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Development of metacognitive skills in young adolescents : a bumpy ride to the high road

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Appendix A

Criteria for assessing the quality of metacognitive skillfulness in history

	Score
Orientation	
• Not reading the title and/or subtitles of paragraphs	0
• No activity prior to task performance	1
• Some orientations while reading, not (entirely) prior to task performance	2
• Obvious orientation at text level (e.g., looking at the structure of the text; reading subtitles of paragraphs) prior to task performance	3
• Aforementioned activities, including deeper (e.g., stating expectations about the content of the text prior to reading; activate prior knowledge)	4
Planning	
• Absent	0
• Superficial action (e.g., rereading arbitrary parts without specific goal)	1
• Navigating through text with a goal or another planned activity (e.g., selectively marking text parts; take notes)	2
• Aforementioned activities plus good time management	3
• Aforementioned activities plus executing a plan that was thought of in advance, (e.g., first reading whole text, followed by reading each paragraph and paraphrasing each paragraph in one's own words before reading the next paragraph)	4
Evaluation	
• Absent	0
• Just utterances like "I don't understand this", not followed by any action	1
• Self-corrections after having noticed failure or misunderstanding	2
• Variety of deeper evaluation and/or monitoring (e.g., checking comprehension, self-control by selecting text parts looking for information)	3
• Aforementioned plus explicitly formulating the learning outcome of this evaluation process	4

Elaboration

- Absent 0
- Some shallow elaborations elicited by questions/assignments in the text, not spontaneously 1
- Some shallow elaborations during text reading (e.g., paraphrasing almost literally) 2
- As below, but not during the whole task performance 3
- Deeper elaborations with clear conclusions formulated in whole sentences 4

Appendix B

Criteria for assessing the quality of metacognitive skillfulness in math

	Score
Orientation	
• Absent	0
• Reading the assignments/task demands carefully prior to task performance	1
• Reading the assignments/task demands prior to task performance plus superficial orientations (e.g., verifying the number of assignments)	2
• Obvious orientation (visualizing the problem by making a sketch or by schematizing important information) prior to task performance	3
• Aforementioned activities, but deeper and more complete (e.g., activating prior knowledge; relating to a previously encountered, similar problem)	4
Planning	
• Absent	0
• Action plan consists in consulting explanation sheet, not followed by any action	1
• Action plan is executed only partly, followed by trial-and-error	2
• Action plan is executed partly, followed by a new plan	3
• Problem is solved by action plan that was formulated in advance	4
Evaluation	
• Absent	0
• Just utterances like “I don’t understand this”, not followed by any action	1
• Self-corrections after having noticed failure or misunderstanding; uncertainty leading to consult the explanation sheet	2
• Variety of deeper evaluation activities (e.g., checking comprehension, self-control, verifying the outcome systematically, questioning the appropriateness of the plan)	3
• Aforementioned plus explicitly evaluating the outcome of the learning process	4

Elaboration

- Absent 0
- Occasionally relating the outcome to the assignment or problem statement 1
- Systematically relating the outcome to the assignment or problem statement 2
- Concluding which information was important to solve the problem; stating which information was redundant 3
- After having solved the problem, student reflects on what was learned and its usefulness for future situations 4

Appendix C

Correlations between intellectual ability, metacognitive skills, and learning performance over the years

Legend

1. Intellectual ability (IA) Number Series 13 yrs
2. IA Verbal Analogies 13 yrs
3. IA Unfolding Figures 13 yrs
4. IA Memory 13 yrs
5. IA Number Series 14 yrs
6. IA Verbal Analogies 14 yrs
7. IA Unfolding Figures 14 yrs
8. IA Memory 14 yrs
9. IA Number Series 15 yrs
10. IA Verbal Analogies 15 yrs
11. IA Unfolding Figures 15 yrs
12. IA Memory 15 yrs
13. Metacognition Math quality (MetaMQI) Orientation 13 yrs
14. MetaMQI Planning 13 yrs
15. MetaMQI Evaluation 13 yrs
16. MetaMQI Elaboration 13 yrs
17. Metacognition History quality (MetaHQI) Orientation 13 yrs
18. MetaHQI Planning 13 yrs
19. MetaHQI Evaluation 13 yrs
20. MetaHQI Elaboration 13 yrs
21. MetaMQI Orientation 14 yrs
22. MetaMQI Planning 14 yrs
23. MetaMQI Evaluation 14 yrs
24. MetaMQI Elaboration 14 yrs
25. MetaHQI Orientation 14 yrs
26. MetaHQI Planning 14 yrs
27. MetaHQI Evaluation 14 yrs
28. MetaHQI Elaboration 14 yrs
29. MetaMQI Orientation 15 yrs
30. MetaMQI Planning 15 yrs
31. MetaMQI Evaluation 15 yrs
32. MetaMQI Elaboration 15 yrs
33. MetaHQI Orientation 15 yrs
34. MetaHQI Planning 15 yrs
35. MetaHQI Evaluation 15 yrs
36. MetaHQI Elaboration 15 yrs
37. Metacognition Math quantity (MetaMQn) Orientation 13 yrs
38. MetaMQn Planning 13 yrs
39. MetaMQn Evaluation 13 yrs
40. MetaMQn Elaboration 13 yrs
41. Metacognition History quantity (MetaHQn) Orientation 13 yrs
42. MetaHQn Planning 13 yrs
43. MetaHQn Evaluation 13 yrs
44. MetaHQn Elaboration 13 yrs
45. MetaMQn Orientation 14 yrs
46. MetaMQn Planning 14 yrs
47. MetaMQn Evaluation 14 yrs
48. MetaMQn Elaboration 14 yrs
49. MetaHQn Orientation 14 yrs
50. MetaHQn Planning 14 yrs
51. MetaHQn Evaluation 14 yrs
52. MetaHQn Elaboration 14 yrs
53. MetaMQn Orientation 15 yrs
54. MetaMQn Planning 15 yrs

55. MetaMQn Evaluation 15 yrs
56. MetaMQn Elaboration 15 yrs
57. MetaHQn Orientation 15 yrs
58. MetaHQn Planning 15 yrs
59. MetaHQn Evaluation 15 yrs
60. MetaHQn Elaboration 15 yrs
61. Learning Performance Math (LPM) 13 yrs
62. Learning Performance History (LPH) 13 yrs
63. LPM 14 yrs
64. LPH 14 yrs
65. LPM 15 yrs
66. LPH 15 yrs

Note: N=25

$p < .05$ if $r \geq .40$; $p < .01$ if $r \geq .50$

Correlations between intellectual ability, metacognitive skills, and learning performance over the years

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
2	.58															
3	.70	.56														
4	.18	.29	.29													
5	.56	.53	.49	.45												
6	.34	.59	.37	-.07	.59											
7	.49	.39	.82	.33	.55	.20										
8	.27	.06	.36	.44	.31	-.10	.53									
9	.48	.39	.38	.40	.78	.36	.55	.23								
10	.44	.58	.51	.11	.36	.63	.32	.03	.21							
11	.35	.43	.61	.36	.60	.29	.77	.21	.75	.32						
12	.17	.19	.43	.49	.41	.03	.63	.59	.37	.20	.40					
13	.03	.28	.13	.09	.19	.01	.33	-.09	.17	.16	.37	.34				
14	.55	.64	.58	.18	.61	.32	.70	.22	.55	.43	.61	.40	.48			
15	.27	.32	.29	.14	.52	.25	.38	.04	.25	.06	.34	.22	.61	.45		
16	-.04	.23	-.03	.39	.23	.20	-.01	.09	.24	.30	.18	.43	-.04	.06	-.31	
17	-.11	.25	-.24	.09	.05	.15	-.36	-.46	.17	.18	-.04	-.14	-.03	.08	-.17	.43
18	.36	.33	.12	.12	.33	.11	.00	-.22	.27	.26	.18	.03	.25	.44	.08	.42
19	.03	.41	.09	.24	.27	.25	-.10	-.09	.15	.21	.08	.02	-.09	.20	.06	.37
20	.19	.36	.02	.08	.12	.02	-.04	-.39	.06	.26	.15	.00	.42	.44	.13	.31
21	-.23	.02	-.21	.06	.06	.17	-.28	-.43	.09	.15	.06	-.38	.05	-.09	.03	.09
22	.39	.44	.30	.28	.67	.40	.35	.26	.68	.31	.39	.21	-.04	.60	.14	.15
23	.23	.45	.13	.24	.52	.50	.23	.04	.40	.41	.42	.07	.23	.39	.34	.35
24	.30	.41	.17	.23	.62	.29	.35	.03	.63	.22	.51	.04	.26	.55	.44	-.01
25	.00	.43	.25	.35	.26	-.05	.43	.27	.23	.23	.52	.44	.42	.39	.16	.37
26	-.07	.17	.09	.07	.08	-.04	.16	-.06	.18	.01	.18	.25	.12	.20	-.04	.15
27	-.15	.41	.00	.12	.20	.29	.06	-.38	.11	.18	.26	.06	.44	.25	.41	.22
28	.02	.46	.20	.45	.42	.20	.29	-.10	.36	.28	.39	.21	.34	.41	.30	.22
29	-.04	.00	-.06	.18	.08	.18	-.08	-.01	.10	.20	.00	.19	.07	-.28	-.22	.38
30	.34	.59	.37	.36	.53	.34	.48	.35	.67	.35	.61	.41	.33	.51	.11	.44
31	-.04	.23	-.03	.39	.23	.20	-.01	.09	.24	.30	.18	.43	-.04	.06	-.31	1.00
32	.36	.55	.29	.29	.43	.23	.32	-.05	.58	.50	.57	.20	.47	.54	.18	.43
33	.02	-.05	-.10	.24	.00	-.21	-.04	-.05	-.07	.04	.04	-.05	.28	.00	.24	.09
34	.05	.24	.00	.23	.33	.10	.10	-.10	.40	.30	.27	.32	.43	.33	.21	.44
35	-.24	.17	-.15	.06	.08	.30	-.15	-.28	.18	.33	.17	.05	.17	.15	-.04	.49
36	.07	.30	.00	.34	.39	.13	.06	-.12	.43	.33	.30	.23	.26	.38	.06	.51
37	-.01	.13	.18	.33	.26	-.08	.36	.31	.11	.07	.42	.23	.56	.21	.65	-.20
38	.51	.43	.53	.24	.66	.23	.65	.21	.63	.18	.62	.32	.28	.86	.54	-.09
39	.10	.25	.32	.24	.30	.30	.32	.07	.08	.12	.36	.23	.55	.17	.76	-.14

Appendix C

	1	2	3	4	5	6	7	8	9	10	11	12	13	14	15	16
40	.59	.74	.54	.35	.58	.27	.52	.03	.45	.34	.51	.21	.46	.81	.58	-.02
41	-.18	.17	-.01	.41	.17	.15	-.05	.04	.05	.06	.01	.22	-.11	.11	.02	.31
42	.19	-.07	.04	.33	.24	-.08	.02	.22	.00	-.03	-.12	.30	.17	.18	.17	.33
43	-.16	.20	-.12	.39	.09	-.02	-.21	.01	.03	-.05	-.01	-.04	-.09	.09	.09	.30
44	.27	.35	.02	.05	.26	.11	.01	-.27	.24	.19	.18	.07	.32	.47	.13	.23
45	-.36	-.07	-.25	.16	.06	.04	-.21	-.30	.03	.12	.18	-.26	.29	-.18	.15	.00
46	.27	.15	.19	.10	.53	.42	.25	.11	.54	.16	.30	-.06	.03	.31	.23	-.10
47	-.27	-.11	-.18	-.03	.05	.19	-.20	-.23	-.01	.02	.13	-.17	.12	-.26	.21	.07
48	.44	.55	.25	.25	.63	.44	.21	-.15	.47	.38	.41	-.07	.28	.51	.48	-.01
49	-.08	.24	.12	.37	.25	-.06	.25	.17	.07	.15	.36	.43	.57	.23	.50	.19
50	-.03	.34	.16	.22	.19	-.06	.31	.00	.31	.17	.39	.34	.49	.39	.10	.20
51	-.30	.10	-.03	.09	.01	.17	.05	-.23	.00	.10	.25	.11	.50	.01	.36	.10
52	-.29	.03	-.14	.23	.24	.02	.11	-.13	.35	.02	.28	.14	.29	.22	.04	.17
53	-.05	.07	.00	.07	.07	.18	-.15	-.35	-.07	.25	.05	-.06	.11	-.11	-.16	.35
54	-.10	.04	-.07	-.03	.43	.51	.04	-.21	.43	.13	.28	.11	.20	.21	.31	.18
55	-.23	-.01	-.17	.46	.08	.18	-.24	-.06	.01	.15	-.02	.14	-.08	-.31	-.17	.66
56	.18	.52	.29	.30	.27	.25	.30	-.03	.38	.62	.48	.31	.53	.42	.13	.51
57	-.08	.04	-.08	.37	.04	-.23	.09	.19	-.07	.15	.05	.19	.40	.16	.17	.11
58	-.16	-.04	-.14	.28	.19	.10	-.05	-.09	.24	.32	.23	.00	.09	.00	.01	.35
59	-.12	.04	-.22	.09	.01	.18	-.34	-.24	-.07	.07	-.14	-.14	.00	-.13	-.06	.31
60	-.26	.10	-.19	.33	.11	.07	-.15	-.24	.19	.25	.12	.11	.15	.04	-.13	.52
61	.64	.64	.64	.42	.75	.40	.71	.49	.61	.44	.56	.47	.22	.86	.40	.09
62	.41	.50	.24	.23	.60	.33	.12	-.10	.39	.36	.19	.13	.11	.56	.24	.17
63	.33	.45	.14	.22	.69	.36	.28	.19	.59	.31	.39	.31	.26	.64	.36	.32
64	.29	.46	.14	.28	.45	.26	.09	-.13	.29	.47	.15	.12	.22	.57	.23	.19
65	.32	.42	.41	.36	.67	.40	.49	.29	.75	.41	.64	.51	.19	.62	.17	.37
66	.22	.46	.04	.00	.32	.25	.00	-.19	.32	.23	.12	.04	.21	.48	.00	.35

Correlations between intellectual ability, metacognitive skills, and learning performance over the years

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
18	.48															
19	.56	.42														
20	.43	.81	.30													
21	.33	.27	.41	.17												
22	.26	.36	.38	.16	.13											
23	.13	.29	.38	.34	.40	.32										
24	.10	.30	.20	.23	.24	.70	.37									
25	.10	.15	.36	.27	-.09	.14	.27	.30								
26	.24	-.06	.24	.19	-.21	.18	-.08	.07	.44							
27	.36	.18	.47	.51	.31	.06	.63	.19	.40	.44						
28	.46	.33	.44	.50	.24	.47	.40	.51	.48	.52	.71					
29	.02	.08	-.33	-.07	.14	-.12	.03	-.19	-.16	-.35	-.15	-.09				
30	.25	.36	.29	.17	.13	.49	.43	.41	.53	.12	.19	.42	.23			
31	.43	.42	.37	.31	.09	.15	.35	-.01	.37	.15	.22	.22	.38	.44		
32	.52	.58	.43	.51	.28	.39	.55	.39	.55	.27	.46	.56	.07	.73	.43	
33	.04	.28	-.04	.41	.08	-.21	.04	.20	.21	.02	.14	.26	-.13	.09	.09	.19
34	.42	.61	.55	.57	.35	.34	.40	.37	.43	.27	.52	.58	.08	.48	.44	.69
35	.65	.40	.45	.33	.45	.14	.43	-.03	.08	-.07	.44	.28	.26	.29	.49	.50
36	.58	.68	.54	.64	.50	.44	.49	.37	.31	.22	.50	.67	.16	.48	.51	.67
37	-.28	-.13	-.02	.03	.00	.03	.21	.32	.52	.13	.28	.33	-.19	.21	-.20	.22
38	.02	.36	.17	.30	.05	.66	.30	.63	.18	.11	.15	.37	-.35	.38	-.09	.34
39	-.29	-.14	-.02	-.01	.05	-.16	.39	.08	.12	-.06	.43	.18	-.03	.08	-.14	.09
40	.15	.42	.35	.53	.02	.39	.45	.48	.38	.28	.51	.56	-.32	.36	-.02	.55
41	.39	.25	.45	.32	.09	.40	.05	.21	.12	.15	.25	.51	-.13	.14	.31	-.04
42	-.03	.49	.11	.34	.03	.04	.23	-.18	-.11	-.13	.02	-.02	-.09	.04	.33	.13
43	.50	.36	.82	.30	.42	.31	.32	.20	.22	.02	.36	.40	-.36	.18	.30	.24
44	.38	.77	.23	.90	.02	.36	.27	.33	.18	.16	.38	.47	-.01	.23	.23	.40
45	.11	-.03	.10	.08	.75	-.05	.34	.17	.07	-.10	.33	.20	.14	.11	.00	.25
46	.00	.23	.21	-.04	.44	.54	.45	.47	-.22	-.14	.10	.29	.06	.34	-.10	.25
47	.14	-.01	.29	.04	.42	-.17	.53	-.12	-.03	-.15	.49	.11	.03	.01	.07	.19
48	.21	.53	.20	.47	.29	.61	.41	.81	.11	-.12	.26	.53	.04	.29	-.01	.37
49	-.07	.00	.23	.13	.05	-.05	.28	.27	.70	.16	.35	.26	-.13	.17	.19	.29
50	.31	.18	.33	.35	.00	.27	.17	.22	.75	.69	.51	.61	-.14	.49	.20	.65
51	.17	.03	.20	.21	.30	-.09	.48	.03	.20	.06	.67	.44	.10	.13	.10	.29
52	.38	.31	.29	.39	.35	.34	.26	.34	.30	.32	.50	.72	.08	.39	.17	.40
53	.11	.26	-.24	.21	.33	-.19	.02	-.16	-.27	-.26	-.01	-.08	.66	-.03	.35	.06
54	.23	.24	.13	.19	.36	.48	.38	.39	-.18	.12	.38	.38	.16	.21	.18	.17
55	.31	.22	.23	.18	.31	-.07	.36	-.19	-.05	-.09	.30	.26	.52	.11	.66	.16

	17	18	19	20	21	22	23	24	25	26	27	28	29	30	31	32
56	.43	.46	.40	.43	.29	.23	.45	.26	.57	.25	.46	.54	.19	.67	.51	.90
57	.05	.00	-.16	.19	-.05	-.27	.05	.02	.29	.00	.09	.19	-.01	.15	.11	.22
58	.42	.30	.33	.24	.51	.11	.51	.09	.15	-.11	.37	.37	.30	.23	.35	.51
59	.34	.30	.41	.29	.27	-.16	.49	-.33	-.12	-.20	.42	.05	.19	-.02	.31	.22
60	.67	.50	.54	.52	.46	.23	.31	.18	.30	.24	.51	.69	.20	.36	.52	.52
61	-.03	.27	.23	.22	-.19	.66	.43	.53	.32	.16	.15	.41	-.24	.48	.09	.39
62	.44	.62	.47	.56	.24	.73	.31	.49	.12	.26	.29	.56	-.09	.24	.17	.41
63	.37	.52	.47	.42	.12	.73	.55	.69	.41	.20	.32	.54	-.23	.58	.32	.56
64	.51	.53	.35	.54	.26	.52	.19	.58	.18	.16	.21	.56	-.15	.26	.19	.40
65	.37	.31	.30	.06	.11	.64	.33	.43	.32	.05	.03	.29	.10	.66	.37	.55
66	.61	.71	.59	.59	.28	.48	.42	.25	.21	.25	.42	.49	-.04	.45	.35	.63

Correlations between intellectual ability, metacognitive skills, and learning performance over the years

	33	34	35	36	37	38	39	40	41	42	43	44	45	46	47	48
34	.29															
35	-.09	.52														
36	.17	.83	.62													
37	.44	.16	-.13	.02												
38	.03	.23	.03	.33	.24											
39	.20	.00	.03	-.08	.67	.19										
40	.20	.37	.11	.41	.30	.72	.34									
41	.22	.26	.24	.36	.06	.24	.00	.11								
42	.29	.26	.14	.25	.03	.17	.18	.19	.13							
43	.15	.39	.43	.48	.13	.18	.07	.23	.65	.22						
44	.25	.55	.27	.61	-.04	.38	-.11	.48	.42	.24	.22					
45	.29	.22	.31	.23	.45	-.07	.36	-.06	.07	-.02	.24	-.09				
46	-.14	.28	.23	.43	-.01	.39	.15	.27	.00	.10	.17	.08	.12			
47	-.01	.21	.49	.21	.27	-.21	.53	-.12	.04	.01	.37	-.04	.54	.25		
48	.17	.32	.12	.46	.25	.56	.21	.56	.29	-.04	.22	.57	.15	.48	.01	
49	.21	.25	.00	.16	.69	.14	.54	.28	.05	.03	.24	-.02	.29	-.21	.20	.19
50	.08	.56	.14	.39	.34	.20	-.02	.40	.09	-.05	.10	.29	.15	-.14	-.07	.03
51	-.05	.26	.44	.31	.38	-.06	.63	.08	.14	-.05	.28	.11	.44	.19	.79	.18
52	.20	.66	.44	.70	.12	.21	-.09	.22	.44	.00	.28	.48	.26	.41	.17	.28
53	.01	-.03	.37	.17	-.21	-.15	.10	-.09	-.07	.20	-.17	.07	.30	.00	.04	.15
54	-.07	.36	.44	.45	.09	.35	.29	.07	.36	.13	.17	.31	.33	.55	.41	.45
55	.14	.26	.54	.43	-.06	-.33	.21	-.16	.34	.37	.36	.08	.30	.15	.50	.05
56	.25	.70	.56	.63	.27	.15	.20	.43	.02	.12	.23	.26	.33	.16	.22	.25
57	.72	.15	.11	.13	.41	.01	.22	.25	.07	.25	.04	.00	.23	-.19	-.12	-.05
58	.17	.59	.75	.66	.13	-.03	.04	.08	.10	.16	.33	.17	.45	.35	.52	.19
59	-.08	.32	.67	.36	-.22	-.27	.14	.07	.07	.36	.38	.24	.14	.20	.62	-.04
60	.29	.76	.65	.84	.00	-.04	-.13	.12	.54	.10	.53	.49	.32	.23	.33	.26
61	-.03	.20	.02	.33	.22	.77	.23	.75	.23	.18	.16	.33	-.29	.45	-.21	.53
62	-.09	.41	.16	.62	-.02	.59	-.08	.56	.40	.23	.34	.63	-.06	.34	-.15	.69
63	.13	.53	.21	.60	.22	.61	.07	.48	.38	.17	.41	.51	-.03	.40	.05	.60
64	.33	.40	.20	.59	.05	.53	-.07	.55	.47	.12	.34	.52	.05	.21	-.29	.65
65	-.22	.31	.41	.46	.08	.61	.07	.34	.24	.03	.21	.17	.00	.34	.00	.37
66	-.18	.57	.49	.74	-.25	.30	-.18	.44	.16	.20	.40	.59	-.13	.43	.11	.38

	49	50	51	52	53	54	55	56	57	58	59	60	61	62	63	64	65
50	.38																
51	.43	.20															
52	-.02	.52	.33														
53	-.11	-.29	.13	.10													
54	-.04	-.01	.46	.44	.26												
55	.05	-.15	.46	.24	.53	.36											
56	.37	.60	.38	.36	.23	.17	.31										
57	.31	.16	-.02	.17	.06	-.24	.12	.35									
58	.07	.16	.36	.55	.20	.29	.56	.53	.25								
59	-.09	-.08	.41	.23	.18	.13	.60	.21	.00	.60							
60	.07	.41	.40	.80	.12	.36	.58	.58	.20	.71	.44						
61	.21	.20	-.02	.17	-.22	.18	-.12	.27	.15	.01	-.07	.02					
62	.10	.28	.04	.30	.01	.41	.03	.23	-.22	.11	.02	.35	.55				
63	.34	.35	.17	.38	-.32	.45	.01	.39	.04	.18	-.02	.38	.66	.69			
64	.20	.20	-.07	.32	.05	.24	.00	.35	.34	.14	-.13	.43	.54	.74	.66		
65	.26	.28	.11	.24	-.01	.37	.05	.44	.00	.26	-.04	.25	.63	.48	.66	.47	
66	-.01	.37	.26	.44	.00	.33	.16	.48	-.19	.27	.38	.54	.38	.69	.63	.48	.41