

PRELIMINARY ANALYSIS OF MULTI-SCALE SPATIAL COGNITION AND ITS LONGITUDINAL CHANGES IN SKETCH MAPS OF HIGH SCHOOL STUDENTS

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Abstract Whereas numerous studies have been done on spatial cognition using hand-drawn maps, little is known about how different these maps are between spatial scales. In particular, the need for multi-scale spatial knowledge has been growing as the progress of globalization in economy and politics. In addition, few attempts have been done to capture temporal change of spatial cognition on different scales. Hence, I attempted to analyze the relationship between hand-drawn maps showing the large range of world maps and the hand-drawn small range maps involved in school commuter route maps. A questionnaire survey was conducted to 74 high school students to collect hand-drawn maps. The results of the analysis revealed that when drawing world maps, focus was placed on “correctness of form”, whereas when drawing maps for school commuter routes, “correctness of orientation” was emphasized. World maps are drawn “in the order of all to part”, whereas for school commuter routes, the majority of the students drew “in the order of part to all”. Whereas with world maps, many of the students “draw while imagining the maps in an atlas”, maps for school commuter routes are drawn by reproducing the “feeling of when you are walking”.

Key words: Spatial cognition, Multi-scale, Route map, Survey map, Longitudinal changes

1. Introduction

The analysis of spatial cognition appeared in hand-drawn maps has attracted interest from a wide variety of fields. In particular, a number of studies using hand-drawn maps have been done in geography. Okamoto (1998) pointed out the three trends of geographical research of spatial cognition using maps as follows: (1) Representation of peoples’ spatial cognition as a map, (2) Inference about people’s cognition of space and environment from hand-drawn maps, (3) Elucidation of the numerical relationships between cognitive maps and actual maps from a cartographic viewpoint.

Researchers in geography education also have paid much attention to this research topic. Yamaguchi (1988) classified the studies in geography education concerning the students’

cognition of space as shown in Table 1. Specifically, these include (1) Studies verified from the place-name awareness of students (Miyahara 1995) and awareness of local industries (Tsuchida 1987). (2) Studies verified students' awareness of residential environment using the hand-drawn maps (Ishii 1995). (3) Studies verified from the practice for improving the geographical skills of students (Kobayashi 2013).

Table 1 Classification of spatial cognition research in geographical education fields

(1)	Children's or students' awareness of the real world (<u>Environmental cognition</u> : understanding of the arrangement of the earth surface and specific places)	1. Neighborhood area, and spaces directly experienced or observed
		2. Country
		3. Foreign countries and the world
(2)	Children's or students' understanding of geographical viewpoints, way of thinking and basic geographical concepts (<u>Understanding basic spatial relationships</u> : ability of spatial thinking, ability to understand spatial concepts abstractly, ability to use space as a means of communication to structure knowledge and problem solving)	1. Geographical viewpoints and way of thinking
		2. Basic geographical concepts
(3)	Children's or students' awareness of geographical skills	1. Maps and globes
		2. Pictures, paintings and images
		3. Field observation

Based on Yamaguchi (1988)

On the other hand, correlation of the style of hand-drawn maps with the development of spatial cognition has attracted attention of psychologists. Many researchers in developmental psychology have attempted to clarify the relationship between route maps (representation configured based on movement along a path) and survey maps (general symbol from the respective positional relationships of multiple locations). Many of them pointed out that spatial cognition develops from the route map into the survey map according to the developmental stage. However, Okamoto (1998) pointed out that recent research of psychology questioned the unidirectional development scheme from route map to survey map has been questioned, and there has been a growing consensus that even after capturing the survey map representation, the route map representation remains.

Further, from the perspective of developmental psychology, it has been pointed out that in the "cross-sectional survey, the spatial maps are drawn as the length of residence becomes longer" and "in the longitudinal analysis, depending on the region, they are used differently in terms of area (spatially) or linearly (sequentially)", and that "the survey map is not always more accurate than the route map".

On the other hand, researchers in ethnography and historical geography have paid attention to this topic from a different research interest. For example, Nonaka (2004) pointed out that the spatial recognition of bushmen have a hierarchical structure. In addition, Uesugi (2015) proposed a method for analyzing the concepts underlying ancient maps from the perspective of historical geography using the five dimensions of scientific nature, functionality, practicality, artistry and social aspect.

However, little is known about how different hand-drawn maps are between spatial scales. In particular, the need for multi-scale spatial knowledge has been growing as the progress of globalization in economy and politics. In addition, few attempts have been done to capture temporal change of spatial cognition on different scales. Hence, by comparing multiple maps of different scales by the same person, I attempted to analyze the relationship between hand-drawn maps showing the large range of world maps and the hand-drawn small range maps involved in school commuter route maps.

2. Method

In order to grasp the trends in the hand-drawn map of the same person, a questionnaire survey was carried out for 74 third-year high school students (36 males and 38 females), in regard to (1) focused items when drawing a map, (2) order of the elements drawn and (3) type of the map imagined while drawing world maps and school commuter maps. Before this questionnaire conducted in December 2015, the same students made hand-drawn maps of the world and school commuter route in April 2015. In addition, 19 students (10 male and 9 female) were required to make the map of Japan, the map of administrative area of residence and the map from home to station close to the school in May 2015. Also, the same students at their first grade made maps of the world and school commuter route in April 2013. These maps enable us to make cross-sectional and longitudinal analysis. Furthermore, I examined examples of maps from two students to make detailed analysis of the change and relationship between maps of the same person.

3. Results of the Analysis

The following result was obtained from the aggregate data analysis of 74 answers to the questionnaire.

Items emphasized when drawing maps

Respondents were asked to answer which items out of correctness of form/correctness of orientation/correctness of place names/beauty of map/detail of landmarks/detail of form/detail of place names/other (free wording) they focused on, and could select multiple answers. As shown in Table 2, it is evident that what was emphasized when drawing maps differed depending on the scale of the map. The differences for each scale are shown in Fig. 1.

Table 2 Items emphasized when drawing map

	World map	Map of Japan	School commuter route map
1 st	Correctness of form	Correctness of form	Correctness of orientation
2 nd	Correctness of orientation	Correctness of orientation	Correctness of form
3 rd	Beauty of map	Detail of form	Detail of landmarks

Multiple answers.

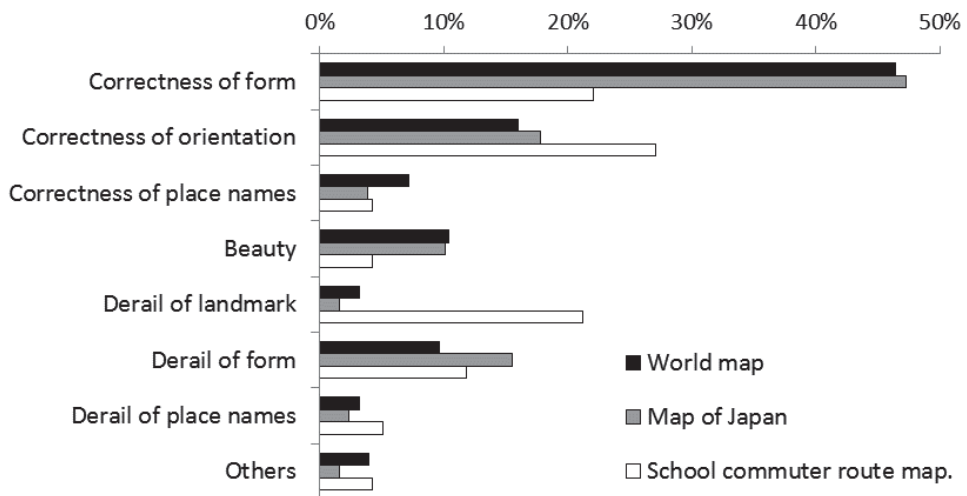


Fig. 1 Items emphasized on when drawing maps.

Order of drawing maps

To examine the way of drawing maps, I asked the students to answer the order of drawing maps. “Whole to part” refers to first being aware of the longitude and latitude and then gradually drawing each part after grasping the total image. “Part to whole”, on the other hand, refers to starting with the peninsulas or islands and gradually drawing the whole. Moreover, when drawing the school commuter route map by setting the start point as “closest station to school” and destination as “school”, I classified the way of drawing maps by whether they first conceived of the whole and drew from the destination (all to part) or drew as if they themselves were tracking their morning route to school (part to all). The results, as shown in Table 3, show that while drawing world maps and maps of Japan, most people drew in the order from whole to part, maps of school commuter routes were generally drawn in the order of start point (station) to destination (school).

Table 3 Order of map drawing

	World map	Map of Japan	School commuter route map
1st	Whole to part	Whole to part	Start point to destination
2 nd	Part to whole	Part to whole	Destination to start point
3 rd	Others	Others	Others

The way of drawing the world map and that of the map of Japan was the same for 84 % (62 persons) , with only 12 % (9 persons) drawing the world map in order of whole to part but the Japan map drawn in order of part to whole; only 4% (3 persons) drawn in reverse order. Furthermore, in the case of “Others” for the map of Japan, some people started to draw “from

Hokuriku” or “from the North”. Concerning the case of “Others” for the school commuter route map, some people answered “no obvious order” and others. Details of the differences for each scale are as shown in Fig. 2.

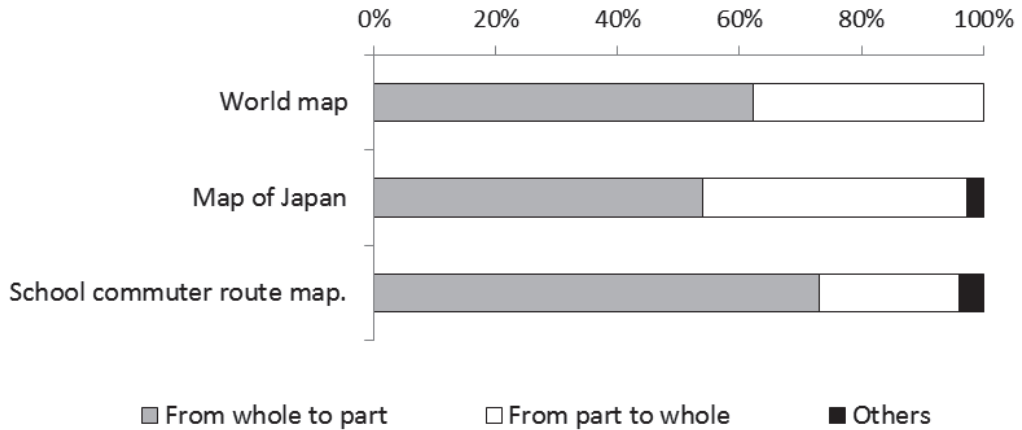


Fig. 2 Order of drawing maps by the type of map.

Maps imagined when drawing maps

To know what kind of maps are imagined when drawing maps, I took map examples familiar to high school students and asked them to choose the relevant one. This gives us a clue to know what kind of map is being input in the head of the student.

Table 4 Maps imagined in their heads when drawing maps

	World map	Map of Japan	School commuter route map
1 st	Atlas maps	Atlas maps	Others
2 nd	Other maps	Textbook maps	Digital maps
3 rd	Textbook maps	TV maps	Atlas maps

The breakdown of maps imagined when drawing school commuter route were “Others (34 persons)”, “digital maps (27 persons)”, “atlas maps (8 persons)”, “TV maps (2 persons)” and “newspaper maps (1 person)”. The reasons given by a student answered “Others”, which was most frequent, were as follows:

Relied only on space I perceived; did not imagine a map; I followed a path I walked in my head; scenes from my daily route to school; the route I walk; train route map; don't know; school commuter route; usual scenes; from my own experiences; followed concept or route in my head; direction of my body when going to school; I put the station below and school above, and drew while remembering the actual route; bird's eye view from memory; myself walking; route I took that morning; my school commuter route scene; I consider in my head the way how I walk when I go to school; the way I usually come; usual sensation; the map distributed when I joined the school; map in my head; scene when I walk; walking route; own memory; drawn while walking in my head; direction and length I usually walk; guide diagram often found in the town; the map I drew before; imagined an overhead view of what I normally see when walking; did not remember; schematic diagram used for signposts; what I remember and memory; memory of the scene I see when walking.

Based on the analysis of images remembered when drawing the school commuter route map and school commuter route map drawn, I can classify these images into bird's eye type (survey map-style output) and experiential type (route map-style output).

4. Detailed analysis of the maps derived from two students

Based on an overall analysis described in the above chapter, I will show examples of the maps derived from two students (1 male and 1 female) to make longitudinal and multi-scale comparison of hand-drawn maps. Furthermore, I will describe an interview to confirm how these maps were drawn. The female student in case of Example 1 (Fig.3) drew a world map in her first grade, but as a result of her studies into world history and the like, her knowledge of the regions deepened, she used that knowledge to draw a well-organized world map. The map of her school commuter route in the first grade was in survey map-style, while in the third grade it could be said to have elements of a route map. On the other hand, in the case of the male student in case of Example 2 (Fig.4), the knowledge of the place names steadily increased without changing the style of drawing the world map. His school commuter route maps in both the first and third years were route/survey compound type maps. His map of Tokyo metropolis where he lived contains areas he had experienced such as "Tokyo Sky Tree" or "Toyosu", and this can be said to be a highly organized map for himself.

In terms of the overall trend as well, when drawing a world map and going in the order of "whole to part", the output tends to be that of a survey type. As the Japan map was of a more familiar region and scale, there seemed to be a higher rate of people going in the order of "part to whole". Concerning the school commuter route map the student was asked to draw "the commuter route taken that morning from the station to the school", but there was a comparatively high ratio of those drawing in the order of "destination (school) to start point (station)". Hence, it is thought that drawing from the destination was due to the output being of a survey type.

Findings obtained in this analysis implies that the method of "creating a route map in your head based on physical feeling (route map-type spatial recognition)" is considered an effective method of knowing "known space acquired by knowledge etc. (survey map-type spatial recognition)" in more detail. Hence, I can suggest that combining both scales and creating a map in your head is an effective means of improving geographical learning and spatial recognition.

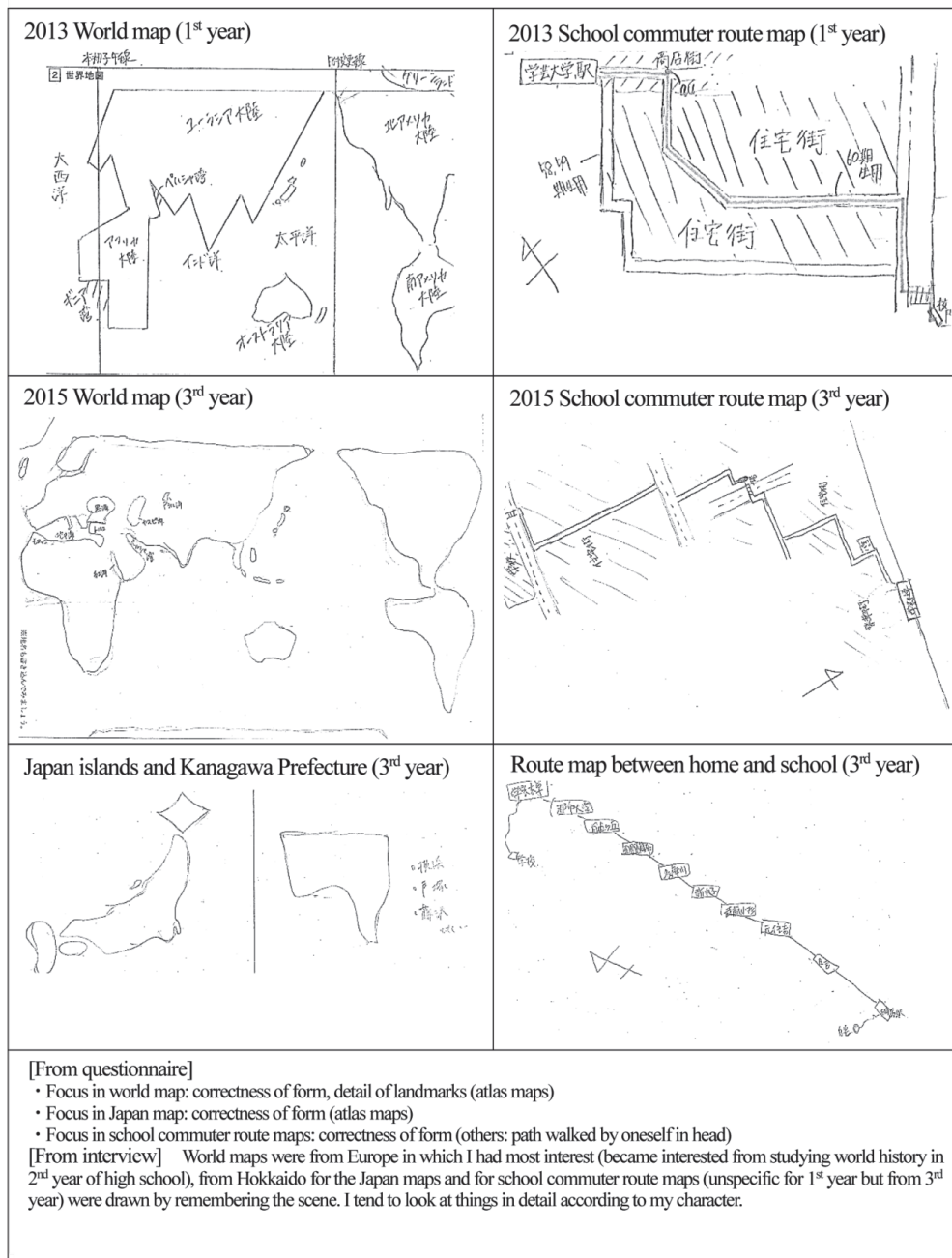


Fig. 3 Example 1 (Female): Whole to part order for both world map and Japan map; school commuter route map is the type of “start to destination”.

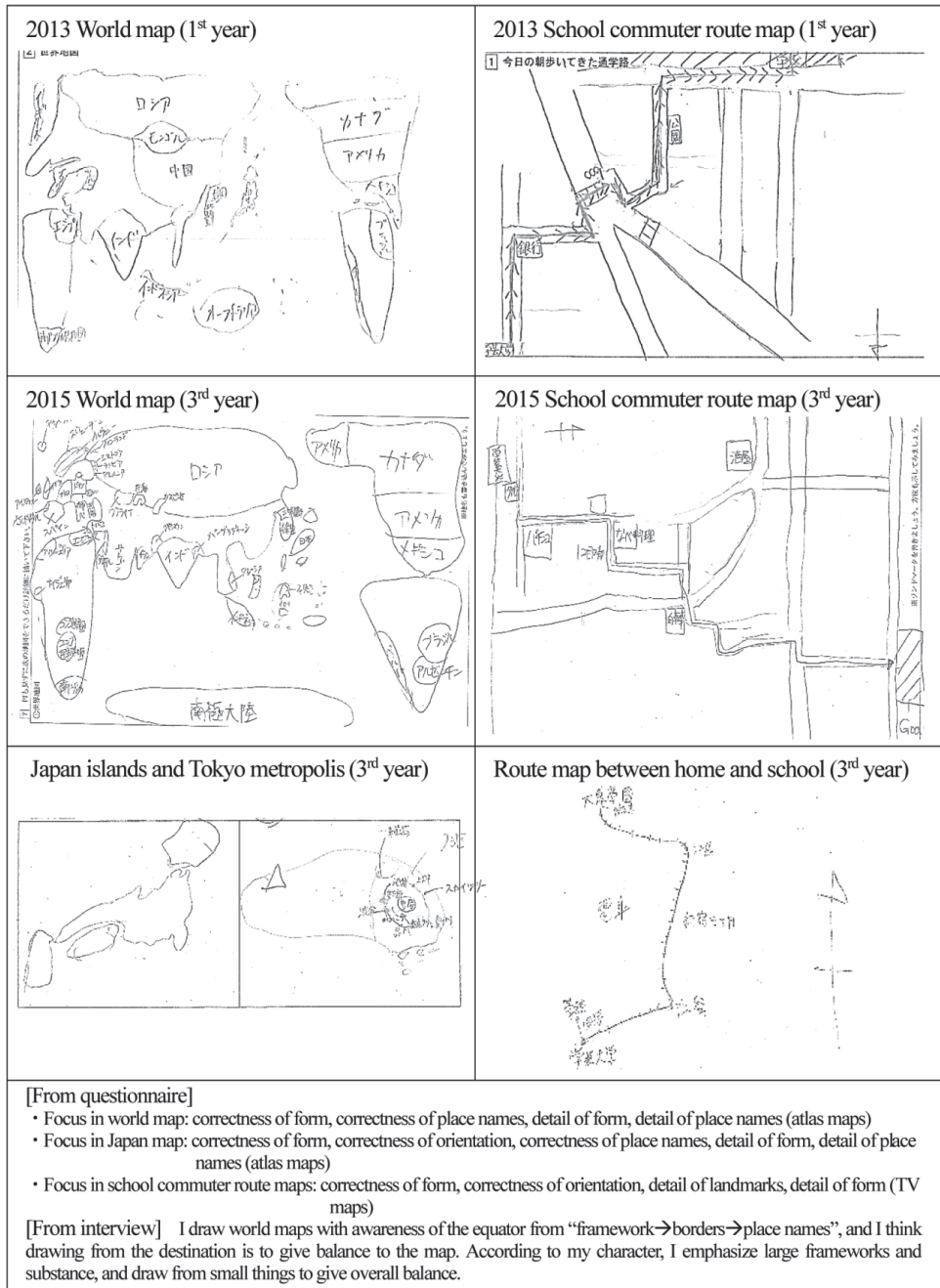


Fig. 4 Example 2 (male): Whole to part order for both world map and Japan map; school commuter route map is the type of “from start to destination”.

5. Concluding Remarks

Whereas there is a lot of room to improve the method of analysis, I can examine the meaning of deep understanding of region by analyzing the multi-scale spatial cognition. In geography education, it is important to make extensive use of both scheme and scale of maps. In addition, with the increase in popularity of maps for walking in Japan in recent years, it can be suggested that “creating a route map in your head (route map-type spatial recognition)” is an effective method for knowing familiar space (survey map-type spatial recognition) in more detail. Furthermore, nowadays when digital maps become more popular with the public, the finding obtained implies a way of breeding the necessary spatial recognition to use maps.

I plan to continue to study hand-drawn maps as a clue for cross-sectional and longitudinal analysis of multi-scale spatial cognition. In April 2016, I had already collected hand-drawn maps and conducted a questionnaire to 125 first grade high school students. I am going to carefully analyze these to understand spatial cognition in more detail.

Acknowledgements

I would like to express my thanks for all of the students who so readily agreed to the publishing of the hand-drawn maps. I am extremely grateful for the warm support of Professor Yoshiki Wakabayashi of Tokyo Metropolitan University in this research. Outline of this paper was presented at the Annual Meeting of the Association of Japanese Geographers at Waseda University in March 2016.

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(*: in Japanese,**: in Japanese with English abstract)

3. About “maps of Japan”.

① When drawing “map of Japan”, which of the following items did you focus on?

(Circle the items you focused on)

- | | |
|---------------------------|--------------------------------|
| Correctness of form | Correctness of orientation |
| Correctness of place name | Beauty of map |
| Detail in landmarks | Detail in form |
| Detail in place name | Others: () |

② Tell me about the map you imagine in your head while hand-drawing the “map of Japan”.

(Circle the relevant items).

- Atlas maps Textbook maps Newspaper maps TV maps Digital maps
Others : ()

③ When drawing the “map of Japan”, what kind of order did you draw it in?

(Circle the relevant items)

1. Order of all to part using graticules and contours etc.
2. Part, such as islands and peninsulas etc, to all.
(In detail, I started from _____)
3. Others : ()

4. About your preferences for maps and geography. (Circle the relevant item)

① To what extent do you use maps (paper maps / atlases / magazine and Internet maps etc.) ?

1. Often use 2. Sometimes use 3. Do not use often 4. Almost never use

② Do you like looking at and using maps?

1. Really like 2. Generally like 3. Do not like much 4. Dislike

③ Do you like studying geography?

1. Really like 2. Generally like 3. Do not like much 4. Dislike

④ To what extent are you interested in the following items?

Mountain climbing • Outdoor activities

1. Very 2. Somewhat 3. Not very 4. Not at all

Riding vehicles such as trains

1. Very 2. Somewhat 3. Not very 4. Not at all

Travel

1. Very 2. Somewhat 3. Not very 4. Not at all

Digital maps

1. Very 2. Somewhat 3. Not very 4. Not at all

* Do you consent to the viewing and publishing of the hand-drawn maps you have drawn so far for the purpose of publishing research? These shall not be used for objectives other than research. These shall be published anonymously and not identify any individuals. [Consent • Do not consent]

Year group no. Name : _____