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Students' Spatial Thinking Toward the School Environment in Indonesia

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Abstract: *This study describes the level of cognitive mapping among students in one of the senior high schools in Indonesia. This study aimed to determine the cognitive map of secondary students using a sketch map. The cognitive map elements studied were paths, edges, landmarks, districts, and nodes. This research uses an interpretive paradigm to reveal how students make meaning of their school environment through map sketches. The research approach used was descriptive qualitative. Data collection techniques included a map sketching test and direct interviews with six randomly selected key informants. Cognitive map analysis was used to analyse the cognitive map elements in students' map sketches. The results showed that second-grade students have diverse cognitive maps of their school environment. Thus, this study recommends that attention and substantial efforts from various parties, especially geography subject teachers, be more intense in utilising the surrounding environment as a geography learning laboratory at SMUK ST. Fransiskus Xaverius Ruteng.*

Keywords: Spatial thinking, school environment, students, cognitive map, sketch map.

1. Introduction

The environment is where humans live and carry out their daily activities. The physical environment can influence human cognition, experience, and behaviour by facilitating or inhibiting various perceptions, thoughts, emotions, and actions (Montello, 2014). One of the environments that exist in human life is the school environment. Physically, the school environment is complex, consisting of various buildings that are arranged as needed to support the overall school activities. The school environment has an important role and affects the level of student learning success. Sudikno and Aminah (2014) explain that a conducive school environment can create peace and comfort in learning so that the learning process at school can be carried out optimally. One aspect that is influenced by the school environment on students is spatial intelligence. In this respect, Newcombe and Frick (2010) state that any mobile organism must be able to navigate in its world to survive and must represent the spatial environment to do so. The statement shows that spatial intelligence is one of the most important aspects of learning. Furthermore, the statement shows that spatial intelligence is closely related to the environment. This is supported by Wuellner et al. (2017), that individuals can store their mental representations of the surrounding environment. In relation to students, environmental conditions could affect spatial intelligence, although it is not a factor that directly influences it.

Spatial thinking is one of the crucial abilities in understanding and interpreting the surrounding environment in everyday life. It is how a person understands the surrounding physical environment that can be obtained directly through sensory experiences that are felt or obtained, or indirectly through knowledge gained about the environment (Downs & Stea, 1973). Humans use spatial cognition to be able to always harmonise themselves with the surrounding environment (Quintana

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& Holahan, 1992). According to Solem et al. (2008), spatial thinking is a first-order skill that a person must possess and use. Spatial thinking or spatial intelligence enables humans to adapt and fulfil their needs. Although psychologically, spatial thinking is a genetic ability that naturally exists in every individual, and the development process varies from individual to individual. In the world of education, this can be developed for the better with the right education pattern, such as can be used in various subjects, including geography.

Spatial thinking ability, as one of the main and first skills, provides many benefits in everyday life. The National Research Council (NRC) (2006) explains that Spatial thinking is a form of thinking that has many benefits, is widely used in various disciplines and situations, and can be used to solve everyday problems. These various benefits are important to continue to get attention from educators. NRC (2006) explains that one of the important elements in spatial thinking is the context of the everyday physical world. Furthermore, NRC (2006) explains that spatial thinking includes three main things that can improve students' competence, namely knowledge, skills, and habits in thinking that use spatial concepts and can use existing tools in spatial and processes that provide reasons for spatial existence.

Spatial thinking can be described through cognitive maps. This is supported by previous studies highlighting that cognitive map is beneficial to shaping certain areas such as cities, bridges, streets, stations, or other public areas. In this respect, its citizens' perceptions, experiences, imaginations, and feelings might be crucial elements in shaping the areas in question (Pettricia, 2014; Ramadan et al., 2019). In the meantime, focusing on the teaching and learning process, there is an effect of Problem-Based Learning on outdoor adventure education on spatial Intelligence (Susetyo et al., 2017). On the other hand, Richter et al. (2012) and Hegarty (2014) found that map sketches can be used as a language medium analysis; therefore, it is very important for students to think spatially.

The above-mentioned studies generally examined a large area and informants from various levels, such as students majoring in geography, communities, and experts, emphasising efforts to find out and improve spatial thinking. However, research that describes spatial thinking ability in a narrow or limited area with the subject of high school students has never been done. In fact, judging from the distribution of teaching materials, senior high school students have learned about map sketching since junior high school. So, to fill the void, the researcher wants to examine the condition of spatial thinking in secondary-level students using cognitive mapping.

Cognitive mapping is part of the spatial approach in geography and is closely related to the analysis of geospheric phenomena through maps. According to Kaplan (1973), a Cognitive map is a picture made to determine the extent to which individuals know their environment. Laurens (2005) have confirmed that a cognitive map is a process that allows individuals to collect, organise, store in memory, and re-describe all the information they get related to the environment and signs that exist in the geographical environment. This can be proven by referring to the sketch map of the location space described by the individual (McAndrew, 1993). Basic and individual cognitive mapping processes can be measured and assessed through cognitive mapping in the form of sketches. Richter et al. (2012) explained that cognitive mapping in the form of sketch maps is one way to analyse geographic reasoning in a spatial context. This is supported by the view of the Tolman, E. C. (1948) Cognitive maps organise experience and guide behaviour, so they can be used to strengthen an individual's knowledge of the physical characteristics of a place.

Ideally, secondary students majoring in social studies have good cognitive mapping because, in lessons, they are often invited to use the environment as a social study learning laboratory so that students can access information from memories about the surrounding environment. This is in accordance with the opinion of Cosmides and Tooby (2000), who assert that the ability to redraw or visualise environmental knowledge can train various skills to help achieve various adaptive goals. This is confirmed by the statement of Mondschein et al. (2013), saying that psychologists and

geographers describe cognitive maps as the end result of spatial learning, a developmental process that depends on navigation and wayfinding". However, preliminary studies conducted by researchers on random informants found that some students still cannot represent the surrounding environment in a good sketch map. Based on this, further research on cognitive mapping related to spatial thinking of students' level using sketch map analysis is challenging. Such analysis, which is pioneered by Lynch (2011), has some elements, namely: 1) path elements consisting of major paths and minor paths. 2) district area element, which is the area that becomes the object depicted. 3) landmark element, which is a landmark. 4) element nodes, 5) element boundaries or borders.

2. Methods

This study employs interpretive paradigm to illuminate the process by which students derive significance from their school environment through the creation of map sketches. This qualitative research explores and understands a central symptom (Creswell: 2015). The locus of this research is at the secondary school of Santu Fransiskus Xaverius located in a small town called Ruteng. This school was chosen based on the initial observation (interview with the teacher), where it was found that they had learnt about map sketching in grade one but were still confused about presenting the environment in a sketch drawing. The qualitative approach emphasises the central symptom, namely exploring and understanding the level of cognitive mapping of grade 2 students. The data generated were descriptive data related to cognitive maps that were analysed from the results of student drawings in the form of map sketches and compared with data from interviews.

Data collection techniques were carried out through two stages, namely, the drawing test and interviews. The drawing test was conducted by asking students to sketch a map of the school environment. After obtaining the cognitive map data from the results of student drawing tests, the next step is to reduce the data to randomly determine the selected key informants. Out of the 20 students who participated in drawing, six key informants were randomly selected, and then each selected informant was given the code A1, A2, B1, B2, C1, C2. The researchers interviewed each key informant to learn more about the student's cognitive map.

Furthermore, the data were analysed using sketch map analysis of Lynch's theory in Portugali (2011) with the following classification of elements: 1) path elements consisting of major paths and minor paths. 2) district area element, which is the area that becomes the object depicted. 3) landmark element, which is a landmark. 4) elements of nodes, 5) elements of boundaries or borders. The data validity test was carried out using data triangulation by repeatedly checking the data from the drawing test results and interviews to verify the data analysis results.

3. Results

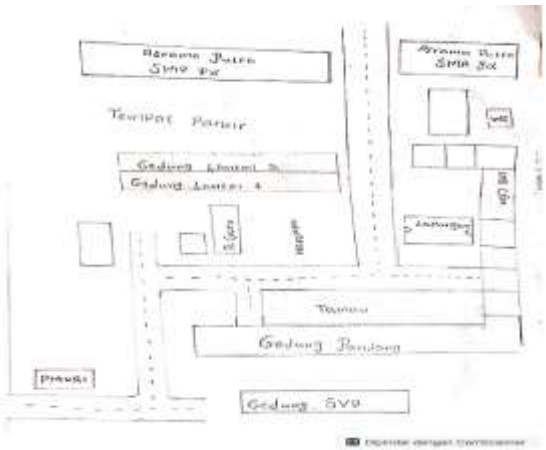
Students' cognitive abilities towards the school environment are quite varied. This varied ability is divided into several categories, namely low, medium and high.

3.1 Students with low cognitive

Students' cognition in the low category can be seen from the results of students' drawings through sketches of their school environment. A1 and A2 displayed a drawing of the school environment with several building areas. In the sketches drawn by informants A1 and A2, several elements, such as very few minor paths, non-complex district areas, and no asterisks are the starting point of the informants' drawing. In addition, informants A1 and A2 did not draw some important things such as cardinal directions, major paths to the east and south, and landmarks inside and around the school. However, they have differences. A1 did not depict the minor roads that border the buildings, the roads leading to the boys' dormitory and girls' dormitory, and some minor roads leading to some classrooms. Furthermore, A1 did not depict the ceremonial ground and basketball court as gathering points and did not depict the boundary points between the school and other buildings that are not

his school area. Informant A2, on the other hand, only described one minor path from the entrance gate to the basketball court and boys' dormitory, while other minor paths were missing. A2 also did not draw any landmarks near his school, nor did he draw the boundary points between the school and other buildings that are not his school area.

Picture A1



Picture A2

When examined closely, the suitability of the sketch map is very far from the actual conditions. Informants A1 and A2 both experienced confusion in organising and describing the cognitive map in their minds. In addition, there were also several errors, including errors in location. Informants A1 and A2 seemed to only describe a collection of buildings they often encountered at school but did not place and organise them appropriately according to reality. Informant A1 felt less able to draw a place but was able to go to the place without knowing its name. This is in accordance with A1's statement in the interview that he was only able to show the place without being able to explain the surrounding environment. The following is an excerpt of A1's statement:

> "*I can't explain the direction of my destination like the cardinal directions or the direction of the road. If I'm told, what I can do is to go directly to the space that is the destination, then I can*".

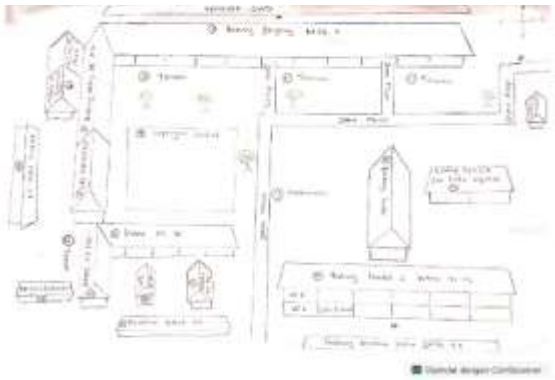
A1 and A2 live in the school dormitory. This is one of the reasons why they are not familiar enough with the major path. Their statement supports this in that they rarely leave the school while living in the dormitory. In addition, they also stated that they know that a major road divides their school from the school to the east, but they do not know the name of the road. In this respect, it is difficult to draw it because they rarely leave the school through the road. Even on Sundays, they go to the church via another road (path minor) directly related to the church's location, such as passing through the gate opposite the church gate. This statement is reinforced by the following interview with A2: "*when I get back to the dormitory, I don't do anything else, I just take lunch, sleep, and study in the afternoon at the dormitory. I rarely go to the eastern part of the school area (path major) because the location of the dormitory is inside the school.*"

One of the factors that shape the cognitive maps of A1 and A2 is lifestyle. Both came from villages very far from the school. In addition, both explained that they could not represent the surrounding environment well through drawings.

3.2 Students with moderate cognition

B1 drew the school area quite completely when seen from the buildings and landmarks in it. B1 started drawing from the east side of the gate. Besides drawing the school building, he also drew another building, namely the old cathedral church located at the east entrance gate of the school. B1

also drew the landmark of the new cathedral church located in the south. Another landmark drawn by B1 is the monastery building situated to the north and directly adjacent to the school.



Picture B 1

Picture B1

B1's cognitive map is more complete when compared to A1 and A2, although there are still missing areas, namely the minor path to the major path on Jalan Pelita No. 6 as well as the minor path to the women's dormitory.

The sketch map drawn by B1 was influenced by several factors that triggered the formation of the cognitive map. B1 is a student who comes from a village quite far from his school, and since junior high school, he has been studying in the same town. B1 is more familiar with the school's location, not only because he lives in the dormitory but also because he has explored many parts of the school. This is consistent with B1's statement:

> "*I think I am quite familiar with this town and the school location. We often walk when we go out on Sundays or on a free day from the dormitory. We play in the school area and walk to the city, market, and other places nearby without taking public transportation.*

The next informant is B2. In his sketch, the elements found are paths, landmarks, districts, and nodes. Informant B2 drew his starting point at the old cathedral church (east). The old cathedral church is a landmark because it is located near the school. Informant B2 started drawing at the east gate with the car park area. Besides, B2 described the school location as consisting of several areas and several buildings that are quite complex.

B2's cognitive map sketch from the point of view of the location of the areas depicted is in accordance with the original reality. B2 describes almost all areas of the school site. However, there are missing areas, such as the south of the minor path element connecting the school with the boys' dormitory and the west of the minor path connecting the school with the girls' dormitory. There are also some boundary points that divide the school from other areas outside the school.

3.3 High Cognitive Students

C1 comes from the village and has been in town since junior high school. C1 lives in a boarding house west of his school. C1 goes to and from school on foot, but during the rainy season, he uses public transport.

Picture C1

Picture C1

The sketch map depicted by C1 has a large and complex district area. In the southern part, C1 draws all facilities, such as buildings, basketball courts and ceremonial grounds, as gathering points. In the east, C1 drew the office, the teachers' residence, the car park, the principal's, and the administration's office. The north area depicts a long classroom building, a women's bathroom, and a garden in front of each classroom, as well as a minor path that separates the north and south areas, a minor path leading to each classroom. Furthermore, the western part depicts a long building containing various classrooms, male bathrooms, gardens, and female dormitories. In addition, C1 also depicts various minor paths that limit between buildings and minor paths leading to each class in the north area.

C1 depicts more detailed landmarks, such as the new cathedral church located in the south and the old cathedral church in the east. Other landmarks found in the C1 drawing and not found in other cognitive sketches are the second-floor building which is used as a classroom, and a bridge located in the northwest direction. In addition, C1 also drew the point that separates the school from other areas, such as the monastery, a junior high school, and the market to the west.

C1 is a student who has many friends both from school and outside school. C1 also joined a student organisation from his home sub-district. The relationships that C1 has with people makes him often travel to attend his community events. This condition also builds his cognitive map, so C1 is used to observing and remembering the environment and surrounding areas.

> "*On holidays or weekends, I usually play with friends from the home sub-district community and often get involved in home community events*".

The next informant was C2. C2 came from the East district. C2 lived in a boarding house. C2 has lived in Ruteng for more than four years. C2's cognitive map sketch was different from the others. C2 gave codes to the buildings he described in the form of numbers that were not sequential according to direction. In addition, C2 also gave codes to other buildings, such as parking lots and teachers' official houses. The district area described by C2 was very dense and numerous in accordance with reality.

C2 described several landmarks, such as the new Cathedral Church, the Old Cathedral Church, and the monastery. Interestingly, the new landmarks described were the second floor building of the school, another secondary school located to the east, a local cake shop located in the north area of the school, and the traditional market located to the west of the women's dormitory.

C2 is active in organisations and enjoys travelling. C2 was an active member of the intra-school student organisation at his school. This made C2 often go around his school to organise other students or also meet teachers for interests related to the student council. C2 acted as a big brother

because he had a younger studying in the town. In addition, C2 also has an uncle who also lives in the town. C2 has extensive networking, so he often travelled around the school and visited various places in the town.

C2 said that while studying at school, a lot of knowledge was gained, especially related to the surrounding environment. According to C2, social studies teachers at school were very helpful in srecognising and understanding the surrounding environment. Teachers not only teach theory but also introduce the application of daily life, including phenomena in the surrounding environment. This suffixes in the following statement of C2: "*The teachers at school really help us in understanding the surrounding environment by providing acceptable explanations."*

4. Discussion

The students' cognitive maps are still diverse. This diversity is reflected in the completeness and appropriateness of the elements of the students' cognitive map drawings that act as key informants. There are some students who draw school sketches very completely and the accuracy of the elements is in accordance with the facts in the field. However, there are some students who are still confused about placing the various elements of the cognitive map. This condition reflects the different abilities of individuals in presenting and interpreting the environment in the context of cognitive mapping into sketches. This is supported by the opinion of Sudes and Gokten (2012) and Gold (2009) that the cognitive map does not only reflect the exact objective environment with its geographical elements but is a process by which individuals acquire, store, and remember information related to the location or place where they live and interact daily.

Cognitive maps are not just representations of neighbourhood objects that can be depicted but also have important geographical elements in cognitive maps. Lynch in Golledge (1997) explains that there are five elements of geography in cognitive maps: paths, boundaries, nodes, landmarks, and districts. These cognitive map elements are reflected in the sketch map drawings of key informants, although the results of the drawing differ. The following presents each of these elements from all key informants.

Firstly, the path element. Most key informants described major paths and minor paths in their sketches. Major paths are roads that can be travelled by four-wheeled vehicles or more and are usually larger or wider and can be used by the public. Meanwhile, minor paths are roads that can only be travelled by two-wheeled vehicles and are usually specialised for certain people and not for the public.

The school is surrounded by major paths in the south and east, while in the west, there is a public market bordered by a river, and the north is bordered by a minor path that separates the school from the monastery. Key informants A1 and A2 did not describe major roads in the east and south. Both key informants assumed that the eastern and southern areas were less prioritised and not important enough to use due to the lack of interaction with these areas. In addition, it also does not depict most of the minor roads within the school area. This is in accordance with the opinion of Hannes et al. (2012) that one's cognitive map can be shaped by one's experience. Furthermore, the proportion of major and minor paths from A1 and A2 is difficult to distinguish because they have the same size and shape.

Meanwhile, B1, B2, and C1, C2 drew the complete major paths in both the east and south areas. C1 and C2 also draw almost all the minor paths up to the westernmost district. Lynch (1962) explains that concentrations of special uses or activities, such as shopping. studying, and cinemas can strengthen users' cognition of a path. Lynch further emphasised that paths that are close to special features will have a higher importance. This can be seen on the east side, which has landmarks of the old Cathedral Church and the New Cathedral Church. This is still considered reasonable because the cognitive map is formed by the intensity of the informant's experience in interacting with the

environment. This is supported by Portugali (2011), that the description on the sketch map of a particular environment is part of a person's autobiographical memory and a way of remembering one's daily experience in that space from the time that has passed.

Secondly, the landmark element. Landmarks within the school drawn by some key informants are the 2nd-floor building, which has a high imager. It is different in shape and size when compared to other buildings. Meanwhile, landmarks located outside the school are the new cathedral building and the old cathedral building. Key informants who described the new and old cathedral are B1, B2 and C1, C2. Both churches are landmarks because they are geometrically different from the others, have a special character, and are easier to capture. According to Lynch (1962), a landmark can be easily recognised if it has a shape that contrasts with the background scenery. The bridge is another interesting point from key informants (C1 and B2). This shows that C1 and B2 pay great attention and have a lot of experience in the area around the school. C1 and B2's experience is influenced by their frequent involvement in organisations around the school and frequent walking during activities, giving them more experience than other key informants. The ability to explore the environment and path integration is very useful for individuals to build a cognitive map by observing landmarks (Schenk et al.,2013; Vecchi et al., 2006).

Thirdly, the Nodes element. The nodes element is one of the elements of cognitive mapping as a sign of where informants start drawing. All key informants marked it by drawing a star. According to Sudas and Gotken (2012), the starting point of informants in the drawing is an interesting and very important part. Key informants who drew a star as a starting point were in the east, starting from the eastern intersection and parking lot and B1, B2, and C1, C2 drew from the south side. This is in line with what Lynch (1962) said, that an intersection and a place where transportation stops can have an important meaning for users. In these places, the user must make a decision about where to go, so the user's attention to the place is high.

Fourthly, the District element. District is a homogeneous area that coincides with each other and is usually called an area. The scale used in this study is limited to the school area. The school is a homogeneous area with similar building forms, and the district or area is a collection of buildings that are not separated by a minor road. According to Lynch in Scholz et al. (2014), the image of an environment is the result of a two-way interactive process between the observer and the environment. To describe this, Lynch uses two terms, namely imageability and legibility. Imageability, according to Lynch (1962), is the quality of a physical object that can give an observer a strong image of it. The image can be a shape, colour, or arrangement that is very clear to identify, structured, and useful for the environment. Dahl et al. (2010) also added that imageability is the quality of an environment based on the patterns and feelings stored in the observer's cognition of the environment. Legibility is a collection of objects that can be seen and presented, and organised into coherent patterns (Lynch, 1962; Montello, 2014). Thus, the legibility of a city refers to the ease with which residents develop a cognitive map over a period of time (Lynch, 1962; Herzog & Leverich, 2016).

Fifthly, the edges/boundaries or border element. The boundaries used in this research are the outer spaces of the school. The boundaries are either walls, buildings, gates or minor paths. Referring to the data, not all key informants drew up to the outer boundaries. Key informants who draw up to the outer boundary are C1, C2. According to Lych in Portugali (2011), the boundaries element is not more dominant than the path, but it is very important because it can organise the boundaries of the depicted area.

Observing the varying conditions of students' cognitive maps, cognitive maps are subjective, which indicates that each student's ability is different in understanding and interpreting the surrounding environment. In this context, there are various factors that influence the spatial thinking ability of individuals. Prasetyo in Sutomo (2013) said that cognitive maps between individuals differ because

they depend on individual lifestyles, individual familiarity with environmental conditions, the number of friends, social class, and gender differences. In this case, individual capacity determines its influence on factors that will shape spatial thinking ability. Liu & Lin (2015) explain that individuals with a more complex mental environment tend to have more positive emotions. C1 and C2 are informants with a good cognitive map, while informants B1 and B2 are in a moderate cognitive map condition, and informants in a low cognitive map are C1, C2. As such, Portugali (2011) explains that cognitive mapping is a synergy of information representations obtained from external and internal individuals. Internal information representation consists of innate representations that arise from birth, while external information representation arises and develops within a person who is influenced by the culture or environment around the individual.

The cognitive map shown in the form of a sketch map in this study is part of the way of reasoning geography. According to Ritcher (2012), geography reasoning in high school students is closely related to using scientific reasoning in everyday life. Thus, cognitive mapping through sketch maps is one way to present, develop, and improve a person's mind map. This is in line with Sudas and Gotken (2012), who asserted that a person's geography knowledge affects the representation of the map image depicted.

The various levels of cognitive maps that have been described reflect that the subjects have various cognitive levels towards their school environment. This is also inseparable from the arrangement of spatial patterns both inside and outside the school, which can lead to a personal picture of the environment. This mirrors the opinion of Bell et al. (2001), saying that the cognitive map is a sketch of the individual environment through a series of experiences. In addition, cognitive maps are the main component in humans to be able to adapt to their environment and become the basis for determining and implementing various plans on individual spatial behaviour (Quintana & Holahan, 1992; Singh & Kumar, 2018) and spatial thinking knowledge (Wakabayashi & Ishikawa, 2011).

5. Conclusion

Cognitive mapping is an important part of spatial thinking. The ability of spatial thinking is one of the important skills in everyday life. Cognitive mapping, as outlined in a map sketch, is one way to determine the extent to which a person knows and interprets his environment through geographical reasoning. Based on the description that has been presented, it can be concluded that the students' ability to interpret the surrounding environment through cognitive maps is still very diverse. This condition is caused by several factors, including individual abilities in interpreting the surrounding environment, lifestyle, interaction with the surrounding environment and the intensity of using the five important elements in the sketch map. These various factors encourage further research topics such as the causes of students' low knowledge of the surrounding environment, how teachers teach about sketching, and how teachers introduce the surrounding environment to students.

6. **Conflict of Interest:** Authors declare no conflict of interest whatsoever.

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