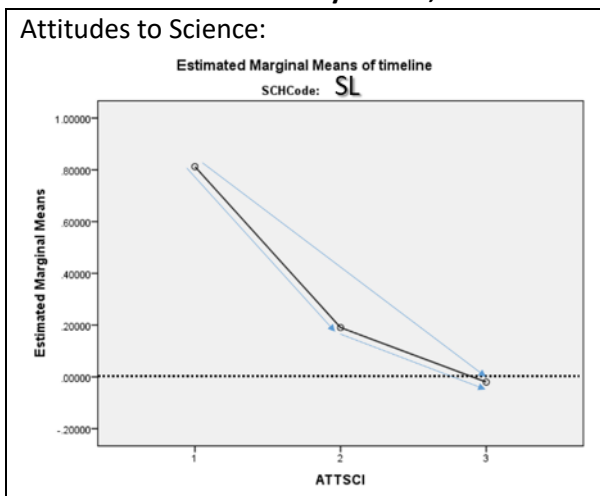


Attitudes to STEM+Space:

Cleverness&well-paid jobs:

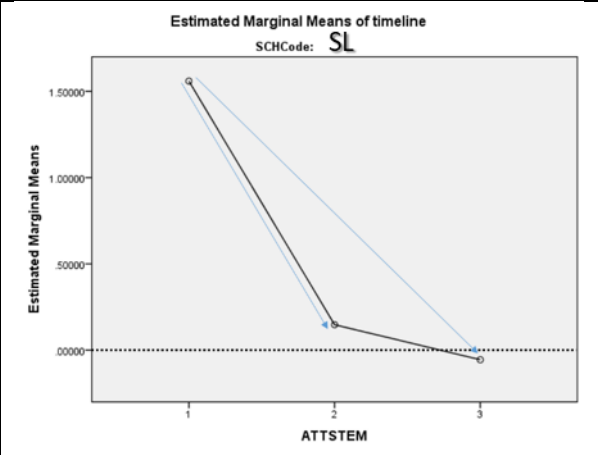
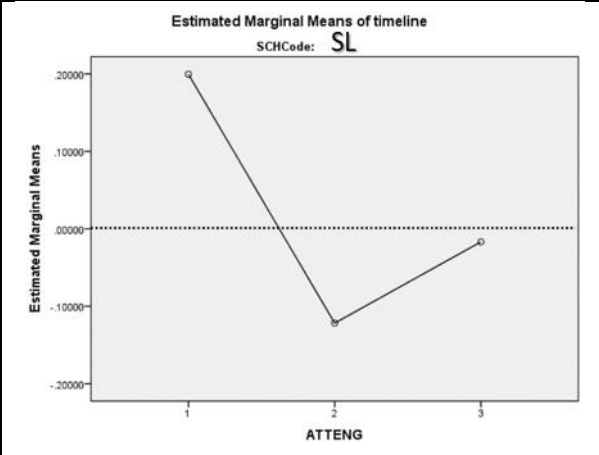


School SL – not a case study school; n=49

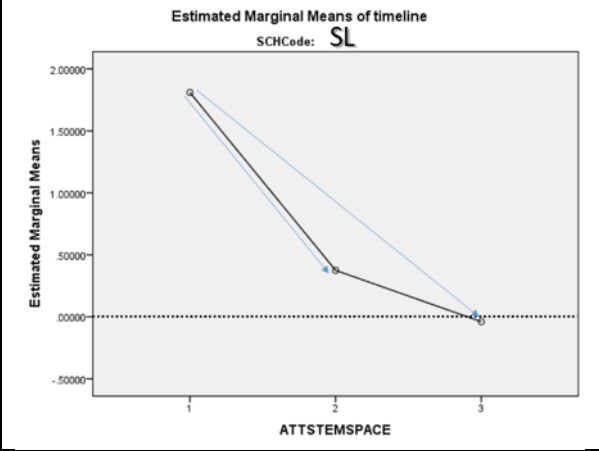


Attitudes to engineering:

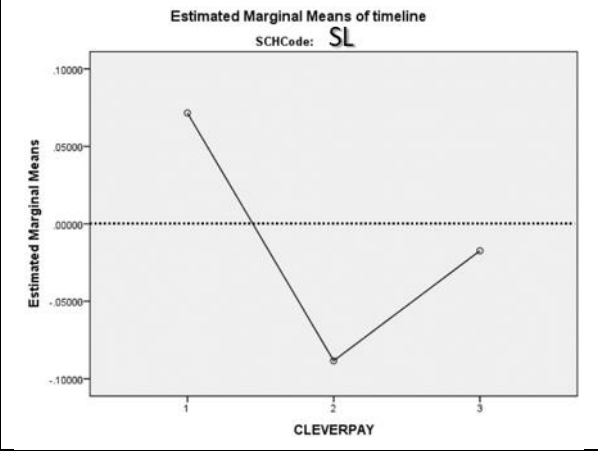
Attitudes to STEM:



Attitudes to STEM+Space:

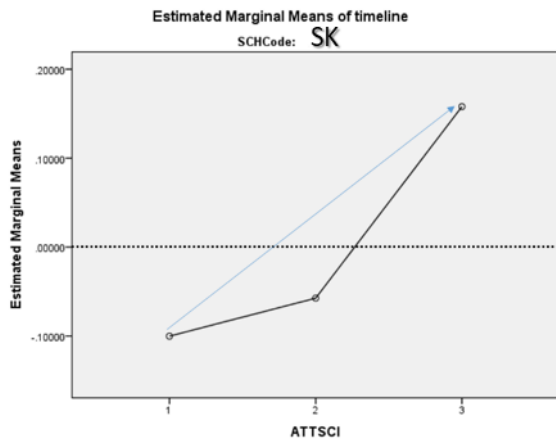


Cleverness&well-paid jobs:

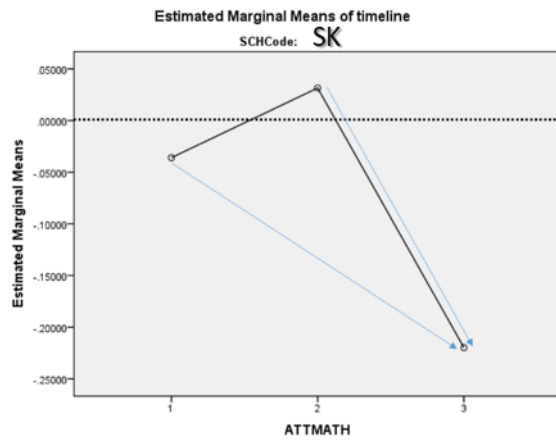


School SK – not a case study school; n=178

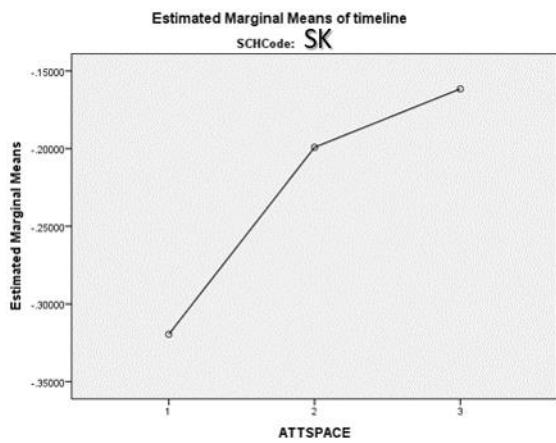
Attitudes to Science:



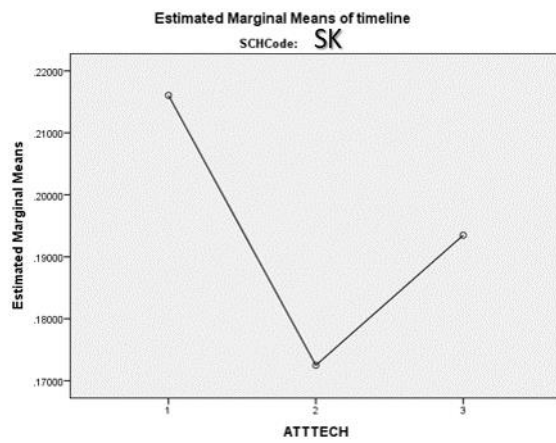
Attitudes to Mathematics:



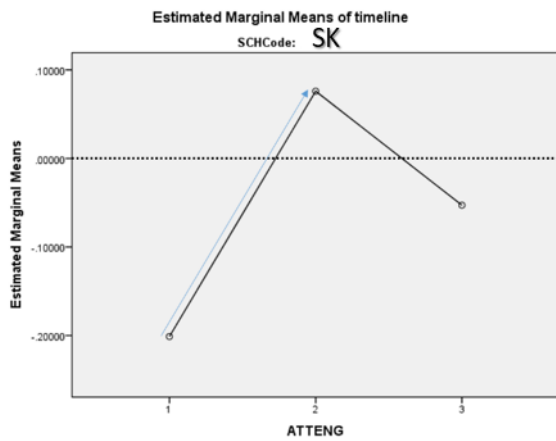
Attitudes to Space:



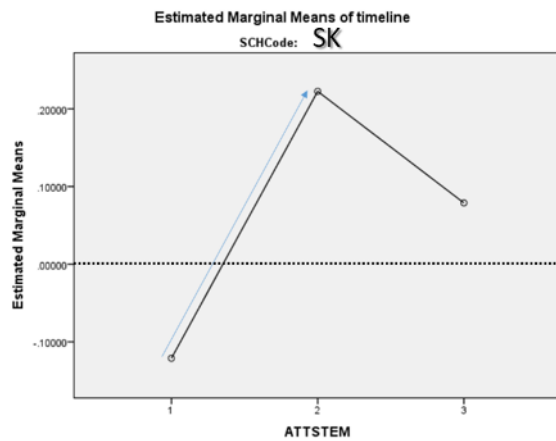
Attitudes to Technology:



Attitudes to engineering:



Attitudes to STEM:



Attitudes to STEM+Space:

Cleverness&well-paid jobs:

