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The Relationship Between Different Types of Learning Environments and Individual Differences in Navigation Abilities

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Types of Learning Environments;
Walking Corsi Test;
Wayfinding task;
Learning types

Abstract
The study attempted to determine the relationship between the different types of learning environments and the performance in wayfinding tasks. The mixed analysis was used to analyze the data. The types of learning environments were measured by the Walking Corsi test while the wayfinding task performance was measured by the travel time in finding the target location. The wayfinding task performance was measured three times. Eighty-nine (89) undergraduate students aged between 18-23 years were divided based on the types of learning environments into 3 groups, namely route learning type (31 students), map learning type (30 students) and verbal learning type (28 students). The results showed that there were significant differences in the travel time to find the target location between three types of environmental learning groups F (3.6, 172) = 11.040; p<0.01). In the first occasion, the travel time of the map learning type group was faster than the route learning type group and the verbal learning type group. In the second occasion to track the target location, the travel time of the map learning type group was faster than route learning type group and the verbal learning type group. In the third occasion, the travel time of the map and verbal instruction learning type group were not different.

1. Introduction

People travel across one place to another every day. They who cross space are called navigators. In order to find a way to the destination or not get lost, people need three navigation abilities. First, the ability to absorb and process different (visual, spatial, verbal) information from the environment. Second, the ability to synthesize different information from the environment into spatial representations or cognitive maps. Third, the ability to use these cognitive maps to move the body efficiently to approach and achieve goals.

There are abundant studies on individual differences in navigation abilities (Schinazi et al., 2013)(Wiener et al., 2009). Individual differences in the formation of accurate spatial representations in studies in which the participants went around the new area by car once a week for ten weeks. Individual differences in the ability to study the area were measured through sketch drawings of building locations and accuracy points to locations around the area. There were participants who showed good performance consistently for ten trials and performed less consistently for ten trials. The consistency of an increase or a decrease in the individual performance also occurs in the connection of two routes in the fourth and subsequent trials.

The participants involved in Ishikawa and Montello's 2006 study above were passivewhen receiving environmental exposure (Weisberg et al., 2014). Therefore, Schinazi et al., (2013) conduct a research study that actively exposes the environment by asking participants to walk across the environment once a week for three weeks to see the formation of cognitive maps. Schinazi et al., (2013) find that the participants have experienced an increase in spatial assignments about buildings along the route and have formed accurate spatial representations of the environment.

A measurement of individual differences is challenging when a researcher wants to conduct a spatial learning experiment in a new environment. The recent research on the route learning paradigm distinguishes three strategies for finding a way, namely 1) allocentric place ; 2) egocentric associative sign , and 3) beacon response (de Condappa & Wiener, 2016). Hölscher et al., (2011) mention the choice of route strategies following the principles of cognitive economics that greatly adjust to the availability of perceptual information for tasks. Sameer & Bhushan, (2015) mention the learning of routes and the method of loci in navigation in an unfamiliar environment in which the route memory is better without a landmark compared to the condition of the landmark imagination.

Landmarks are important for the performance of older adults who are looking for a way (Marquez et al., 2015). This is also supported by Lingwood et al.,(2015) who find children aged 6, 8, and 10 years experienced an increase in learning routes with landmarks as a reference. There are two types of environment learning, namely primary learning and secondary learning. Individuals with primary learning type which is also called route learning move through the environment directly. Meanwhile, individuals with secondary learning type observe and study the environment indirectly through a map and or verbal instructions.

Preliminary studies on Indonesian subjects with self-report measurements shows that Indonesian people used the secondary learning type in a balanced way using maps and verbal instructions (Dinah Charlota Lerik et al., 2016). The way how primary learning type and secondary learning type influence navigation skills is unidentified. This study aims to examine differences in navigation capabilities in terms of individual environment learning types.

2. Research Method

Participant

The participants of this study were 89 engineering faculty students aged 18-2 years rom the state university in Yogyakarta.

Measurement

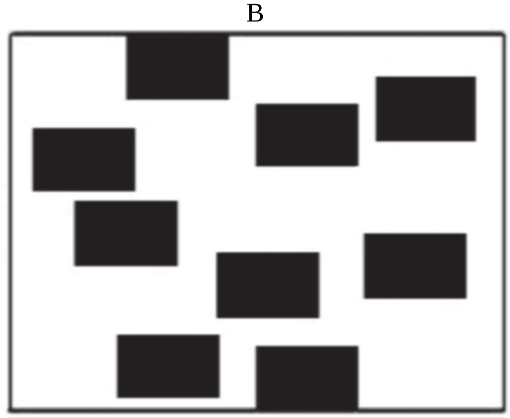
1. The Walking Corsi Test.The environmental learning type test was adopted from The Walking Corsi Test developed by Piccardi et al., (2008) as follows:
   a. Primary learning: Walking Corsi Test was made in the form of a plastic base measuring 2.5 x 3 m, containing eight squares that would form a route that could be passed by participants. Guided by a research assistant, participants walked along the routes consisting of a minimum of three-square route to the maximum of eight-square route on the plastic mat (Figure 1). If the participants performed correctly, they walked across the four-square route, but if they did it wrong the participant would be corrected by the research assistant three times at maximum until it was correct. The same procedure was carried out until the eight-square route. When the participant managed to walk alone across the eight-square route after being taught by the assistant, the study session ended and the participants took a break for five minutes in another room. After the break, the participants were taken back to the room with the display of The Walking Corsi to reproduce the eight-square route learning one more time. The score was the number square route that the participant has successfully passed. Scores ranged from 0 - 8.

Figure 1.

The Walking Corsi Test display was adopted to measure the types of learning from eight-square route.

b. Secondary learning of maps: The participants were given a map of a three-square route on A4 paper (Figure 2A) to be studied for four minutes at maximum (following the procedure performed by Piccardi et al., (2008)). The first map was presented to the participants for 80 seconds and they immediately reproduced correctly the three-square route on A4 paper (Figure 2B) three times. Then the map was closed and the participants reproduced correctly the image of the route on the A4 paper three times. The same procedure was carried out until the eight-square route. After the participants reproduced correctly the image of the eight-square route on the A4 sheet of paper three times, they took a break for five minutes in another room. Furthermore, they were taken back to the room with the display of The Walking Corsi Test and then reproduced walking across the eight-square route that had been studied. The score was the number of boxes that were successfully recalled, ranged from 0-8.

B



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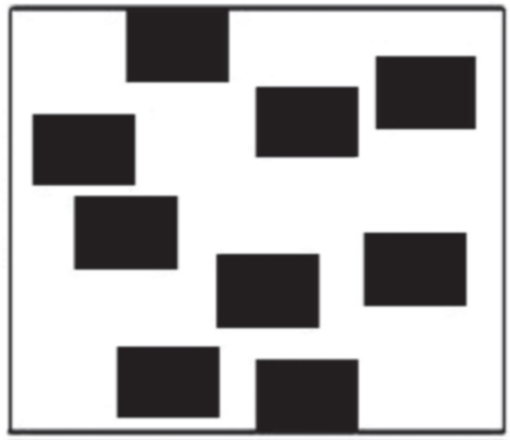

Picture 2.

2A) Example of a secondary learning stimulus map: an eight-square route is printed on an A4 sheet of paper that the participants learn. 2B) Outline maps on A4 paper sheets reproduced by the participants

1) Secondary learning verbal instructions: participants were given a verbal stimulus on a three-square route on A4 paper (Figure 3A) to be studied for eight minutes (the instructions were modified by the author with reference to the secondary task of the map above). The verbal instruction stimulus for the three-square route was displayed on the subject for 180 seconds. Then the participants immediately reproduced the three-squares route by drawing arrows as an analogy to the route on an A4 paper three times. The same thing was also done in verbal instructions for four-square route, five-square route to eight-square route. Five minutes later, the participants were taken back to the room with a display of The Walking Corsi Test and reproduced walking across the eight-square route that had been studied. The score was the number of boxes that were successfully recalled, 0-8.after learning eight-square route maps.

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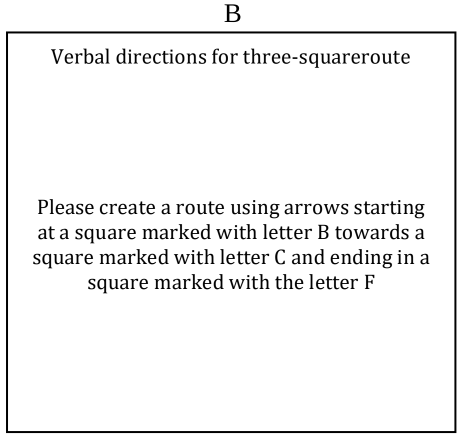

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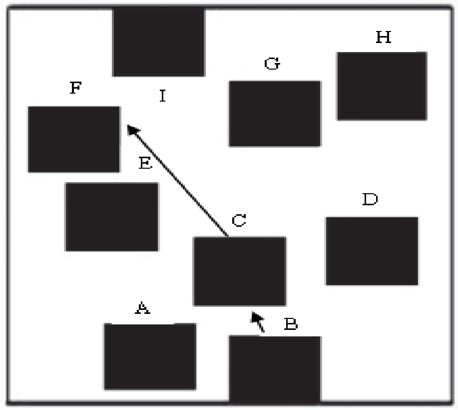


Picture 3.
3A) Examples of secondary instructions for verbal learning: a three-square route is printed on an A4 sheet of paper that the participants learn. 3B) A verbal guidance outline on an A4 sheet of the paper reproduced by the participants after learning verbal instructions on a three-square route.

2) Navigation Capability was measured in travel time tracing routes in the UGM Faculty of Psychology (Fig. 3) which was conducted once every week for three consecutive weeks according to the time agreement with participants.

Procedure

The participants were invited to participate through the google doc link that was shared through whatsapp application. After registering, they were confirmed to determine the schedule of the data collection. The data collection was done once a week for three consecutive weeks. They signed an informed consent sheet before being tested for the type of environmental learning in the laboratory and tracing the route for the first time in the Faculty of Psychology UGM (see Figure 5). In the second data collection, participants walked based on the same route a second time. In the third data collection, the same participants traced the route in the Faculty of Psychology UGM for the third time. The travel time data was recorded as dependent variable measures. The participants received debriefings about the nature of the study and reward for participating in this study at the end of the meeting.

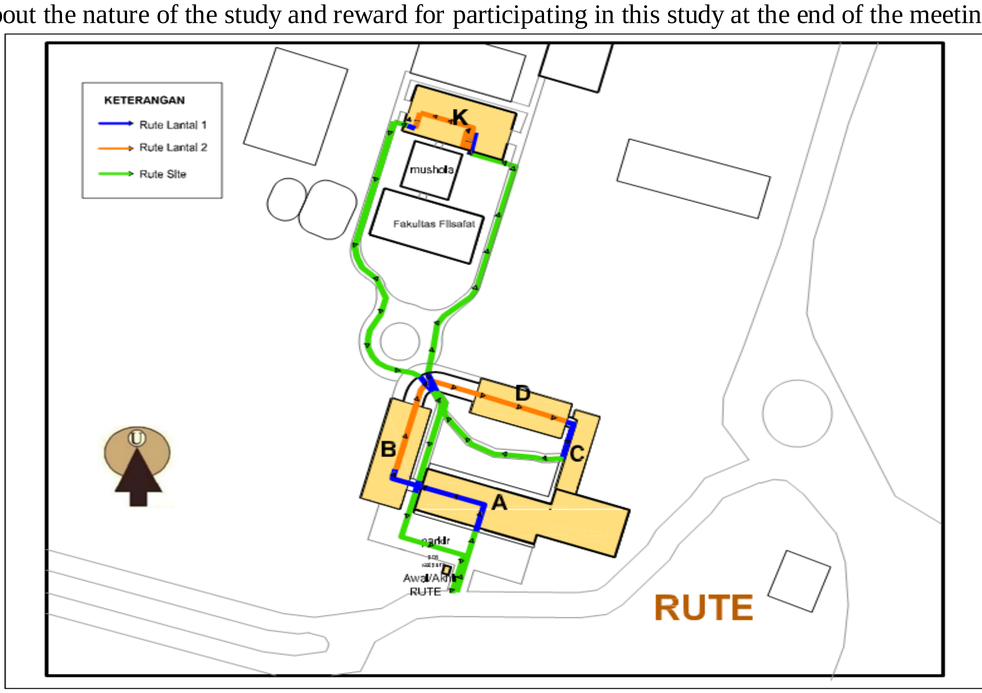


Figure 5. Map of space and route that is passed for travel time measurement Analysis The statistical analysis technique used in this study was a 3x3 mixed analysis of variance.

3. Results and Discussions

The analysis result shows that there are significant differences in the average of travel time of tracking the route three times for three consecutive weeks in the three types of learning environment (see table 1). The average of travel time of tracking the first route is the route learning type group (M = 780.3; SD = 78.7) different from the map type (M = 771; SD = 103.4), the map type is faster. Route type (M = 780.3; SD = 78.7) is different from the type of verbal instructions (M = 855.6; SD = 122), route type is faster. The map type (M = 771, SD = 103.4) is different from the type of verbal instructions (M = 855.6; SD = 122), the map type is faster. The average of travel time of tracking the second route is the route learning type group (M = 752.3; SD = 69.7) different from the map type (M = 689.8; SD = 77.3), the map type was faster. Route type (M = 752.3; SD = 69.7) is different from the type of verbal instructions (M = 702.4; SD = 100.1), the type of verbal guidance is faster. Map type (M = 689.8, SD = 77.3) is different from the type of verbal instructions (M = 702.4; SD = 100.1), the map type is faster. The average of travel time of tracking the third route is the route learning type group (M = 705; SD = 69) different from the map type (M = 644; SD = 74), the map type is faster. Route type (M = 705; SD = 69) is different from the type of verbal instructions (M = 645; SD = 83), the type of verbal instructions is faster. The map type (M = 644, SD = 74) is similar to the verbal type (M = 645; SD = 83).

Table 1.
Descriptive Statistics

	Group	Mean	Std. Deviation	N
Time 1	1.00	780.2581	78.69941	31
	2.00	771.7000	103.44152	30
	3.00	855.6429	122.06866	28
	Total	801.0899	107.72056	89
Time 2	1.00	752.2581	69.68212	31
	2.00	689.8000	77.29139	30
	3.00	702.3929	100.96290	28
	Total	715.5169	86.64506	89
Time 3	1.00	704.9677	69.33373	31
	2.00	643.8667	74.07579	30
	3.00	644.6429	82.83594	28
	Total	665.3933	79.99441	89

The results of the simultaneous analysis (see table.3) shows that there are significant differences in the three repetitive measurement times which are reviewed from the three types of learning environments F (3.6, 172) = 11,040; p <0.05; η2 p = 0.204) in which the F value commonly used is a Greenhouse-Geisser. Therefore, there is an interaction between travel time of tracking the route (1,2,3) and the types of learning environment (route, map and verbal instructions). Changes in the first, second third-travel time scores in the learning type group (routes, maps, and verbal instructions) are significantly different.

The travel time of tracking the route for the first to the second travel time in the learning type group has decreased insignificantly with the average difference (MD = 28,000; p> 0.05). There is a significant decrease in the changes in travel time of tracking the route in the second until the second time with average difference (MD = 47.290; p <0.05; η2 p = 0.218). The travel time of tracking the route from the first, second until third time in the map learning type group experience a significant decrease with the average difference (MD = 81,900; 45,933; p <0,05; η2 p = 0,387) Meanwhile The travel time of tracking the route from the first, second, until third time in the group learning type verbal instructions experience a significant decrease with the average difference (MD = 153,250; 57,750; p <0.05; η2 p = 0.614).

The plot shows the significant drop of the line in the decrease in the travel time of tracking the route. The sharp decline occurs in the first travel time to the second travel time in the verbal type group. The plot shows the overlapping line in the third travel time in the group of map type and verbal type.

Table 3
Tests of Within-Subjects Effects

Source		Type III Sum of Squares	Df	Mean Square	F	Sig.	Partial Eta Squared
Time	Sphericity Assumed	867142.429	2	433571.215	113.166	.000	.568
	Greenhouse-Geisser	867142.429	1.788	484995.836	113.166	.000	.568
	Huynh-Feldt	867142.429	1.866	464745.701	113.166	.000	.568
	Lower-bound	867142.429	1.000	867142.429	113.166	.000	.568
time * Group	Sphericity Assumed	169185.406	4	42296.351	11.040	.000	.204
	Greenhouse-Geisser	**169185.406**	**3.576**	**47312.999**	**11.040**	**.000**	**.204**
	Huynh-Feldt	169185.406	3.732	45337.529	11.040	.000	.204
	Lower-bound	169185.406	2.000	84592.703	11.040	.000	.204
Error(time)	Sphericity Assumed	658983.336	172	3831.298			
	Greenhouse-Geisser	658983.336	153.763	4285.718			
	Huynh-Feldt	658983.336	160.462	4106.775			
	Lower-bound	658983.336	86.000	7662.597			

Pairwise Comparisons

Measure: MEASURE 1

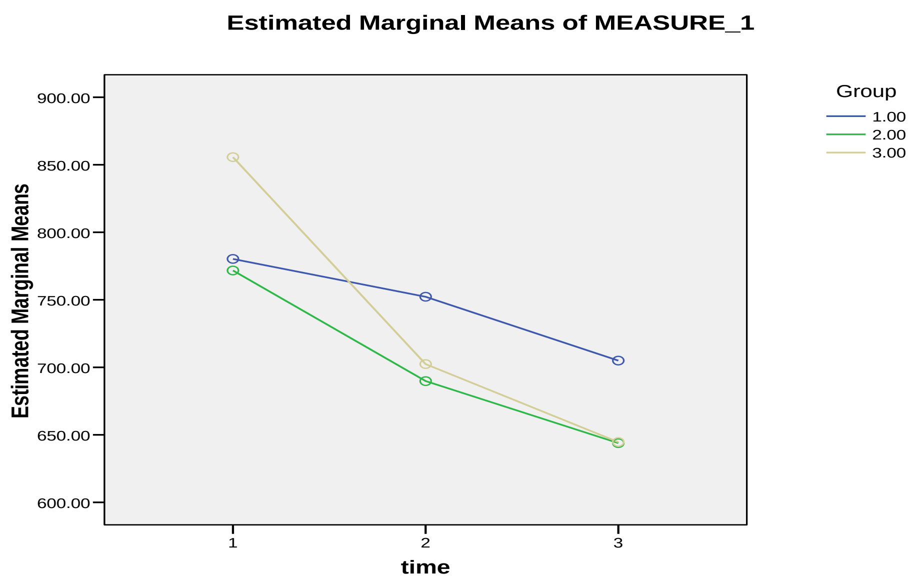
Group	(I) Waktu	(J) Waktu	Mean Differences (I-J)	Std Error	Sig[a]	95% Convidence Interval for difference[a] Lower Bound	Upper bound
1.00	1	2	28.000	16.882	.101	-5.559	61.559
		3	75.290*	17.156	.000	41.185	109.395
	2	1	-28.000	16.882	.101	-61.559	5.559
		3	47.290*	17.737	.000	21.971	72.610
	3	1	-75.290*	17.156	.000	-109.395	-41.185
		2	-47.290*	17.737	.000	-72.610	21.971
2.00	1	2	81.900*	17.161	.000	47.786	116.014
		3	127.833*	17.440	.000	93.165	162.502
	2	1	-81.900*	17.161	.000	-116.014	-47.786
		3	45.933*	12.947	.001	20.195	71.672
	3	1	-127.833*	17.440	.000	-162.502	-93.165
		2	-45.933*	12.947	.001	-71.672	-20.195
3.00	1	2	153.250*	17.763	.000	117.938	188.562
		3	211.000*	18.052	.000	175.114	246.886

2	1	-153.250*	17.763	.000	-188.562	-117.938
	3	57.750*	13.402	.000	31.108	84.392
3	1	-211.000*	18.052	.000	-246.886	-175.114
	2	-57.750*	13.402	.000	-84.392	-31.108

Based on estimated maginal means

* the means difference is significant at the 0.50 level

a Adjustment for multiple comparisons least significant difference (equivalent to no adjustments)



Research Discussion

This study aims to determine the role of the type of learning environment in navigation ability has been shown to differ significantly based on the results of mixed variance analysis. This means that there are individuals who have the potential to learn the route (Head & Isom, 2010). There are individuals who have the potential to learn maps better and there are also individuals who study the environment with better verbal guidance. After the primary learning occurs, individuals get a free spatial orientation that can be accessed from various directions. The map type group has learned a new environment by utilizing the new environmental map in tracking the route to find the specified location (Xiao et al., 2015). Verbal type groups have learned new environment by forming spatial representations of verbal clues when tracking the route to find specified locations. Map and verbal groups are also called to have experienced secondary learning which has strengthened special orientation spatial representations, which are easier to access one-way learning instead of other directions.

These results support the model of spatial knowledge result which state that spatial performance in retracking the route and completing the route are the result of route representation in cognitive map. This cognitive map is in the form of an internal representation of the environment, for example, the sequence of signs encountered along the route passed and physical movement along with the environment or survey representation, for example, a two-dimensional representation of the environmental configuration. Cognitive map distinguishes individuals in all three types of environmental learning groups sourced from:

(a) The process of coding spatial information from the sensory which absorbs the stimulation of types of learning routes, maps, and verbal instructions as well as signs in the environment. The route type group gets stimulation to learn a new environment by walking along the route with the assistant. The map type group gets stimulation of learning the environment from the map. The verbal type group gets stimulation of learning a new environment from verbal instructions. Environmental stimulation in the form of prominent signs such as stand-up frames, upward directions, eleven stairs, UKP receptionists, evacuation routes, boards of lecture hall, west staircase iron gates, and book shit banners. These signs become a stimulus that is perceived by the individuals. Visual senses are the main sensory tools for absorbing the spatial layout of an environment. However, when the individuals move through a real environment, they also perceive their own movements through non-visual senses. Movement is sensed by the vestibular system providing the information on linear and angular acceleration, and kinesthesis, which identifying limb movements, and repeats movements based on signals from the central nervous system to muscles.

(b) The process of maintaining internal representations of high-quality information to construct cognitive maps requires the role of memory. Memory has an essential role in learning the environment because environmental space cannot be captured only by a single view, and spatial space needs to be studied by managing information continuously. Memory construction formed from exposure to an environment is also a source of individual differences. Information can also be stored in memory as the direction of the route or as a configuration. Spatial memory also differs in metric accuracy. Spatial memory has an essential role in drawing conclusions about space memory.

(c) The process of drawing conclusions from new information in spatial memory and then transforming spatial information into spatial performance. When individuals learn spatial layouts of large-scale environments, they pass through the environment in the order of viewpoints along with movements through the environment. The memory of view sequences and the of movement sequences are not enough to perform tasks such as estimation of distance in a straight line and estimation of direction between signs found in a sequence of routes. Therefore, the performance of task estimation and distance estimation requires drawing conclusions from the information perceived at that time.

Individual differences also occur due to a repetition of environmental exposure or familiarity (Dijkstra et al., 2014) through retracking the route once a week for three consecutive weeks (Schinazi et al., 2013). When the familiarity and the environmental exposure increase, there is a relative continual increase and quantity, accuracy and completeness of spatial knowledge.

Exposure to the new environment is seen in the first longest travel time because knowledge of the new spatial environment acquired has not been stable. the second environmental exposure is seen in changes in travel time decrease because new spatial knowledge begins to be stored in memory. The third environmental exposure with the fastest travel time proves that stable spatial knowledge has been formed or called survey knowledge.

Primary learning is when individuals move directly through the environment and secondary learning is when individuals observe and study the environment indirectly through maps or verbal clues. Differences in environmental learning are based on the number of positions that give the advantage to individuals in learning. Maps and verbal instructions are seen as the only one advantageous position and they are easy to be used only in one subsequent orientation. On the contrary, direct routes provide various advantageous positions for individuals. Various orientation positions facilitate the use of spatial information in the orientation variations. Secondary learning types, namely the type of map and verbal instructions are faster than the primary learning type, namely the type of route in re-tracking the route. Individuals with map learning type are faster than the route type in finding locations. Learning type of verbal instructions is faster than the route type. Individuals with map learning type have similar learning speed with individuals with verbal instructions type.

The results also show that repetition of the one-time weekly route for three consecutive weeks has an impact on familiarity (Marchette et al., 2011) (Iachini et al., 2009) which results in a decrease in the speed of the third travel time. Familiarity in this research is carried out in a real environment in line with the results of research familiarity in the virtual environment conducted by Dijkstra et al., (2014).

This research shows important results based on plots where maps and verbal instructions are equivalent tools as a source of new environmental learning information in the formation of individual cognitive maps which are then used to find locations (Meilinger & Knauff, 2008). There are differences especially in terms of depiction. The results of our research which do not differ can be explained as a result of the number of samples that have met the significant requirements of the independent t-test.

Our findings are in line with the findings of other studies that find no difference between map and verbal in time and error that equivalent performance levels indicate that the navigator rotates the map mentally to suit the environment where "above" on the map is suitable for "advancing" in the environment. Another possible reason is depiction or drawing forces participants to store spatial information that may not be relevant if they find the appropriate location during the navigation. Memory needs in managing all spatial relations of the map may consume cognitive resource. Therefore, it is better to rotate the map. Conversely, verbal instructions are very useful but depend on the quality as well. Therefore, the verbal instructions used in this research are made as closely as possible with the environment map to get a description of the best environmental routes.

4. Conclusion

From the study, it can be concluded that there are significant differences in the average of travel time of tracking the route three times for three consecutive weeks in the three types of learning environment. The results of the simultaneous analysis shows that there are significant differences in the three repetitive measurement times which are reviewed from the three types of learning environments F (3.6, 172) = 11,040; $p < 0.05$; η2 p = 0.204) in which the F value commonly used is a Greenhouse-Geisser (Leech et al., 2013). This study aims to determine the role of the type of learning environment in navigation ability has been shown to differ significantly based on the results of mixed variance analysis. These results support the model of spatial knowledge result which states that spatial performance in re-tracking the route and completing the route are the result of route representation in cognitive map.

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