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Strategies used by small student groups to understand a geographical mystery

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Abstract

Relational thinking in geography is often complex, due to the interdisciplinary character of the subject and the many relationships between human and natural systems. We explored the strategies of twelve small groups of students in upper secondary education in the Netherlands as they attempted to understand a regional problem presented as a mystery. Four different relating strategies were found. The six low-performing groups on the mystery assignment employed different relating strategies from the six high-performing groups, who primarily used a webbing strategy. The findings suggest that a webbing strategy, focused on the establishment of multi-causal relationships, is more successful in tackling complex assignments in geography such as understanding regional problems.

Keywords: Mystery, Relational Thinking, Secondary Geography, Strategies

1. Introduction

Thinking about geography, the question could arise: why should we teach it? In our globalised and interconnected world, with big issues such as international migration, climate change, inequality and environmental destruction, what has the school subject which teaches "the world" to offer to young people? It teaches students how people at specific locations on the planet, in different circumstances, try to make their living and how their interrelationships with people at other places and their interaction with the environment form places and landscapes (International Geographical Union, 2016). Geography can help students to understand the world by studying it in a specific way, using key geographic concepts. This is called "the geographic advantage" (Hanson, 2004) or "thinking geographically" (Jackson, 2006; Lambert, 2017). Lambert (2017) states that relational thinking lies at the heart of thinking geographically (p. 28). He uses a slightly modified version of Jackson's (2006) four pairs of key concepts that capture relational thinking in geography: space and place, scale and connection, proximity and distance and people and

environment (p. 28). Relational thinking is also at the heart of the Geographical Analysis Model of van der Schee (2000). This model describes relational thinking from the perspective of regional change. The model is structured by the relationship between man and nature and the unit of analysis is the region. It analyses regional change with vertical relationships (between elements of the natural system and the human system within a region) and horizontal relationships (between regions at different scales). The German Geographical Society DGfG (2012) identifies the systems concept as the core concept of the school subject and has developed a cube model, which describes the human-environmental system containing the human and the physical subsystems. The DGfG mentions the relationships within and between these (sub)systems as "the central object of study" (p. 10) at different scales (from the local to the global). Thus, relational thinking in geography is connected to systems thinking but is structured by the use of key geographical concepts, has a particular focus on the analysis of relationships between man and nature and uses the region as a localised unit at different scales (Favier and van der Schee, 2014; Cox et al., 2019).

Clearly, relational thinking in geography is hard for students, because they have to analyse the interconnections between economic, political, socio-cultural and physical aspects at different scales. Understanding the interconnected problems of our world cannot be achieved by thinking in simple causalities: students need to think in interwoven, complex causalities (DeVane et al., 2010; Fögele, 2017). Research in the earth sciences and geography has shown that students in secondary education have difficulties with complex, multi-causal relational thinking (Assaraf and Orion, 2005; Cox et al., 2017; Favier and van der Schee, 2014; Kali et al., 2003). Consequently, there are large differences between students in their geographical relational thinking. Mehren, Rempfler, Buchholz, Hartig, and Ulrich-Riedhammer (2018) validated a three-stage competence model of systems thinking in geography. Students on a low level (competence stage 1) identified only some elements that were hardly linked. Established relationships were mono-causal or linear. At stage 2, relationships became more complex as linear thinking predominated. At stage 3, networked elements and relationships were identified, illustrating complex relational thinking.

This study examines the different relational strategies that were used by groups with low performance in relational thinking and by groups that performed highly in relational thinking when they had to explain a multi-causal regional problem that was presented as a mystery.

1.1 The mystery as a thinking strategy

The mystery is one of the most powerful strategies from the Thinking Through Geography programme (Leat, 2001, p. 51), which was designed to foster thinking in geography lessons, although this thinking is more generic than thinking geographically (Morgan, 2017). Mysteries are known internationally and used in different school subjects (geography, history, economics). They are designed to promote relational thinking and reasoning in small groups in order to gain insight into a real-life problem that seems odd at first glance (Leat, 2001; Schuler, 2005). In geographical mysteries, these problems are localised in specific regions. In addition to the whole class introduction to the mystery and some additional materials like maps or photographs, students are given 16-30 strips that each contain a piece of information: background data, personal information about a person or people involved, concrete information on the problem situation, the geographical context and some red herrings. Students have to make connections (multiple causal relationships) between relevant information strips in order to understand the regional situation and to explain or solve the problem presented in the mystery (Leat, 2001).

Leat and Nichols (2000) describe several stages in the process of tackling a mystery. The first stage is the *display stage*: students read the strips and try to understand the information. The second stage is the *setting stage*, where groups categorise the data and form sets and subsets of the information strips. All groups form a reject pile of strips that contain information they consider irrelevant or do not understand. Low-

performing groups have larger reject piles than high-performing groups. The third stage is the *sequencing and webbing stage*. In this stage, groups relate sets and individual strips in order to understand the mystery. This relating can have a linear causal pattern (sequencing) or a non-linear pattern (webbing). According to Leat and Nichols, some groups are willing to break up their first relational chains or webs and to reconsider the reject pile to search for a better understanding and integration of more strips in a modest or a radical *reworking stage*. Leat and Nichols (2000) found that many low-performing groups do not rework their data at all, because they fear losing the relationships they have already established. The final stage, *the abstract stage*, is only reached by some high-performing groups as they continue the discussion after the physical manipulation of strips. Leat and Nichols note that not all groups go through all five stages in an orderly manner: some groups miss a stage, compress a stage or work with several stages simultaneously (p. 106).

Leat and Nichols suggest a relationship between students' thinking activities as they move from one stage to another and the levels of the SOLO taxonomy. The SOLO taxonomy (Biggs and Collis, 1982) has five levels of increasing structural complexity of students' responses to an assignment: 1) the *pre-structural level*, where no single relevant piece of information is connected with the question; 2) the *uni-structural level*, where one piece of information is used to give a correct answer to the question; 3) the *multi-structural level*, where two or more pieces of information are correctly related to answer the question but are unrelated with each other; 4) *the relational level*, where two or more pieces of information are interrelated with each other and also correctly related to answer the question; and 5) *the extended abstract level*, where two or more interrelated pieces of information are correctly connected with the question and where abstract principles and hypothesising beyond the given data are used. Leat and Nichols (2000) suggest that the move from the display stage to the setting stage corresponds with a shift from the uni-structural level to the multi-structural response level. The move from the setting stage to the sequencing and webbing stage means a shift from the multi-structural level to the relational response level.

Leat and Nichols' study suggests that the mystery is a promising strategy for fostering relational thinking in geography lessons. Research into the effects of the use of mysteries on relational thinking of secondary school students (Karkdijk et al., 2013) showed a significant positive effect. A multilevel regression analysis revealed that students in Dutch upper secondary education who used mysteries in geography lessons established significantly more correct geographical relationships than students who followed the regular geography curriculum.

1.2 Research aim and research question

A previous study on the use of mysteries and geographical relational thinking (Karkdijk et al., 2019a) found large differences between groups in relational thinking: the majority of the groups used unconnected relationships to explain the mystery question (responses on the multi-structural SOLO level) and only a minority of the groups gave a coherent, interconnected answer (on the relational level of the SOLO taxonomy). Except in the work of Leat and Nichols, we have found no information about strategies groups employ to understand a mystery and the effectiveness of these strategies for relational thinking. The aim of this study was to describe which strategies small student groups employed to understand a geographical mystery. More evidence on these strategies could be helpful to understand differences between groups in their relational thinking when working on assignments which demand multi-causal, complex relating skills (such as mysteries). This evidence could also help teachers to foster multi-causal relational thinking in group work on these assignments and in a whole-class debriefing afterwards. For the current study, we adopted a qualitative approach to answer the following research question: *What are the differences between low-performing and high-performing groups in their strategies to understand a geographical mystery?*

2. Method

2.1 Participants

The participants were students of twelve classrooms of six secondary schools in the Netherlands. Three schools were located in the highly urbanised western region of the country (in Hilversum, Gouda and Rotterdam) and three in less urbanised regions (one in Hoorn, in the north-western region, and the two other schools were located in Goes and Middelharnis, in the south-western region). Twelve professional geography teachers were involved in the research project. A total of 35 groups of three students, 15 to 17-year-olds, in upper secondary education were observed working collaboratively on the mystery. Twelve of these 35 groups were analysed on their strategies for understanding a mystery.

2.2 The mystery

The mystery was designed for students in upper secondary education by the first Author, based on information about severe landslides in Rio in spring 2010. The mystery presents Fabio Pereira, a favela dweller, who was offered a new dwelling on the outskirts of Rio by the government because his neighbourhood was hit by severe landslides in 2010. The mayor had ordered the most threatened favelas to be removed for the safety of the residents. However, Fabio refused to move. The mystery question was why Fabio Pereira refused to move from his threatened house to a safer apartment offered to him by the government. The mystery strips contained information on: Fabio's house that was built by his father thirty years ago; the strong bonds in the migrant community of his neighbourhood, the central location of his present neighbourhood and the peripheral location of the new apartment offered; the high real estate prices in the central city; projects to build luxury apartments in parts of the city where the government had also removed favelas for safety reasons; the start of the rehousing very shortly after the landslides and without consulting the inhabitants; the approaching football World Cup and Olympics in Rio; and Rio as a tourist city. With the help of this information, students had to analyse the geography and society of Rio in order to answer the mystery question. The most important inference students had to make from the data strips was Fabio's distrust of government intentions with regard to the rehousing plan, because his neighbourhood could easily be transformed into a more profitable part of the city. Thus, the assignment focused mainly on vertical relationships within the region.

All 35 groups had to construct a concept map of their explanation of the mystery, because a concept map provides not only a representation of the relational thinking of students (Mehren et al., 2018; Shavelson et al., 2005), but collaborative concept mapping also has the potential to elicit reasoning on relationships (van Boxtel et al., 2002). The concepts had to be connected by labelled arrows to establish propositions (two concepts connected by a labelled arrow). The students had to formulate the concepts by themselves. Each arrow in the diagram had to represent a causal relationship between two concepts.

2.3 Data collection and analysis

The 35 groups worked outside class and all of the group work was recorded with a video camera. No time constraints were set on the group work. Most groups finished their work in about 60 minutes. To determine their level of performance, each group's discussion was verbally transcribed and analysed in conjunction with their concept map on established relationships. To investigate differences in strategies to explain the mystery, we observed the films of the group work of 12 selected groups.

2.3.1 Group performance

The transcriptions of the group discussion and the concept map of each of the 35 groups were both analysed for established correct *and* relevant propositions. We used a criterion map for this analysis. Each proposition was scored and a total score was obtained. A correct and relevant proposition scored two points, an incomplete or unclear proposition one point and incorrect or irrelevant propositions got zero

points. In this way a total proposition score was obtained for each group. For a detailed description of our coding system and the construction of the criterion map, we refer to Karkdijk et al. (2019b).

All propositions with a score of one or two points were represented ("standardised") in the format of the criterion map, to allow comparison of the structural complexity of the groups' explanations. Structural complexity was expressed as a level of the SOLO taxonomy of Biggs and Collis (1982), using the "standardised" concept maps and the transcriptions of the group discussions. In order to operationalise the taxonomy, we followed precisely the description of Biggs and Collis' SOLO taxonomy (1982) and Stimpsons' approach (1992) which corresponds with Biggs and Collis' description. Following Biggs and Collis, we also used transitional levels (see Table 1). For a detailed description of our operationalisation of the SOLO levels, see Karkdijk et al. (2019a).

Level nr	SOLO level
1	Uni-structural U
2	Transitional U/M
3	Multi-structural M
4	Transitional M/R
5	Relational R
6	Transitional R/EA
7	Extended abstract EA

Table 1. SOLO levels used in this study. Source: Authors' elaboration.

2.3.2 Selection of 12 student groups

We decided to compare the strategies of the groups with the lowest proposition scores with those of the groups with the highest proposition scores. Lowest and highest proposition scores were defined as one standard deviation or more from the mean (20.8). Because of the skewed distribution of the scores, we had to add one group in the highest category (with a standard deviation of 0.9342) in order to compare the same number of groups. As can be seen in Table 2, groups with the lowest proposition scores (the first six groups) also had SOLO levels up to the multi-structural level, indicating that their explanations of the mystery consisted of isolated relationships. The groups with the highest proposition scores (the last six groups) had outcomes on the relational level or higher, indicating a coherent explanation consisting of interrelationships.

2.3.3 Strategies employed by groups

In this study, we defined strategies as the acts of the groups in their group work as they tried to understand the mystery. We used Leat and Nicols' stages (2000) for the analysis of these acts to explain the mystery (see Tables 2-5), because they were clearly recognisable, although each particular group had its own sequence in the progress of the group work. We did not operationalise the abstract stage, because all groups started the construction of the concept map immediately after finishing the physical manipulation of the strips.

Concerning the *display stage*, the strategies for reading the strips and familiarising themselves with the data were analysed. How they organised the reading of the strips was important, because it may have meant that not all group members familiarised themselves with all strips, with the result that individual members started with incomplete information. The different strategies for organising the display stage will be described and discussed in the Findings.

Concerning the strategies employed in the *setting stage*, we first observed whether a group started with a priori categories to form sets or whether the categories came from the information provided. In the first case there could be a risk of blinding themselves with an a priori categorisation through which the data were interpreted. Second, we focused on the joint categorisation of the strips into sets as an indication of the level of collaboration. Had the

sets been determined by all members or did individual members form sets for themselves without discussing it with the others? If the latter concerned a single set while all other sets had been determined collaboratively, we categorised this as "almost". Third, we analysed whether all group members were aware of the distribution of the strips among the sets. If not, some group members would have incomplete information about the content of the sets (for example in the reject pile). If this was the case with one to five strips (less than twenty per cent of all strips), we categorised this as "almost". Fourth, we looked at the size of the reject pile. The number of strips in the reject pile varied in the course of the group work. We decided to count the number of strips in the reject pile when the groups had finished the setting stage, because this meant that they were not available in the most important part of the relational thinking process.

Leat and Nicols' describe the *sequencing and webbing stage* as a separate stage, where groups employ a relating strategy in order to find a solution to the mystery problem. We defined the relating strategy as the thinking strategy of the group, when they decided how to connect strips in order to find an answer to the mystery question. Most of the time it was possible to discern a stage in the group work after the categorisation of the strips where the group members were clearly focused on establishing connections between sets or between individual strips of sets. However, already in the setting stage, or sometimes right from the start, comments were often made by group members about how to connect the strips. We therefore decided to take into account the whole group work to characterise the relating strategies. Because the categories to characterise the relating strategies emerged from the analysis, they will be described and discussed in the Findings.

We operationalised the *reworking stage* as the stage before the construction of the concept map, where the group decided to reorganise the established relationships between strips, and to use strips from the reject pile in order to gain a better understanding of the mystery. This stage was easily recognised, because students announced the stage verbally (e.g. "we have to do it differently" or "we have to look at the reject pile again for useful strips") and acted by reconsidering the reject pile and modifying some or all sets. Sometimes the reworking remained modest, when strips were moved from one set to another and strips from the reject pile were included. In other cases, the reworking was more radical, when two or more new sets were established or two or more sets were removed.

The second Author acting as a second rater observed four groups on their relating strategy, the most subjective and complex part of the analysis. The results of the analysis were consistent with those of the first rater.

3. Findings

First, we describe the differences in strategies employed in the different stages by the twelve selected research groups, as represented in Tables 2-5. Second, we present case studies of two groups to illustrate their reasoning processes and their relating strategies as they tried to understand the mystery.

3.1 Differences in strategies

3.1.1 The display stage

As can be seen in Table 2, we observed two main strategies for reading the strips and familiarising themselves with the data: 1) the strips were divided between group members who read them individually; 2) the strips were spread out on the table to be read by all. Groups that used the first strategy risked group members continuing the group work with incomplete information, especially if the reading was done in silence, as was the case in groups 40 and 34. This could be a hindrance for understanding. However, one group with good results (34) also used this strategy. Moreover, although not all strips had been read, Table 2 shows that most groups embarked on a discussion of the information provided right from the start and that low- and high-performing groups had nearly similar strategies in the display stage.

Group No.	Total proposition score	SOLO level	Strategies in the display stage		
			Strips divided between group members to be read individually	Strips spread out on the table to be read by all	Group discussion while reading strips
Low-performing groups					
22	8	3	x		x
24	9	3		x	x
40	9	2	x		
39	10	3		x	x
12	11	2		x	x
66	11	3		x	x
High-performing groups					
34	30	5	x		
65	32	5		x	x
33	35	5		x	x
41	36	5		x	x
18	37	5		x	x
16	49	6		x	x

Table 2. Differences in strategies in the display stage. Source: Authors' elaboration.

Group No.	Strategies in the setting stage						
	Were the categories made and imposed on data a priori?		Were all (sub)sets designed by all?		Were all strips assigned to a (sub)set by all?		Reject pile
	Yes, but (later) also from data	No, all from data	No	Almost/ yes	No	Almost/ yes	Number of strips
Low-performing groups							
22	x			x	x		9
24	x			x	x		11
40		x		x	x		7
39		x		x	x		4
12	x			x	x		2
66	x			x	x		9
High-performing groups							
34	x			x	x		3
65		x		x	x		0
33		x		x	x		0
41		x		x		x	5
18	x			x		x	7
16	x			x		x	0

Table 3. Differences in strategies in the setting stage. Source: Authors' elaboration.

3.1.2 The setting stage

Table 3 reveals no major differences between low- and high-performing groups in their strategies for organising the setting stage. Most groups started with a priori categories to form sets, for example the categories "useless" or "not useless"; or used the economic, political and physical dimensions as a priori categories, but all groups also used the data for categorisation. In all groups the categories and resulting sets were determined jointly, but in most groups not all group members knew all the strips a set contained. However, the three highest performing groups showed a higher level of collaboration and communication: each member was aware of all strips in each set. On average, the reject piles of the low-performing groups were somewhat higher than those of the high-performing groups. The three high-performing groups were able to include all strips in their explanation.

Group No.	Relating strategies in the sequencing and webbing stage and in the other stages			
	Looking for a logical/chronological chain of events	Reasoning from categories	Relating separate strips one by one to Fabio's decision	Webbing
Low-performing groups				
22		x	x	x (very limited)
24		x	x	x (limited)
40	x		x	x (very limited)
39	x	x	x	x (very limited)
12	x		x	x (limited)
66	x		x	x (limited)
High-performing groups				
34				x (main)
65	x			x (main)
33				x (main)
41			x	x (main)
18			x	x (main)
16				x (main)

Table 4. Differences in relating strategies. Source: Authors' elaboration.

3.1.3 Sequencing and webbing stage: four relating strategies

The major difference between low- and high-performing groups was in their relating strategies (Table 4), observed not only in the sequencing and webbing stage, but also in the other stages (see Method). We observed four relating strategies that were employed to understand Fabio's decision to stay in his threatened house: *1) looking for a logical and/or chronological chain of events; 2) reasoning from categories; 3) relating separate strips one by one to Fabio's decision; and 4) establishing causal relationships between the strips, the webbing strategy.*

Groups that were *looking for a logical and/or chronological chain of events* tried to reconstruct the story of the landslides in Rio and the events that happened in Fabio's life. They usually made a sequence of the strips and tried to tell the story in order to understand the question of the mystery. Students argued that if the strips are ordered so that you know what happened first, next and last, as well as the logical consequences of these events, you would be able to understand the significance of the individual strips, Fabio's circumstances, and his decision.

The strategy *reasoning from categories* meant that after the group had made categories and formed sets, these sets became the

organisational frame for their relational thinking. For example, they could try to summarise the information of all strips within a set in one sentence and then to relate these summarising sentences, or to reason about relationships between the strips within a set or about relationships between sets.

Trying to understand the mystery by *relating separate strips one by one to Fabio's decision* was observed when groups tried to understand the significance of each separate strip to the decision Fabio took. For example, Fabio's house being built by his father thirty years ago was easily connected to Fabio's decision. However, this method was not easily applicable to most strips, for instance to the strips containing information that Rio has very high land values and real estate prices. These kinds of strips were labelled as irrelevant by the groups that used this strategy.

Groups that looked for causal relationships between strips before answering the mystery question, the *webbing* strategy, tried to understand the geography and society of Rio with the aid of connections between multiple strips. For example, connecting strips with information on the location of Fabio's present house near the centre of Rio, the location of his new apartment offered by the government on the outskirts of Rio, the long and costly distance between this new apartment and Rio's city centre, and the high land values in Rio gave a group insight into the significance of location in Rio. This insight, connected with luxury apartments being built on formerly released areas near the city centre, explained Fabio's distrust in the government which could have intentions other than helping poor favela residents. In fact, the webbing strategy meant postponing answering the mystery question until a satisfying understanding of the regional and personal situation had been reached.

Table 4 shows that all high-performing groups used the webbing strategy as their main strategy while low-performing groups used the other strategies but hardly employed the webbing strategy. In some low-performing groups, there was almost no webbing to observe; we categorised this as "very limited". Other low-performing groups started off well in webbing but for various reasons they did not continue. In these cases, we categorised the webbing strategy as "limited". Sometimes webbing was hindered by the many strips in the reject pile (groups 22, 24 and 66) and/or by the strategy of reasoning from categories (group 24). In the latter case, relating was limited to strips within a set or to relationships between sets. Consequently, free linking between individual strips was partly blocked. In other low-performing groups webbing was hindered as a result of poor communication between students (groups 12 and 66) or very low concentration (group 12).

Table 4 also shows that low-performing groups used more strategies than high-performing groups. Three high-performing groups only used webbing. Groups (65, 41 and 18) started with another strategy, but turned to the webbing of individual strips to understand the society and (political) geography of Rio.

3.1.4 The reworking stage

Table 5 shows that four low-performing groups used a *reworking stage*, in order to increase their understanding. Only one high-performing group reworked their arrangement of strips.

Group No.	Strategies in the reworking stage		
	Did the group rework the data before constructing the concept map?		
	No	Yes, modest	Yes, radical
Low-performing groups			
22	x		
24		x	
40	x		
39			x
12			x
66		x	
High-performing groups			
34	x		
65	x		
33	x		
41	x		
18		x	
16	x		

Table 5. Differences in the reworking stage. Source: Authors' elaboration.

3.2 Relating strategies presented: two case studies

In this section case studies present the relating strategies and the reasoning process of a low-performing group (40) and a high-performing group (65). The strategies and reasoning process are illustrated by excerpts from the group discussion. Each excerpt is preceded by a description of the relevant part of the group work and some comments on the utterances within the excerpt.

3.2.1 Group 40

This was a group of two boys and one girl, 15/16-year-olds. After the strips were spread out on the table, they decided that each group member would read one third of the strips in silence. After the reading, student 1 proposed that they make a logical order of the strips (lines 56 and 65). When student 2 proposed that they find out which strips provided good reasons for Fabio to stay first (lines 60 and 68), she was corrected by student 1 (lines 61 and 69). Thus, at the start of the discussion, the strategy "relating individual strips one by one to Fabio's decision" was rejected in favour of the strategy "looking for a logical and/or chronological chain of events".

56	S1	Well, order it in a way that seems logical to you.
57	S3	I think it starts with this one.
58	S1	I think it starts with strip number one.
59	S3	I don't think so. The question is about him, so it would make sense if it starts with this and then carries on saying.
60	S2	I would also consider this one.. This is also a good reason why he just needs to leave, I think.
61	S1	Yes, needs to leave, but just start with the beginning. Because why is it said...? Then this would be a good start.
(…)		
65	S1	Yes, shall we have a look at which ones we can put in order then?
66	S2	Yeah
67	S3	I think we should … that one….
68	S2	Yes, or just take the cards which have good reasons, according to us.
69	S1	What do you mean, reasons? Shouldn't you first find the correct order so that you know what is going on and then focus on the reason. Because you can pick the reasons why the school is closed but you do not know that he has four children.
70	S2	Right, that makes sense.

They then started with a chronological order of strips that contained a date or a time indication. The other strips were checked one by one to find out whether they contained a reason for Fabio not to move. Collaborative reasoning on the meaning of the strips or their relationship with other strips (the webbing strategy) was very limited. A promising start connecting tourism in Rio and the distance of Fabio's new apartment on the outskirts of Rio to the city centre, was immediately ended by a lack of insight into the location of Fabio's house (lines 120-124), caused by a superficial or partial reading of the strips. Separate strips judged as useless were put in the reject pile without any discussion (lines 127-131). The strategy "relating individual strips one by one to Fabio's decision" was therefore used alongside the strategy of looking for a chain of events.

120	S2	Well, perhaps with that important tourist city because that way he might have more income.
121	S1	Yes, but he lives in Morro dos Prazeres, right?
122	S2	No, he lives in Rio.
123	S3	No, he lives in Rio, but Rio is big. They use that name for parts of Rio, I thought.
124	S2	Ah all those names. I'm getting so confused. So, where does he live? In Morro dos…
125	S1	Morro dos Prazeres, that's where he lives. He's got his house there. That's probably just a part of Rio.
126	S2	Okay.
127	S3	Fucking film, man. I really don't

need that.

128 S1 Calm down, man.

129 S3 This is about the film. This one should be included as to why he wants to leave.

130 S2 City of God… This has got nothing to do with the topic. (incomprehensible)

131 S3 This should also be included, I think. Why he needs to leave. This has got nothing to do with it. Nor this one. This is about travelling.

Their lack of insight into the location of Fabio's current house and the location of the new apartment also led them to draw wrong conclusions. For example: student 3 reasoned that Fabio had to move to the northeast of Brazil (line 282). However, he was corrected by student 1, who had read a strip with information on Fabio's new apartment on the outskirts of Rio (line 291). Student 3 checked the reject pile and re-used the strip with information on the long distance between the outskirts of Rio and its city centre (line 295). They added this as an argument for Fabio to the causal diagram already under construction (line 298).

282 S3 Look, northeast Brazil is an area gripped by drought, poor soil and unemployment. So they need to leave somewhere, go somewhere, but the place he needs to go to still has poor soil and unemployment.

283 S1 Where do you see that?

284 S3 Six, it is only less dangerous.

285 S1 But northeast Brazil is the place he comes from.

286 S3 No way is he going to live 100 kilometres away.

287 S1 Yes, but he is from northeast Brazil. That's probably why he has left there.

288 S3 Yeah, and he will also move to another place in northeast Brazil, I think. Do you know how much money it costs to move everyone to another place?

289 S1 Is that what you think or what you know?

290 S3 Logical thinking.

291 S1 I think it would make more sense to eh… People will be accommodated in several flat areas close to the outskirts of town. Which happens to be written here.
(…)

295 S3 This is also a good reason: from the outskirts, from Rio's city centre, it's an hour's drive.

296 S1 Yes, good one.

297 S3 Lots of travelling to the city centre.

298 S2 Alright, I'll start a new one then, okay? Yes, long distance to travel to the city centre.

This group work was characterised by two strategies to find an answer to the mystery question: making a chain of events and trying to relate separate strips one by one to Fabio's decision to stay. The discussion shows an almost total absence of collaborative reasoning. Relating strips to one another in order to understand the geography and society of Rio (webbing), was almost completely absent. As a result, their total proposition score was relatively low (8) and their causal diagram was on the multi-structural level with only minimal explanation (Figure 1).

3.2.2 Group 65

Group 65 consisted of three boys aged 16/17 years old. The group started by spreading out the strips on the table. Although the students read the strips individually, they discussed nearly all of them together. Right from the start they focused on relationships between strips, the webbing strategy, (lines 6, 8), as well as possible connections between several individual separate strips and Fabio's decision (line 3).

1 S2 Let's just start with card 1.

2 S3 Yes, that doesn't really matter.

3 S2 This just says that it is hit by heavy rainfall; that doesn't seem like a valid reason to me.

4 S1 Because of the heaviest rainfall.

5 S3 Yes, that's just information, that is just information.
6 S2 You could say, for instance, that this is the cause, and as a result, all those can.
7 S3 The government commands…
8 S1 Yeah, you have to make the right connections between those.

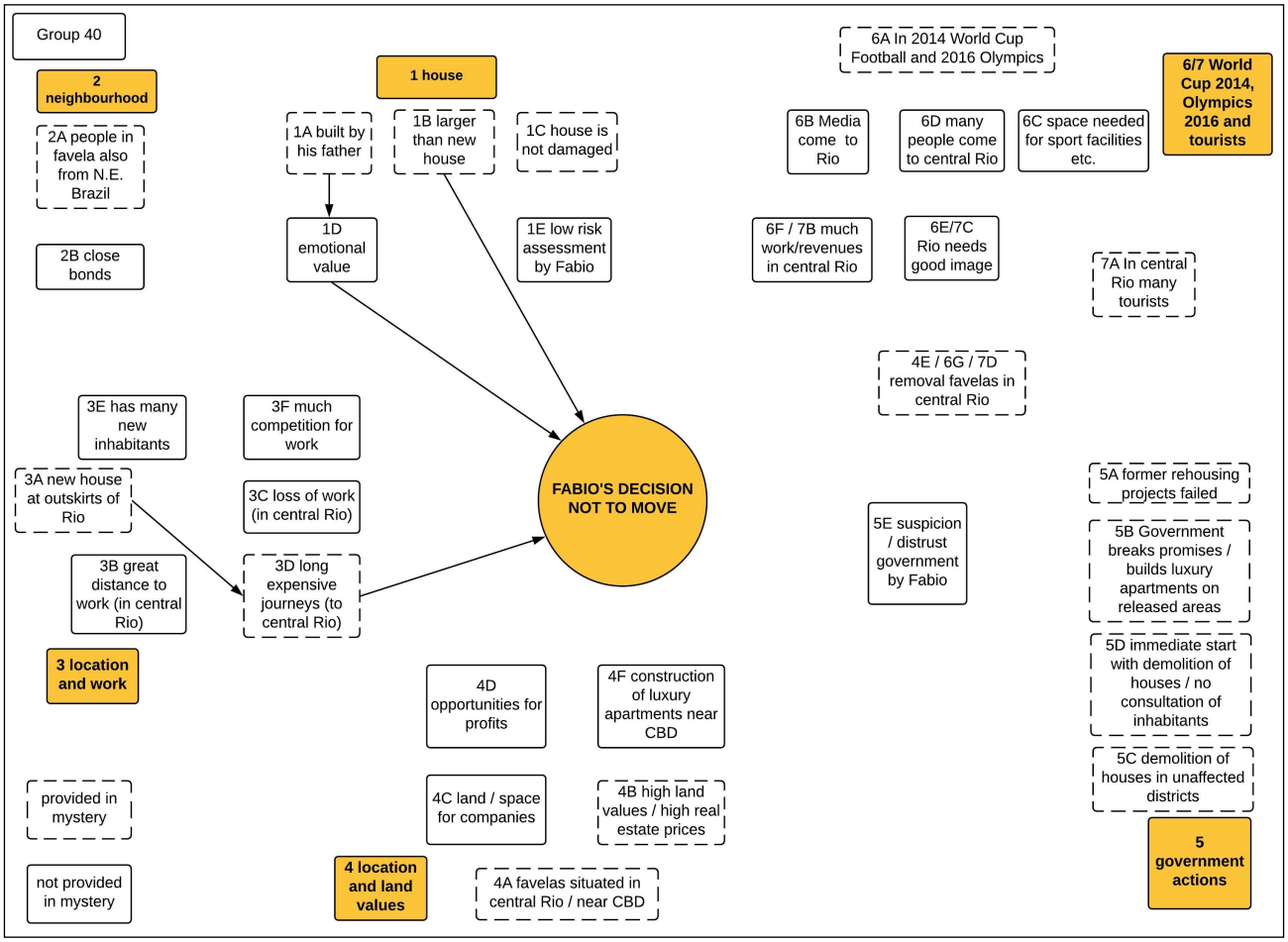

Figure 1. Standardised concept map of group 40. Source: Authors' elaboration.

Within two minutes extensive collaborative reasoning characterised the discussion (lines 33-44). The connection of two strips lead to the inference that the government is not trustworthy: favela dwellers will simply be driven out for the building of luxury apartments (lines 41-44). The webbing strategy had become the dominant one.

33 S1 The mayor wants to plant forests on the released demolition site.
34 S1 Because of the forest, landslides will be less likely to occur, leaving the soil a little firmer.
35 S3 Yes, that's true.
36 S2 But that will only happen after everything has been planted.
37 S1 And that takes quite long, because those forests still need to grow.
38 S2 Yeah, that's written here as well, in 1982, such a village was cleared, because of a serious risk.
39 S3 And did that turn out well?
40 S2 It doesn't really mention whether it was successful.
41 S1 Look check this one: Some years ago, at several "extremely dangerous" sites, favelas were

		removed by the government and replaced with high-rise towers with luxurious apartments.
42	S2	Instead of planting forests. They just removed them! Yes.
43	S3	So, you really cannot always believe them.
44	S1	No.

After that (third minute), they continued the webbing by adding new strips to this connection:

54	S1	The demolition has already started here, while any eh… landslides had not even happened yet.
55	S2	So, in fact, it is just another, um… they just got another destination.
56	S3	Yes.
57	S2	That has to do with those luxurious apartments then.
58	S1	Botafogo is a small favela, south of Rio, in which no house has been destroyed (while the demolition has already started there).
59	S3	It could also be an excuse, he should know.
60	S2	That has to do with those apartments.
61	S1	Yes.

A few minutes later, this web was again further expanded:

110	S3	Land and real estate prices in Rio are among the highest in the world.
111	S2	Yes, that does match with those luxurious apartments.

These excerpts are a good illustration of what is meant by webbing. Although at the start the students also tried to connect strips directly and in a linear manner to Fabio's decision, their focus in the display stage was already primarily on establishing relationships between strips.

After all strips had been read and discussed, the webbing continued. Sentences that contain linking expressions are noteworthy (lines 231, 233, 235, 241).

231	S2	Yes, ah, you could add this to that one then. The mayor says he wants to plant forests on the released demolition site. Yes.
232	S1	Says. But then things will be built.
233	S2	Yes, you could, for instance, connect that to this one, those high housing prices, he had wanted to build luxurious apartments. Yes, that's what he says.
234	S1	So that can be placed here.
	S3	But I thought that, on one occasion, it didn't happen right? Uhm, he'd lied or something, that there wouldn't be a forest after all.
235	S1	This one should also be added here somewhere, that they'd already started demolishing, without having seen any landslides. That has got to do with it as well. That the government just wanted to build and all.
236	S3	Yes.
237	S3	Yeah, residential towers have been built as well.
238	S3	That is in the government's interest.
239	S2	False promises had been made and, in fact, they just earned a lot of money.
240	S3	In 2014, the Football World Cup final was played in Rio and, in 2016, Rio will host the Olympic Games.
241	S2	Yes, here: Rio is the most important tourist city in Brazil, so we can connect that to this one yeah.
242	S3	They want to make their city look good.

After 18 minutes' work, they had formulated their main conclusion, based on their understanding of what is happening in Rio (line 269):

265	S2	But we haven't really drawn a conclusion as to why he wanted

to stay there so much.

266 S3 Yeah, maybe because he just doesn't trust the government.

267 S2 Yes, that more or less sums it up, I think… reading all this text over here.

268 S1 Yeah, that seems to be our main… He

269 S3 Because he obviously knows his city, and he knows what has happened.

Group 65 was characterised by highly concentrated, collaborative reasoning by all three group members. Clearly focused on causal relationships, their understanding of the society and political geography of Rio grew as the group's work continued (line 269). Their total proposition score was 32 and their causal diagram was on the relational level (Figure 2).

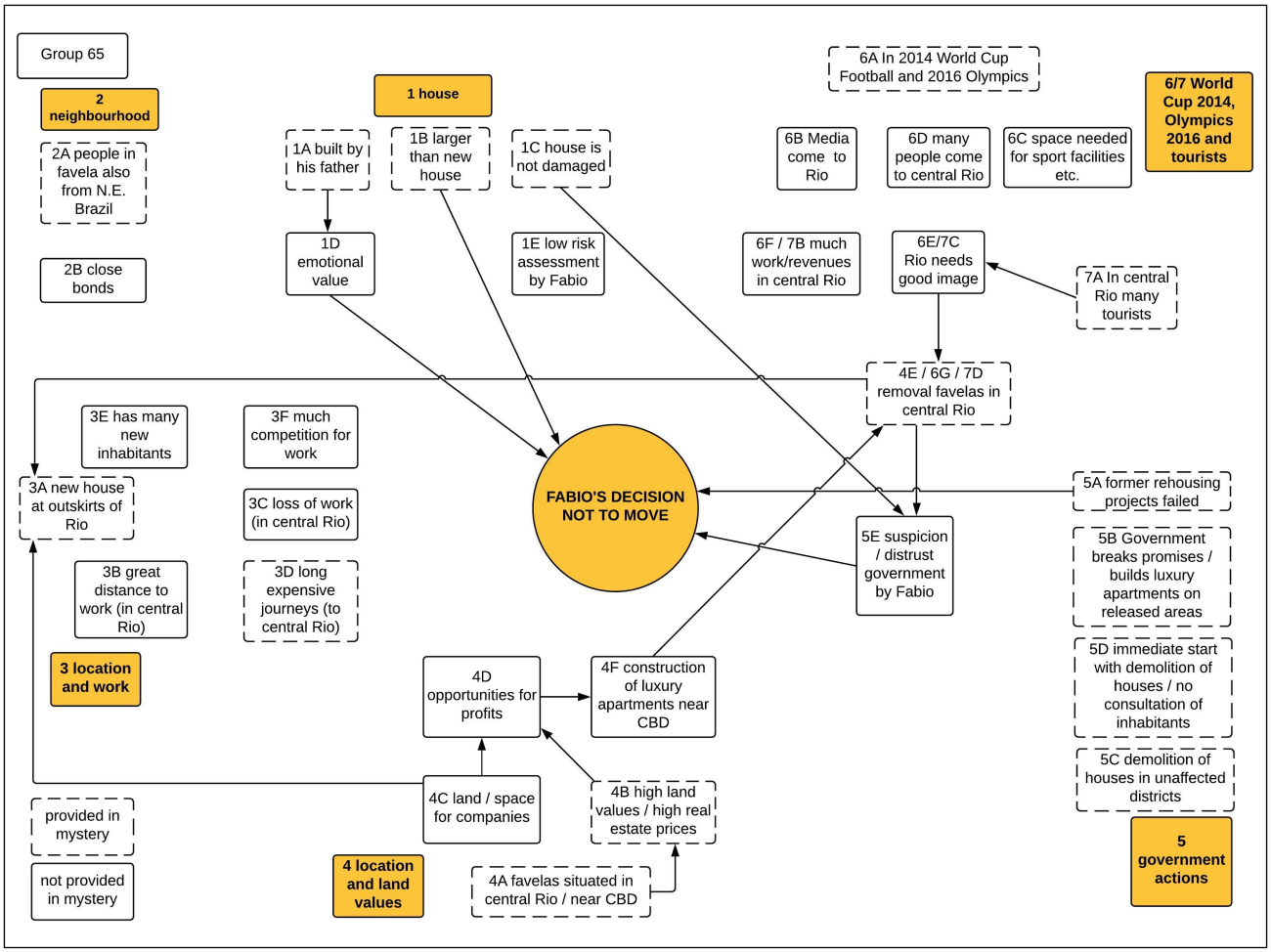

Figure 2. Standardised concept map of group 65. Source: Authors' elaboration.

4. Discussion

In this qualitative research we analysed which strategies low-performing and high-performing groups employed to tackle a geographical mystery. Our major finding was that low-performing and high-performing groups differed in the relating strategies they employed. Whereas low-performing groups used two or more of the relating strategies: looking for a logical and/or chronological chain of events, reasoning from categories and relating separate strips one by one to Fabio's decision and used

the webbing strategy hardly at all, high-performing groups used the webbing strategy as their main strategy. This suggests webbing to be the most promising relating strategy for understanding the multi-causal character of the mystery. In this mystery landslides and their devastating impact on favelas were triggers, while the interrelations between political, economic and personal/emotional factors acted as background factors that had to be analysed in conjunction with each other. Webbing involves postponing the answer to the mystery question and first searching for causal relationships between the strips in order to understand the interconnections between these background factors. As a student from the best-performing group (16) said after they analysed the mystery: "In my head the relationships look like a spider's web". The three other relational strategies had serious flaws when it came to analysing the mystery thoroughly. Relating separate strips directly to Fabio's decision could not lead to a comprehensive explanation, because only a few simple causalities could be found in this way. Making a chronological sequence of events, thus trying to tell the story of what happened to Fabio, also produced disappointing results, because Fabio's story and the landslides were only a story-line in the mystery, while most background factors could not be organised as a chain of events. Finally, categorisation and forming sets was helpful to get an overview of the information provided, but when students continued their thinking with the resulting sets, the risk of blinding themselves was obvious. Thinking in relationships between strips within sets or in relationships between sets hindered webbing between strips of different sets, necessary for the discovery of important causalities. In contrast to the observations of Leat and Nichols (2000), low-performing groups reworked their findings more often than high-performing groups did. They had to do this because of the disappointing results of their discussion so far.

Our findings on differences between low- and high-performing groups in their relating strategies and standardised concept maps (Figures 1 and 2) suggest a resemblance with the three-stage competence model in systems thinking of Mehren et al. (2018). At the lowest competence level, the mystery was explained with mono-causal relationships or short linear relationships by trying to connect separate strips directly to Fabio's decision. At a somewhat higher competence level, linear thinking became more predominant as students tried to make a logical and/or chronological thinking line, a chain of events, or gave separate linear causal explanations using sets. The highest competence level was reached by groups that identified networked elements and relationships by using the webbing strategy.

The suggestion of Leat and Nichols (2000) that the move from the setting to the sequencing and webbing stage resembles a progression from the multi-structural SOLO level to the relational SOLO level is debatable. Most of our observed groups reached the sequencing and webbing stage, but not all had an answer on the relational SOLO level. For in the sequencing and webbing stage, a group can make a chain of events (sequencing) or can make connections only within or between sets, relating strategies that will result in a response on the uni-structural or the multi-structural SOLO level. Only a webbing strategy used in this stage will result in a coherent answer on the relational level.

4.1 Implications

Our analysis of relating strategies revealed the difficulties that low-performing groups had with complex relational thinking in geography: they did not know how to tackle a multi-causal problem. This indicates the need for explicit attention to be paid to relating strategies when setting assignments that, like mysteries, ask for multi-causal thinking. A teacher could give a hint to a group which is stuck to reconsider their relating strategy. Another possibility would be to ask the groups to explain their chosen relating strategy when they present their solutions in a whole-class debriefing. In discussions with students that employed other strategies, a comparison of the relative effectiveness of the strategies could be made and hopefully a more promising relating strategy would then be revealed to students in low-performing groups.

We also recommend the frequent use in geography lessons of assignments that focus on

multi-causal, complex reasoning, like mysteries, thinking with scenarios, simulation games on climate change or water management, etc. This could deliver a "systems disposition" on the part of students. DeVane et al. (2010) state that "given the right scaffolding and structure in a learning community, participants (…) can develop a "systems disposition" towards different problem contexts. Such a disposition is not a universal heuristic for inquiry (…), but it is a set of attitudes toward systems" (p. 15). Although assignments may be quite different in terms of theme or region, students would be inclined to look for coherence, interconnections, networked relationships. The additional use of concept maps or causal diagrams as representational tools can be very fruitful in fostering complex, multicausal thinking (Cox et al., 2018).

4.2 Limitations

This paper describes our observations of the strategies of only 12 groups as they tackled a geographical mystery. We found four different relating strategies and suggest a correlation with the level of group performance. More evidence is needed to support these suggestions.

Our finding that the three best groups demonstrated good communication and collaboration and our observation of poor communication in several low-performing groups indicate that communication could also be a relevant difference between high- and low-performing groups. However, this was beyond the scope of this study.

5. Conclusion

Teaching geography with a clear focus on the analysis of complex regional problems and change offers students the necessary understanding of the relational character of people's lives in specific places of the world. A regular use of complex, multi-causal assignments in geography lessons and explicit attention to students' relating strategies could be useful in helping students to develop an attitude, an inclination to look for the relationships between different dimensions and scales of a regional problem. Such a "systems disposition" could help them to avoid jumping to quick, mono-causal conclusions on complicated regional problems and to look first for a deeper, relational understanding. This makes secondary geography worth teaching.

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