Young People's Map Reading Skills in Flanders: What is the Status?

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Abstract. A user study was conducted during which pupils' (12 -18 year old) and students' (> 18 year old) map reading skills were evaluated. During the test they had to solve 20 questions within a certain time limit using five topographic map samples. The questions varied in complexity, map reading tasks and thinking skills that had to be addressed. It was found that students outperformed pupils. The results of this latter group were influenced by their age and familiarity of the region (which is not the case for the students). Furthermore, female pupils seem to experience a negative effect from the time limit. The overall results were dependent on the complexity of the task and specific symbol knowledge.

Keywords: cartography, map reading, young people

1. Introduction

1.1. Map reading and map literacy

Understanding the meaning of symbols and signs requires some kind of education. According to Gerber (1984), one can use a person's ability to understand cartographic signs to measure his competence in cartographic language. Ikonovic (2001) and Phillips (1989) stressed the need for education regarding learning to read maps (and other graphic displays). In this context, individuals who cannot understand these symbols (and thus maps), can be considered as functional map illiterate (Clarke 2003, 2014). This is also closely linked to the concept of spatial literacy as described by van der Merwe (2009). Clarke (2003, 2014) stated that map literacy is not well understood yet but that it is narrowly connected with literacy (the ability to read and write) and numeracy (the ability to calculate). He defined three levels of competence concerning map literacy, which are associated with the main (subsequent) map use activities as presented by Muehrcke

and Muehrcke (1978) and Kimerling et al. (2009): map reading, map analysis and map interpretation. Nonetheless, other authors used a different subdivision in the subsequent map use activities. Keates (1996), for example, described the map reading process as the detection of symbols; discrimination of symbols; understanding of the symbols' meaning; recognition of symbols; interpretation (adding meaning to it); retaining relationships. Board (1978) identified three main groups of map reading tasks, which should all be addressed in order to effectively evaluate map reading skills: navigation, measurement and visualization.

1.2. Research on Education in Cartography

Most research on education in cartography focused on children (<12 years old) (e.g. Newcombe & Liben 1982; Liben & Downs 1992; Filippakopoulou et al. 1998; Filippakopoulou et al. 2000; Bandrova & Vasilev 2008; Liben 2009). Wiegand and Tait (1999) investigated the use of a software mapping tool in the cartographic education of children in the age span 11-14 years. Another group of researchers focused on the education and training of cartographers at universities (age >18) (Meissner 2003). Other authors discussed the changes that have taken place in the cartographic discipline in higher education during the past decades (Beard et al. 1993; Zentai 2009; Fraser et al. 2011). Nevertheless, few studies focused on the cartographic education of pupils between the age of 12-18 years. It is important however to know how well these pupils are able to read maps, especially in the light of the increasing popularity of cartographic products.

2. Study Design

2.1. Participants

In total, 528 participants took part in the user study: 252 males, 270 females and 6 persons who did not indicate their gender. From this pool of participants, 402 of them were pupils in secondary education and 126 studied at the Department of Geography, Ghent University (Belgium).

2.2. The Experiment's Documents

Every participant received the same set of documents, consisting out of an introduction, a bundle of maps, a bundle of questions related to the maps and a questionnaire (see Figure 1). These documents will be explained in detail in the next paragraphs. All these documents were handed out to the participants at the beginning of the test. They were told to start reading the instructions on the introduction-document before looking at the other documents.

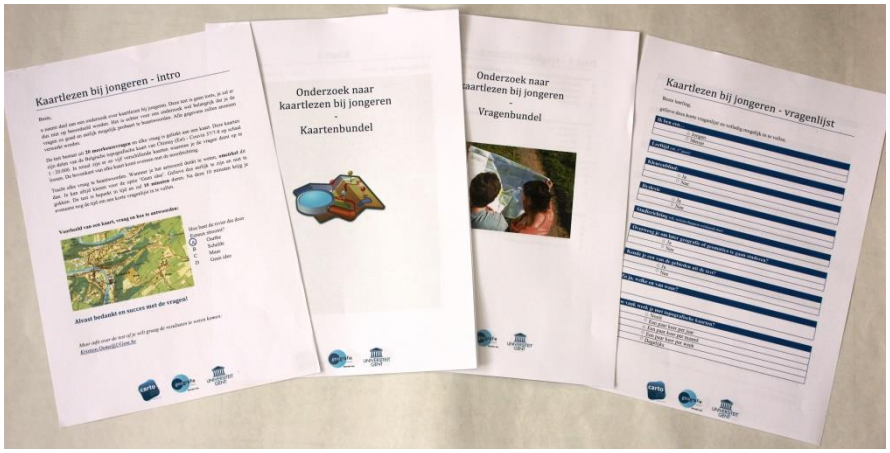

Figure 1. Docuents used during the experiment: introduction, bundle with maps, bundle with questions, post-study questionnaire

The **Introductory text** explained the structure of the questionnaire, the map samples that were used (including the scale) and the post-study questionnaire. Finally, the participants were instructed on how to answer a question correctly (draw a circle around the right answer) and informed that the study was limited in time: they only had 10 minutes to complete 20 questions. After the strict time limit, some additional time was foreseen to fill out the post-study questionnaire.

The **bundle with maps** (Figure 2) contained five topographic map samples, derived from the series on 1 : 20 000. Belgian topographic maps are produced on a national level, which means that all map sheets have the same layout and design (symbology), independent of which community they cover. These large-scale maps are sometimes used for assignments in classrooms, but also for leisure activities such as walking, cycling, locating points of interest and possibly in the context of youth club activities. In order to exclude a bias due to previous knowledge of the areas shown on the map, a map sheet located in the French community of Belgium was chosen: Chimay (Est)–Couvin 57/7-8. Five map samples were extracted at a scale of 1 : 30 000.

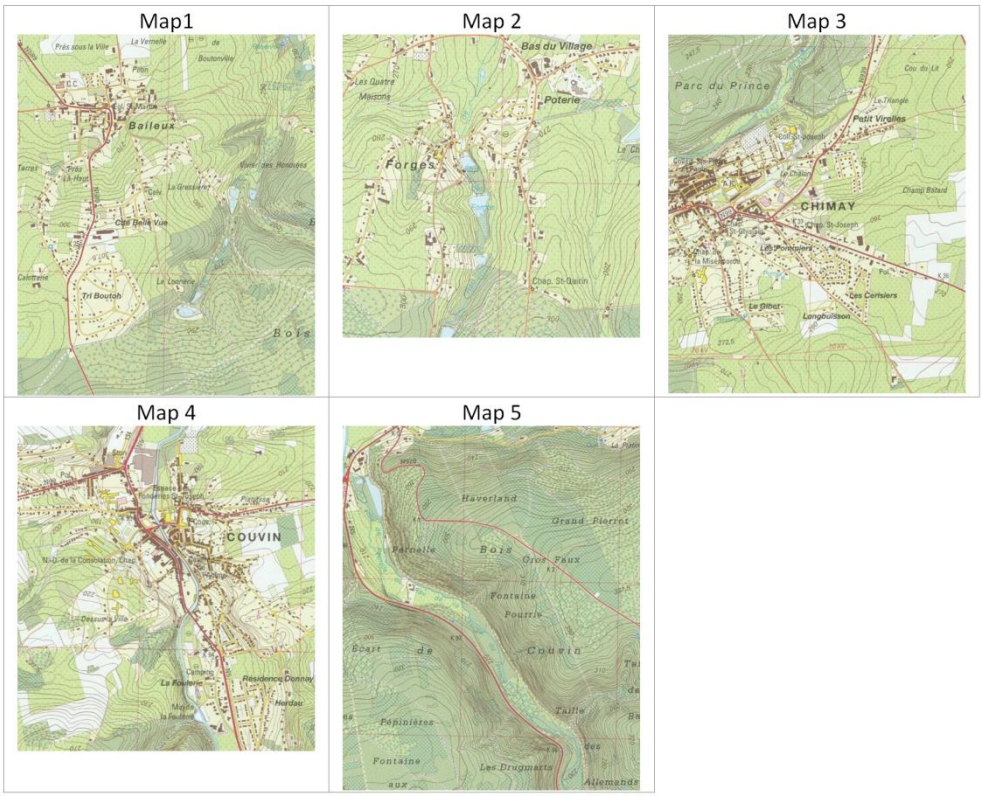

Figure 2. The five topographic map samples used during the experiment

The **bundle with questions** consisted out five pages. On each page – and thus related to each map – four multiple choice questions were listed. The questions listed four potential answers indicated with A to D. The last option (D) was always 'I don't know'. The questions were selected in a way that different map reading skills were tested, taking into account the specific characteristics of topographic maps, such as contour lines. All 20 questions were translated (from Dutch, the native language of the participants) and listed in Table 4 in the appendix. The related map reading task(s), according to Board (1978), is indicated below each question. Often, a combination sub-tasks was required to solve the question. These sub-tasks are also added in the table. For most questions, participants have to be able to recognize a symbol for a certain object. Nevertheless, recognizing a symbol for a church or campsite without a legend might be more straightforward, than for a public pool or supermarket. These latter type of (more difficult) symbols are indicated with an asterisk in sub-task lists.

In education, teachers use Bloom's Taxonomy (Bloom 1956) as a guide to assess on which level their assignments test the pupils thinking skills. This

taxonomy distinguishes between six subsequent levels of thinking skills, each with an increased level of difficulty: Remembering, Understanding, Applying, Analyzing, Evaluating, Creating. Some revisions have been proposed (e.g. Krathwohl 2002), but the structure still remained nearly the same over the years. What is more, the different levels in this (revised) Taxonomy correspond very well to the levels of competence presented by Muehrcke and Muehrcke (1978) and Kimerling et al. (2009) and the map reading process as described byKeates (1996). Therefore, we opted to apply the revised version taxonomy on the questionnaire to obtain insights in the (highest) level of thinking skills that participants should have addressed in order to be able to solve a certain question. The (highest) level of thinking skill that needed to be addressed to solve a questions is also added in Table 4.

A strict time limit of 10 minutes was placed on the completion of this questionnaire. This time limit was determined in the Master Thesis (Van der Veken 2013). With a limited time pupils would only be able to answer the questions they could solve easily. This way, the obtained results would be more pronounced regarding their acquired (map reading) skills. Second, the time limit makes the study more manageable and structured. This ensures that the study can be executed under the same conditions at different locations.

The **post-study questionnaire** consisted of two pages where participants had to fill out certain personal characteristics: age, gender, study, color blindness, dyslexia, familiarity with the maps and the regions, level of experience with topographic and digital maps, etc. (Nielsen 1993; Feeney 2003; Harrower & Brewer 2003; Jenny & Kelso 2007).

3. Results and Discussion

3.1. Scoring Systems

An overview of the scores of all participants on the 20 multiple-choice questions can be found in Table 1. The overall score is 56.52% or 49.85% depending on the scoring system (see last columns after map5/Q20). Due to the time limit, not all participants were able to complete the 20 questions. Consequently, two scoring systems are used. The first one compares the number of correct answers to the number of answers that were given (e.g. 301 correct answers out of 387 answers: 77.78% on Q20). The second one compares the number of correct answers to the number of participants (e.g. 301 correct answers from 528 participants: 57.01% on Q20).

	map 1				map 2				map 3			
	Q1	*Q2*	*Q3*	*Q4*	*Q5*	*Q6*	*Q7*	*Q8*	*Q9*	*Q10*	*Q11*	*Q12*
Avg S1	78.4	74.8	59.6	17.4	42.0	65.6	33.5	68.7	24.7	71.5	86.9	84.9
Avg S2	78.2	73.7	58.9	16.9	41.5	65.3	32.2	68.6	23.7	69.5	84.1	82.2

	map 4				map 5				
	Q13	*Q14*	*Q15*	*Q16*	*Q17*	*Q18*	*Q19*	*Q20*	
Avg S1	39.0	52.9	15.4	26.7	49.6	55.5	58.3	77.8	**56.5**
Avg S2	35.4	48.7	13.5	23.3	38.8	42.2	43.4	57.0	**49.9**

Table 1. Participants' scores (%) on each oft he questions in the two scoring systems

3.2. Influence of user characteristics

Table 2 presents an overview of the participants' response rate on the last question and their scores in the two systems, based on a number of characteristics: pupil (P) vs. student (S); male (M) vs. female (F); member of youth club (YC) or not (NYC); knew the area (KA) or not (NKA). The most striking difference is found between pupils and students, with a much better result for the students. However, this finding can be justified by a difference in age. Therefore, the results of scoring system 1 are set out in a scatterplot versus the age of the participant in Figure 3, with the addition of a general trend line for pupils and students separately. A break line between the results of the pupils and students is clearly visible. However, these characteristics should be further analysed in an integrated approach, as interaction between the different factors may occur.

	P	S	M	F	YC	NYC	KA	NKA
N	402	126	252	270	106	357	177	342
completed? (%)	71.64	79.20	71.71	75.56	75.47	74.23	75.14	73.10
avg_score1 (%)	47.65	74.36	57.19	51.38	57.54	53.66	59.72	51.38
avg_score2 (%)	43.74	69.88	52.33	47.78	53.58	49.69	55.14	47.41

Table 2. Participants' scores related to their characteristics

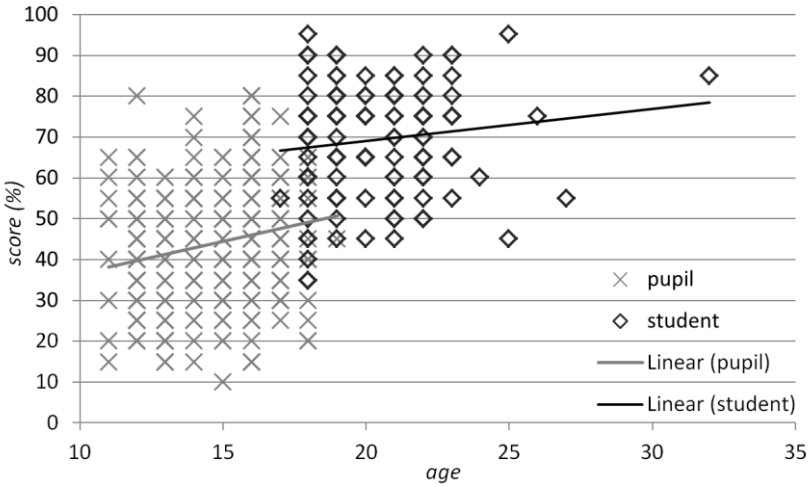

Figure 3. Scatterplot showing the pupils‘ and students‘ scores related to their age

Table 3 below shows the outcome of the ANOVA test for the pupils when all characteristics listed in Table 3 are considered (including interaction terms). This test was repeated for the two scoring systems. Only the factors and interaction terms which are linked to a significant value (P) are presented in the final model listed in Table 3. For the pupils, on the one hand, only the factors age, gender and known areas (KA) had a significant influence on their scores in the first scoring system (score1). When using the second scoring system (score2), the factor gender was not found to be significant. These findings result in the following expressions for the two models:

- score1: $Y_p = 16.462 + 2.002X_{age} + 2.929X_{gender} + 5.282X_{KA}$.
- score2: $Y_p = 20.857 + 1.483X_{age} + 4.682X_{KA}$

From these two models, it can be concluded that the time limit has a different influence on the performance of male and female pupils. This finding is in correspondence with existing research on gender and time pressure: females perform worse than man when a competition is introduced, such as a time constraint (e.g. Chen 2004; Shurchkov 2012). Females have the tendency to pay more attention to details and can stay focused on a certain task for a longer time span. Men focus on the quantity of work, resulting in a larger relative number of mistakes.

For the students, on the other hand, none of the factors was found to have a significant influence on the outcomes in both scoring systems. These results can thus be modelled with these expressions: $Y_s = 74.36$ and $Y_s = 69.88$ for scoring system 1 and 2 respectively.

	score1		score2	
	F	P	F	P
Corrected model	17.654	.000	14.7	.000
Intercept	14.712	.000	18.6	.000
Age	30.414	.000	16.6	.000
KA	13.018	.000	10.3	.001
Gender	4.752	.030		

Table 3. Outcome of the pupils' ANOVA test for the two scoring systems

3.3. Influence of the Map Reading Task

The complexity of the questions attributes significantly to the results: number of subtasks and complexity of the map reading tasks involved. Navigation is more complex than measurement, and visualization is most straight forward. However, this does not hold true in all cases. A very simple task – without many subtasks – can be very difficult for pupils/students when they do not remember or understand what a certain symbol means. This corresponds to mastering thinking skills on the lowest level. For example in Q9, the participants have to be able to recognise multiple schools, a roofed public pool and compare their mutual distances. This is latter assignment requires Level 4 thinking skills (comparing things, which corresponds to analyzing). However, if they cannot distinguish the pool on the map (Level 2 thinking skill) the task cannot be solved. This 'complex symbol knowledge' is indicated with an asterisk in the table with the sub-tasks in the appendix. Therefore, it can be concluded that complexity is not the only predictive factor in the pupils'/students' outcomes.

4. Conclusion and Future Work

In this study we evaluated the status of young peoples' (pupils and students) map reading skills. For pupils, age and knowing an area turned out to have a significant positive effect on the outcomes. However, the introduced time limit had a negative influence on the outcomes of the girls and to a lesser extent on these of the boys. The students scored much better than the pupils and their results were not influenced by any of the evaluated characteristics. However, further research is necessary on this topic as the better results of the students can also be attributed to other cofounding factors: age, a higher interest in geography and cartography, IQ, etc. Furthermore, the influence of the time limit on the participants' outcomes needs to be looked into in more detail.

References

Bandrova, T., & Vasilev, S. (2008, 8-11 September). *Creating and Updating Navigation Maps for Children Purposes (in Crises Situations).* Proceedings of AutoCarto, Shepherdstown, West Virginia, USA.

Beard, R., Cooper, A. D., & Crossley, K. R. (1993). Map Design Education. *The Cartographic Journal, 30*(2), 159-162.

Bloom, B. S. (1956). Taxonomy of educational objectives. Vol. 1: Cognitive domain. *New York: McKay*.

Board, C. (1978). Map reading tasks appropriate in experimental studies in cartographic communication. *Cartographica: The International Journal for Geographic Information and Geovisualization, 15*(1), 1-12.

Chen, J. (2004). *Effects of Test Anxiety, Time Pressure, Ability and Gender on Response Aberrance.* The Ohio State University.

Clarke, D. (2003, 10-16 August). *Are you functionally map literate.* Proceedings of The 21st International Cartographic Conference Durban, South Africa.

Clarke, D. (2014, 25-28 February). *Map literacy: The third element*. Proceedings of Cartocon, Olomouc, Czech Republic.

Feeney, A. E. (2003). Using interactive multimedia for dyslexic students in geographic education. *Journal of Geography, 102*(1), 21-28.

Filippakopoulou, V., Michaelidou, E., & Nakos, B. (1998, 2-4 June). *A study of children's perception of cartographic landform representation.* Proceedings of Maps for Special Users, ICA, Wroclaw, Poland, Wroclaw, Poland.

Filippakopoulou, V., Nakos, B., & Michaelidou, E. (2000, 6-8 September). *Children's understanding of generalisation transformations.* Proceedings of Teaching Maps for Children: Theories, Experiences and Perspectives Beginning the 3rd Millenium, Budapest, Hungary.

Fraser, D., Zentai, L., & Brandalize, M. (2011, 3-8 July). *The challenging face of cartographic education and training*. Proceedings of the 25th International Cartographic Conference, Paris, France.

Gerber, R. (1984). Factors affecting the competence and performance in map language for children at the concrete level of map-reasoning. *Cartography, 13*(3), 205-213.

Harrower, M., & Brewer, C. A. (2003). Colorbrewer. org: an online tool for selecting colour schemes for maps. *The Cartographic Journal, 40*(1), 27-37.

Ikonovic, V. (2001, 6-10 August). *Importance of education in cartography*. Proceedings of the 20th International Cartographic Conference, Bejing, China.

Jenny, B., & Kelso, N. V. (2007). Color design for the color vision impaired. *Cartographic Perspectives*(58), 61-67.

Keates, J. S. (1996). *Understanding maps*. England: Addison Wesley Longman Limited.

Kimerling, A. J., Buckley, A. R., Muehrcke, P., & Muehrcke, J. O. (2009). *Map use : reading and analysis* (6th ed.). Redlands, Calif.: ESRI Press Academic.

Krathwohl, D. R. (2002). A revision of Bloom's taxonomy: An overview. *Theory into practice, 41*(4), 212-218.

Liben, L. S. (2009). The Road to Understanding Maps. *Current Directions in Psychological Science, 18*(6), 310-315.

Liben, L. S., & Downs, R. M. (1992). Developing an Understanding of Graphic Representations in Children and Adults - the Case of Geo-Graphics. *Cognitive Development, 7*(3), 331-349.

Meissner, W. (2003, 10-16 August). *National differences in education and examination in cartography*. Proceedings of the 21th International Cartographic Conference, Durban, South Africa.

Muehrcke, P., & Muehrcke, J. O. (1978). *Map Use: Reading, Analysis, and Interpretation*. Madison, WI: JP Publications.

Newcombe, N., & Liben, L. S. (1982). Barrier Effects in the Cognitive Maps of Children and Adults. *Journal of Experimental Child Psychology, 34*(1), 46-58.

Nielsen, J. (1993). *Usability Engineering*. San Francisco: Morgan Kaufmann.

Phillips, R. J. (1989). Are Maps Different from Other Kinds of Graphic Information. *The Cartographic Journal, 26*(1), 24-25.

Shurchkov, O. (2012). Under pressure: gender differences in output quality and quantity under competition and time constraints. *Journal of the European Economic Association, 10*(5), 1189-1213.

van der Merwe, F. (2009, 15-21 November). *Concepts of spatial thinking*. Proceedings of the 24th International Cartographic Conference, Santiago de Chile, Chile.

Van der Veken, N. (2013). *Het positieve effect van jeugdbewegingen op kaartlezen: een mythe of realiteit*. Ghent University, Ghent.

Wiegand, P., & Tait, K. (1999, 14-21 August). *Promoting children's collaborative learning in cartography with a software mapping tool.* Proceedings of the 19 th International Cartographic Conference, Ottawa, Canada.

Zentai, L. (2009, 15-21 November). *Change of the meaning of the term 'cartographer'in the last decades.* Proceedings of the 24th International Cartographic Conference, Santiago de Chile, Chile.

Appendix

	Question Sub-tasks	
Map 1	**1. The roads are depicted in different colors. What do they stand for?**	
	Level 4: Analyzing	Visualization
	1. Distinguish roads on the map 2. Distinguish different colors on these roads	3. Derive meaning of colors
	2. What is the name of the district of Chimay, depicted on the map?	
	Level 3: Applying	Visualization
	1. Read labels 2. Distinguish difference in typography	3. Select correct label
	3. The original scale of the map is 1 : 20 000. What does this mean?	
	Level 3: Applying	Measurement
	1. Read scale correct 2. Know 1cm = 20 000cm	3. Recalculate cm to km
	4. What is the equidistance on this map?	
	Level 3: Applying	Measurement
	1. Know meaning of equidistance 2. Find altitude lines on the map	3. Read height information 4. Determine difference in altitude between subsequent lines
Map 2	**5. What is the name of the river that runs through Forges?**	
	Level 2: Understanding	Visualization
	1. Locate Forges (find label) 2. Locate river (symbology)	3. Read label
	6. From the chapel St-Quirin, can I see the church of Forges?	
	Level 4: Analyzing	Visualization; Measurement
	1. Locate chapel (symbology + label) 2. Locate Forges (read label) 3. Locate church (symbology)	4. Compare altitude information a. Find altitude lines b. Read height information c. Compare height information d. Analyze visibility
	7. I would like to play soccer and meet my friends at the church. How do I have to walk starting from the church? (a direction is indicated at every crossroads)	
	Level 4: Analyzing	Visualization; Navigation
	1. Locate church (symbology) 2. Locate soccer field (symbology)	3. Find route (navigation) a. Distinguish roads b. Analyze roads between start and end point c. Derive route instructions (left, right, etc.)
	8. If you go from the chapel St-Quirin via the orange road to the	

	chapel situate somewhat more to the north then… (up/down/same height)	
	Level 4: Analyzing	Visualization; Navigation
	1. Locate chapel (symbology + label) 2. Find North direction	3. Read altitude information a. Find altitude lines b. Read height information c. Compare height information
Map 3	**9. Which school is situated closest to the roofed public pool?**	
	Level 4: Analyzing	Visualization; Measurement
	1. Locate pool a. Determine correct symbol* b. Find symbol on map	2. Locate schools a. Determine correct symbol* b. Find symbol on map c. Repeat multiple times 3. Compare distances a. between each school and the pool
	10. Which N-way does not run through Chimay?	
	Level 3: Applying	Visualization
	1. Locate Chimay (label) a. Determine Chimay = city b. Read label	2. Locate N-ways a. Know N-way is a road b. Distinguish roads c. Distinguish N-way among roads d. Find label of N-way
	11. What is the highest point on the map?	
	Level 3: Applying	Measurement
	1. Read altitude information a. Find altitude lines b. Read height information c. Compare height information	
	12. What does the dark green color on the map mean (eg. Upper left corner)?	
	Level 2: Understanding	Visualization
	1. Locale area with dark green color	2. Derive its meaning (symbology)
Map 4	**13. Is there a police office on the map?** *(indicate associated road number in answer)*	
	Level 3: Applying	Visualization
	1. Derive symbology of police office* 2. Recognize abbreviated label Pol. 3. Locate office	4. Link names (N5, N99) to roads 5. Find & read label road where office is located
	14. This picture is taken from which position on the map?	
	Level 4: Analyzing	Navigation
	1. Recognize objects in picture a. River, bridges, row of houses, church (located at an higher point), …	2. Find objects in map a. Derive symbology of recog-nized objects b. Find symbols on map

		c. Analyze locations (map vs. picture) d. Determine viewpoint of picture
	15. How many supermarkets are there in the city?	
	Level 2: Understanding	Visualization
	1. Determine symbol of supermarket* 2. Locate symbols on map	3. Count number
	16. At which height is the camp site situated?	
	Level 3: Applying	Visualization; Measurement
	1. Determine symbol camp site 2. Locate symbol	3. Read altitude information a. Find altitude lines near symbol b. Read height information c. Compare height information
Map 5	**17. In which direction is the river flowing?**	
	Level 4: Analyzing	Visualization; Navigation
	1. Locate river a. Distinguish symbology of river b. Find symbology on the map 2. Know that rivers flow from high to low altitude	3. Read altitude information a. Find altitude lines that cross river b. Read height information c. Compare height information 4. Know NSEW-directions
	18. What does the section of the river's valley look like?	
	Level 4: Analyzing	Visualization; Measurement
	1. Locate river a. Distinguish symbology of river b. Find symbology on the map	2. Read altitude information a. Find altitude lines along the river b. Read height information c. Compare height information d. Estimate steepness based on distance e. between altitude lines 3. Estimate width of riverbed
	19. I organize a hike. To avoid traffic and walk in a calm environment, it would be best to walk on the … (color and shape of the lines).	
	Level 4: Analyzing	Visualization
	1. Distinguish roads on the map 2. Distinguish different colors on these roads	3. Distinguish different patterns on these roads 4. Derive meaning of colors & patterns 5. Select appropriate
	20. Which slope is most steep?	
	Level 3: Applying	Visualization; Measurement
	6. Read altitude information 7. Find altitude lines that intersect with line	8. Compare steepness between slopes

	a. Read height information b. Compare height information c. Estimate steepness based on distance between altitude lines	

Table 4. The 20 questions with the associated level of thinking skills, map reading tasks, and sub-tasks that need to be addressed