

ELECTRONIC SUPPLEMENTARY MATERIAL 1

Coding scheme used to indicate students' level of reasoning on the lesson-specific graph interpretation tasks with examples of student responses

Level of reasoning	Description	Code	Example of student response to Task 1	Example of student response to Task 3	Example of student response to Task 5
No reasoning Level 0	Students' reasoning is not related to the graphical representation or the motion event	R0_empty R0_don't know R0_repeat question	- '...' - 'I have no idea' - '...' - 'He walks and waits for the traffic light' - '...' - 'It is a guess'	- '...' - 'No idea' - '...'	- '...' - 'No idea' - '...'
		R0_process	- 'It is a guess'	- 'That is what I think, I do not have a reason for this one.'	- 'Just no'
Iconic reasoning Level 1	Student reasons on the basis of the shape of the graphical representation or superficial characteristics of the motion event	R0_unclear R0_unrelated	- 'She [...] out' - 'Then you can trace the height' - 'Because you cannot make turns'	- 'Not one [...] up and fort down.' - 'a and b are too small, or is that just me?' - 'A hot air balloon is everywhere'	- 'He goes up in 2 straight lines' - 'Not the measurement'
		R1	- 'Because an airplane takes off in a straight line' - 'He is not going up' - 'The stars go up' - 'In the graph it goes up, and here the plane is also going up' - 'I think the graph does not contain a traffic light and it does not go up' - 'The staircase has almost the same shape as the graph'	- 'It does not go upwards, but straight' - 'A hot air balloon can go upwards' - 'It does not go diagonally' - 'The line goes up and the boat stays at the same height' - 'Because a hot air balloon rises, and the line does too' - 'A Ferris Wheel makes circles, and does not go up in a straight line'	- 'First the line goes diagonally upwards and then straight and then downwards again' - 'It has a similar shape' - 'This one has to go down as well' - 'It's almost identical, however, this one is higher' - 'It is identical to the one above' - 'He goes like this [drawing: diagonal line] and then [drawing: horizontal line] and the other goes like this [drawing: example graph] in nothing this is similar'
Single variable reasoning Level 2	Student reasons on the basis of a single variable (distance/time/speed)	R2	- 'An airplane usually does not stop' - 'Yes, he travels a distance and then continues.' - 'Its appearance is correct, but the time is not' - 'You see that the line above is making a stop, and the plane does not' - 'You see him stop, so does the line in the graph' - 'She does not stop anywhere, in the graph there is a stopping point, and here there is not'	- 'The distance is increasing because the boat is moving' - '...' - 'He goes around in circles, so the distance should become bigger and smaller, so bumps actually' - 'The boat moves forwards and the graph as well, if the graph goes up it means you go forward' - 'Because it goes upwards, and the graph represents an increase in distance' - 'Daan moves both forwards and backwards, and in the graph you only see movement forward'	- 'The shape is not identical, but if the kilometres are 2 times as much, then the line will be longer as well' - 'He does not go until 30 kilometre from the sensor' - 'It does not come closer again' - 'This graph goes until the 30 kilometre, so does the one above' - 'You see that it goes until 15, and the one above till 30' - 'It does not take 15 minutes as it does in the graph above'
		R3	- 'Then it will be like this' [student made a drawing of a graph] - 'It depends on how long he waits' [student made a drawing of a graph] - 'No, because the graph represents time and distance (it would if it represents the distance upwards!)	- 'If the sensor is at point A, he goes further away at the same speed' - 'Well, he may go straight up, he also travels within a certain amount of time a certain amount of distance' - 'He may go around in circles, he travels within a certain amount of time a certain amount of distance'	- 'In 45 minutes you walk 30 kilometre, then stand still, and back again' - 'In this graph the line in the middle does stand still for 15 minutes, but not at 30 meters' - 'You only see half of it, but it is identical in meters and minutes' - 'It goes until 30 kilometre and that takes 15 minutes, just like the graph above' - 'This one goes 15 kilometres in 45 minutes and that you do not see in the large graph'
Multiple variable reasoning Level 3	Student reasons on the basis of multiple variables (distance/time/speed)				

ELECTRONIC SUPPLEMENTARY MATERIAL 2

Coding scheme used to indicate students' level of reasoning on the lesson-specific graph construction tasks with examples of student responses

Level of reasoning	Description	Code	Example of student response to Task 2	Example of student response to Task 4	Example of student response to Task 6
No reasoning Level 0	Student constructs graph without taking into account the description of the motion event	R0			
Iconic reasoning Level 1	Student constructs graph on the basis of superficial characteristics of the description of the motion event	R1			
Single variable reasoning Level 2	Student constructs graph taking into consideration a single variable (distance or time or speed)	R2			

Multiple variable reasoning
 Level 3

R3

Student constructs graph taking into consideration multiple variables (distance and/or time and/or speed)

