Supplementary material

Pupils' prior knowledge about technological systems: design and validation of a diagnostic tool for primary school teachers.

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Supplementary material 1   Initial scoring rules

Level	Buzz-Wire	Stairs Marble Track

Single abstractions (Rp4/Sa1)
An abstraction is used to realise the solution. Here only the BW-task needs abstract thinking to realise a correct solution: the proper connection of the loop and spiral as an off/on switch within an electric circuit.

(7) Abs1/Rp4 Single abstraction	The correct solution, use of all representations *If not: go to Rp3*	Not included.

Representational system (Rp3)
The relations between all elements of the system are incorporated into the solution.

(6) Rp3 Representational system	One element of the correct solution is missing, representation 1 or 2 (see Rp1) *If not: go to Rp2*	Correct solution.

Representational mappings (Rp2)
Causal relationships with an intermediate step, linking single causal relations.

(5) Rp2 Representational mapping	The solution contains the representations 1 and 2 (see Rp1) *or* there is a circuit in which the lamp and buzzer will function *or* the spiral and loop will function as a switch *If not: go to Rp1*	Combination of two representations. 1. Slanted tops upward and in the correct direction (but not all bars at the correct position). 2. Bars in the correct position and slanted tops enabling a marble to move to the next bar (but not all slanted tops in the correct direction).

Single representations (Sm4/Rp1)
A single representation (mental coordination of two or more sensory-motor systems) is part of the action. Single causal relationships.

(4) Rp1/Sm4 Single representation	All connections are on metal, *or* the battery is used as a source of pone pole to the other by another part. *If not: go to Sm3*	Use of one representation. 1. Orientation of slanted top prevents marble from rolling sideways *or* 2. Bars in the correct order

Sensorimotor – system (Sm3)
Observable causal relationships. A manipulation is linked to an observable consequence.

(3) Sm3 Sensorimotor system	At least four objects are connected, considering the spiral and loop as different objects. *If not: go to Sm2*	The frame contains at least 5 bars. Within that condition, there are several possibilities. 1. The slides are upside down, positioned around the profile of the eccentric wheel. 2. Slides are placed upward, but not in the correct order and not preventing a marble to roll-off sideways. 3. The bars are skewed in the frame.

Sensorimotor mapping (Sm2)
Combining features of two objects.

(2) Sm2 Sensorimotor mappings	At least two objects are connected. *If not: go to Sm1*	A combination of two parts (two bars or bar and frame), based on their length or shape.

Sensorimotor actions (Sm1)
Single feature of object or task. Observable.

(1) Sm1 Sensorimotor actions	Remaining solutions.	Remaining solutions. For instance, observation or inserting a single bar into the frame.

Supplementary material 2   Buzz-Wire variables correlation matrix. Variable values see Table 1

		Connections			Conduction			Circuit				Wires		System		
		Battery	Lamp	Switch	Lamp	Buzzer	Switch	Battery	Lamp	Buzzer	Switch	Connection	Circuit	Connected	Circle	Circuit
Connections	Battery															
	Lamp	.606														
	Switch	.406	.485													
Conduction	Lamp	.079	-.061	.165												
	Buzzer	.320	.285	.174	-.049											
	Switch	.290	.257	.275	.202	.118										
Circuit	Battery	.527	.289	.167	.122	.121	.076									
	Lamp	.577	.322	.159	.172	.111	.066	.803								
	Buzzer	.545	.212	.147	.107	.087	.041	.781	.687							
	Switch	-.004	-.157	.059	.185	-.098	-.169	.227	.250	.242						
Wires	Connection	.591	.730	.442	-.070	.400	.272	.166	.113	.104	-.191					
	Circuit	.516	.289	.183	.140	.112	-.002	.651	.747	.776	.333	.129				
System	Connected	.702	.795	.773	.058	.376	.301	.237	.284	.242	-.087	.739	.310			
	Circle	.627	.558	.499	.152	.241	.104	.731	.698	.689	.226	.412	.715	.412		
	Circuit	.502	.307	.119	.092	.220	.099	.667	.655	.648	.133	.258	.693	.258	.574	

Supplementary material 3   Stairs Marble Track variables correlation matrix. Variable values see Table 2.

		Length						Rotation						Vertical						General	
		Bar 1	Bar 2	Bar 3	Bar 4	Bar 5	Bar 6	Bar 1	Bar 2	Bar 3	Bar 4	Bar 5	Bar 6	Bar 1	Bar 2	Bar 3	Bar 4	Bar 5	Bar 6	Position	Horizontal
Length	Bar 1																				
	Bar 2	.471																			
	Bar 3	.386	.846																		
	Bar 4	.329	.614	.628																	
	Bar 5	.415	.710	.713	.813																
	Bar 6	.502	.333	.395	.345	.494															
Rotation	Bar 1	-.124	.088	.066	.164	.073	-.059														
	Bar 2	-.045	.145	.105	.153	.096	-.034	.756													
	Bar 3	-.129	.029	.003	.060	.020	-.029	.774	.795												
	Bar 4	-.018	.074	.041	.080	.058	-.026	.728	.799	.759											
	Bar 5	-.094	.036	.055	.016	.000	-.045	.690	.709	.699	.722										
	Bar 6	-.034	.094	.085	.130	.109	.028	.599	.655	.685	.619	.650									
Vertical	Bar 1	.255	.270	.183	.163	.186	.206	-.118	-.103	-.143	-.122	-.080	-.055								
	Bar 2	.251	.274	.201	.161	.194	.227	-.114	-.105	-.128	-.113	-.070	-.050	.989							
	Bar 3	.249	.265	.192	.156	.186	.212	-.117	-.103	-.148	-.127	-.074	-.048	.989	.984						
	Bar 4	.257	.275	.198	.168	.201	.227	-.112	-.104	-.143	-.128	-.068	-.055	.986	.981	.981					
	Bar 5	.262	.268	.187	.182	.195	.214	-.106	-.097	-.137	-.116	-.074	-.043	.976	.970	.976	.978				
	Bar 6	.272	.259	.171	.175	.194	.211	-.111	-.096	-.141	-.120	-.073	-.048	.973	.962	.973	.976	.992			
General	Position	-.151	-.052	-.059	-.109	-.097	-.198	.038	.033	.048	.041	.024	.016	-.115	-.114	-.118	-.113	-.113	-.117		
	Horizontal	.219	.040	.049	.076	.043	.234	-.045	-.040	-.057	-.049	-.028	-.019	.136	.135	.139	.134	.134	.139	.067	
	Combination	.279	.070	.082	.134	.104	.319	-.062	-.054	-.078	-.067	-.039	-.025	.185	.183	.190	.183	.182	.189	-.793	.390

Supplementary material 4   Buzz-Wire Extended Rasch Model Table

Sm1	Sm2	Sm3	Rp1a	R1b	Rp2a	Rp1c	Rp1d	Rp2b	RSys1	RSys2	Sa1	t	y2	y3	y4	y5
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	0	0
1	1	0	0	0	0	0	0	0	0	0	0	2	1	0	0	0
1	1	0	1	0	0	0	0	0	0	0	0	3	3	1	0	0
1	1	0	1	0	0	1	0	0	0	0	0	4	6	4	1	0
1	1	0	1	1	0	0	0	0	0	0	0	4	6	4	1	0
1	1	0	1	1	1	0	0	0	0	0	0	5	10	10	5	1
1	1	0	1	1	1	1	0	0	1	0	0	7	21	35	35	21
1	1	1	0	0	0	0	0	0	0	0	0	3	3	1	0	0
1	1	1	0	0	0	0	1	0	0	0	0	4	6	4	1	0
1	1	1	0	0	0	1	0	0	0	0	0	4	6	4	1	0
1	1	1	0	1	0	0	0	0	0	0	0	4	6	4	1	0
1	1	1	0	1	0	1	0	0	0	0	0	5	10	10	5	1
1	1	1	1	0	0	0	0	0	0	0	0	4	6	4	1	0
1	1	1	1	0	0	0	1	0	0	0	0	5	10	10	5	1
1	1	1	1	0	0	1	0	0	0	0	0	5	10	10	5	1
1	1	1	1	0	0	1	1	1	0	0	0	7	21	35	35	21
1	1	1	1	0	0	1	1	1	0	1	0	8	28	56	70	56
1	1	1	1	1	0	0	0	0	0	0	0	5	10	10	5	1
1	1	1	1	1	0	0	1	0	0	0	0	6	15	20	15	6
1	1	1	1	1	0	1	0	0	0	0	0	6	15	20	15	6
1	1	1	1	1	0	1	1	1	0	0	0	8	28	56	70	56
1	1	1	1	1	1	0	0	0	0	0	0	6	15	20	15	6
1	1	1	1	1	1	0	1	0	0	0	0	7	21	35	35	21
1	1	1	1	1	1	0	1	0	0	1	0	8	28	56	70	56
1	1	1	1	1	1	1	0	0	1	0	0	8	28	56	70	56
1	1	1	1	1	1	1	1	1	1	1	1	12	66	220	495	792

Variables

Sm1   Wire connected (Sm1)
Sm2   Components connected (Sm2)
Sm3   All components connected
Rp1a   Poles of battery connected by component
Rp1b   Both poles of lamp .AND. buzzer connected to battery
Rp2a   Lamp .OR. buzzer in circuit

Rp1c   All connections on metal
Rp1d   Ring and spiral linked by other component
Rp2b   Rp1c .AND. Rp 1d
Sys1   Rp1a .AND. Rp1b .AND. Rp1c
Sys2   Ring and spiral connected as switch
Abs1   Sys1.AND. Sys 2

Supplementary material 5   Stairs Marble Track Extended Rasch Model Table

Sm1	Sm2a	Sm2b	Sm3a	Sm3b	Sm3c	Rp1a	Rp1b	Rp1c	Rp2a	Rp1d	Rp2b	Rp3	t	y2	y3	y4
0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0
1	0	0	0	0	0	0	0	0	0	0	0	0	0	0	0	1
1	1	0	0	0	0	0	0	0	0	0	0	0	1	0	0	1
1	1	1	0	0	0	0	0	0	0	0	0	0	3	1	0	1
1	1	1	0	1	0	0	0	0	0	0	0	0	6	4	1	1
1	1	1	1	0	0	0	0	0	0	0	0	0	6	4	1	1
1	1	1	1	0	0	0	1	0	0	0	0	0	10	10	5	1
1	1	1	1	0	1	1	0	0	0	0	0	0	15	20	15	1
1	1	1	1	0	1	1	1	0	0	0	0	0	21	35	35	1
1	1	1	1	0	1	1	1	0	0	1	0	0	28	56	70	1
1	1	1	1	1	0	0	0	0	0	0	0	0	10	10	5	1
1	1	1	1	1	0	0	1	1	0	0	0	0	21	35	35	1
1	1	1	1	1	1	0	0	0	0	0	0	0	15	20	15	1
1	1	1	1	1	1	0	1	1	0	0	0	0	28	56	70	1
1	1	1	1	1	1	1	0	0	0	0	0	0	21	35	35	1
1	1	1	1	1	1	1	0	0	0	1	0	0	28	56	70	1
1	1	1	1	1	1	1	0	0	0	1	1	0	36	84	126	1
1	1	1	1	1	1	1	1	1	1	0	0	0	45	120	210	1
1	1	1	1	1	1	1	1	1	1	1	0	0	55	165	330	1
1	1	1	1	1	1	1	1	1	1	1	1	1	78	286	715	1

Variables

Sm1	Any action		Rp1a	Slanted top aligned
Sm2a	Any combination of bars		Rp1b	Bars at correct position
Sm2b	Any combination of bar and frame		Rp1c	All bars at correct position
Sm3a	Vertical position bar in frame		Rp2a	Slanted top of >= 5 bars guide marble
Sm3b	Frame filled		Rp1d	Slanted top correct position
Sm3c	Slanted top upward		Rp2b	Slanted top of >= 5 bars correct position
			Rp3	Correct configuration