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Measurement of Visualization Ability of Architectural Space

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Abstract. Mental Cutting Test (MCT) [1] is the well-known measurement of visualization ability, but MCT only addresses small objects used in descriptive geometry, not the large objects as buildings and architectural space enveloping the human body. In order to measure the visualization ability of the architectural space, the Plan Interpretation Test (referred to as PIT) is developed. To know the features of visualization ability of architectural space, PIT and MCT-J [2] were applied to the 253 Osaka University students at the same time. The average score of PIT and MCT-J with standard deviation are 23.9±3.7 points (full score: 30 points), and 19.2±4.5 points (full score: 25 points), respectively. The correlation coefficient between the two is 0.3413. As far as the PIT applied in this experiment is concerned, the average score of the problems on the interior space is higher than that of exterior space ($P < 0.01$). Moreover, the average score of the problems on the interior space enclosed in one floor is higher than the interior space open for two floors or more ($P < 0.01$).

Key Words: visualization ability, architectural space
MSC 1994: 51N05

1. Introduction

Mental Cutting Test (MCT) [1] is the well-known measurement of visualization ability, but MCT only addresses small objects used in descriptive geometry, not the large objects as buildings and architectural space enveloping the human body. The features of buildings and architectural space are that the same object is viewed both from the building exterior perspective and interior perspective concurrently. In many places, the floor plans are used on the directory signboard or to show the emergency egress route, but it is not clear how

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Table 1: Contents of PIT

PAGE	PROBLEM	PHOTO*	FLOOR NUMBER	TYPE**	PAGE	PROBLEM	PHOTO*	FLOOR NUMBER	TYPE**
1	P1	INT	2	A	6	P16	INT	2	B
	P2	INT		A		P17	INT		A
	P3	EXT		–		P18	EXT		–
2	P4	INT	3	B	7	P19	INT	2	B
	P5	INT		B		P20	INT		B
	P6	EXT		–		P21	EXT		–
3	P7	INT	2	A	8	P22	INT	2	B
	P8	INT		A		P23	INT		B
	P9	EXT		–		P24	EXT		–
4	P10	INT	3	A	9	P25	INT	6	A
	P11	INT		A		P26	INT		B
	P12	EXT		–		P27	EXT		–
5	P13	INT	3	B	10	P28	INT	3	A
	P14	INT		B		P29	INT		A
	P15	EXT		–		P30	EXT		–

* INT:interiror photo EXT:exetrior photo

** TypeA :1floor recognize Type.B :2floors recognize

many visitors visualize the space with the floor plans. The Plan Interpretation Test (hereafter referred to as PIT) is developed to measure the visualization ability of the architectural space. PIT is an objective test to identify the point and direction of the photo's sight in the floor plan. The authors regard the reading/interpreting ability of the architectural floor plans as visualization ability of the architectural space. To know the feature of visualization ability of architectural space, PIT and MCT-J [2] were applied to the same students at the same time. The test results are analyzed statistically. The results of experiments are in the followings.

2. Experimental method

2.1. Contents of PIT

Fig. 1 shows sample problems of PIT. All problems consisted of photos and floor plans with numbered arrows. The arrows on the floor plans show the point and direction of sight. Each problem asks the students to select the point of photo's sight among five options out of nine numbered arrows indicated on the corresponding floor plans. Five options are selected using the table of random numbers [3], provided that one option, at least, should be the exterior viewpoint. The test has thirty problems; ten buildings with three photos each. The buildings selected are the private residences designed by the same architect [4], most famous in Japan. As listed in Table 1, among ten buildings, five are 2 floors high, four are 3 floors high and the remaining one is higher than those (6 floors high). For each building, two interior photos, one exterior photo and the floor plans are with nine numbered arrows: six arrows for interior view points and three for exterior ones are given. Among twenty interior photos, ten shoot the space enclosed in one floor (hereafter referred to as Type A) and the remaining ten shoot the interior atrium open for two floors or more (hereafter referred to as Type B). In applying the test, the students should know drawing jargons, so example exercise is given on the cover page explaining the process to reach the answer. MCT-J is applied at the same time as control. Time limits of both tests (PIT and MCT-J) are 25 minutes and 20 minutes, respectively.

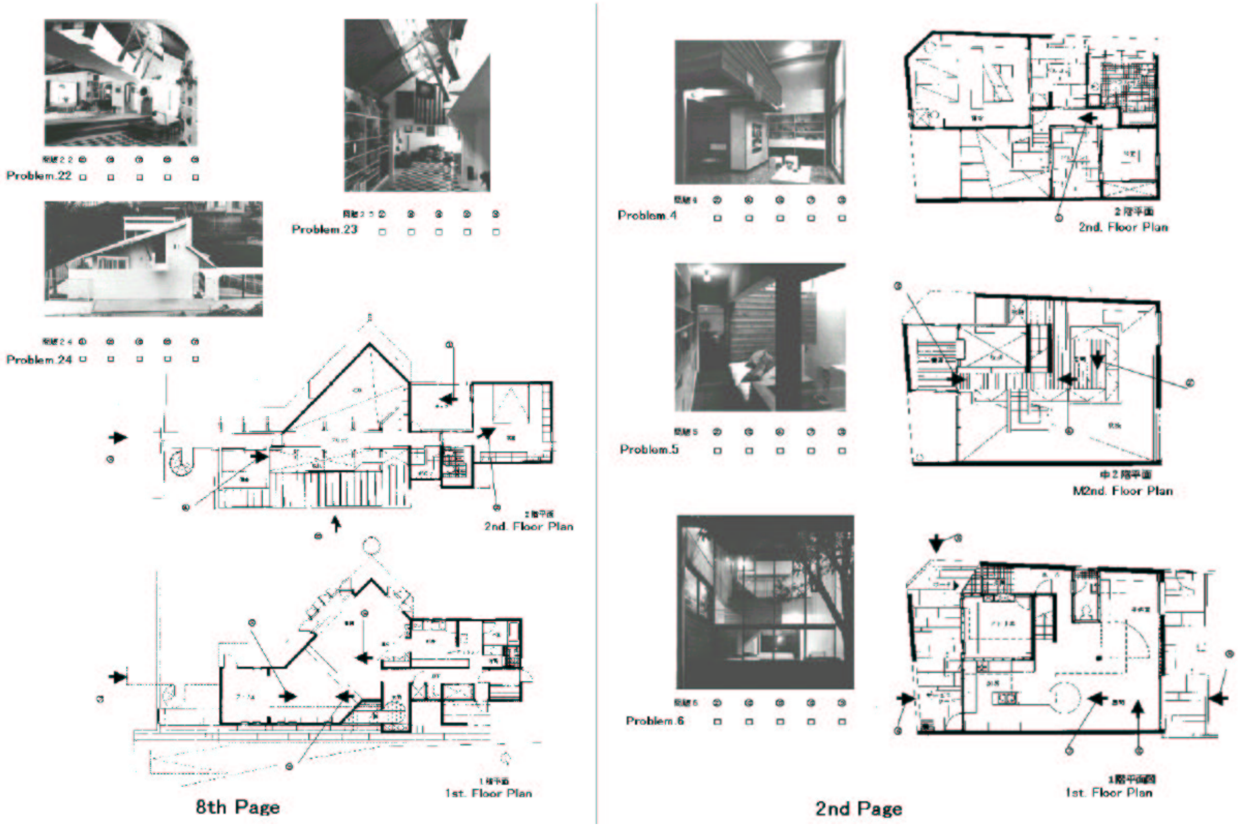

Figure 1: Example of PIT

2.2. Subjects

The PIT is applied to 253 students taking descriptive geometry course in three classes at Osaka University: 93 students of architectural engineering and environmental engineering (referred to as AE), 88 students of civil engineering and naval architecture (referred to as CN), and 72 students of some other classes (referred to as SC). They are freshmen and sophomores, not yet instructed on professional architectural education.

3. Result and discussion

3.1. Scores of MCT-J

Fig. 2 shows the distribution of the frequency (number of the subject students marking each scores / total number of the students $\times 100$) for the score of MCT-J. The average score with standard deviation for all classes is 19.4±4.3 points. Fig. 3 shows the distribution of the frequency for the score of MCT-J according to the each class. The average score with standard deviation for the students in SC, CN, and AE is 17.9±4.7 points, 20.1±4.0 points, and 20.0±3.9 points, respectively. Fig. 4 shows the correct answer rate of MCT-J score in the order of the problems with higher correct answer rate recorded for the MCT previously applied to Tokyo University students [5], The distribution of correct answer rate for Osaka University students is generally lower than that of Tokyo University students, while the relative distribution giving the correct answer rate is in good similarity. This suggests that our subjects are sufficiently credible. This suggests that our subjects are sufficiently

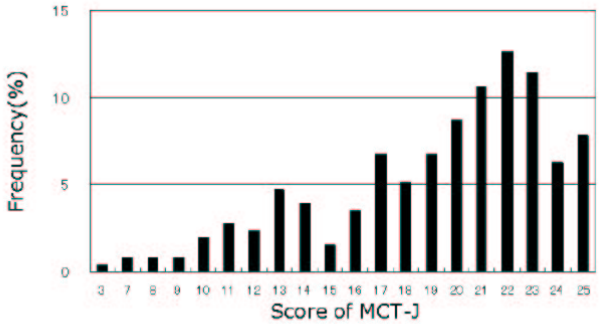

Figure 2: Distribution of MCT-J
(all classes)

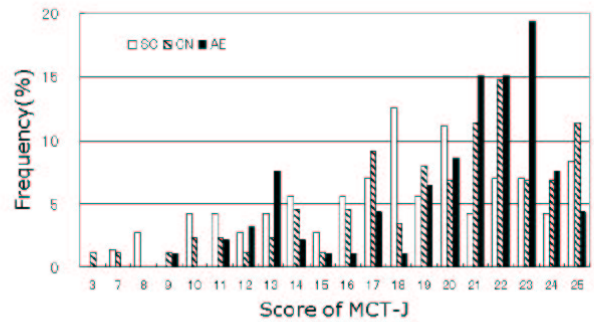

Figure 3: Distribution of MCT-J
(each class)

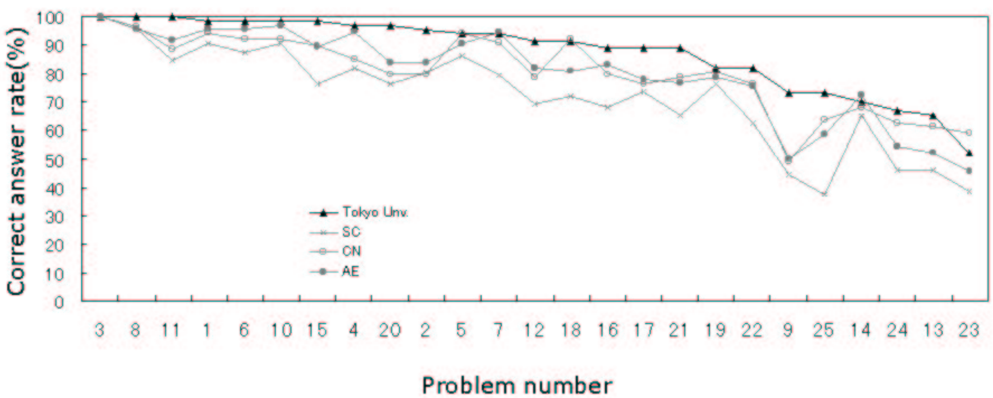

Figure 4: Correct answer rate of each problem

credible.

3.2. Scores of PIT

Fig. 5 shows the distribution of the frequency for the score of PIT. The average score with standard deviation for all classes is 23.9±3.7 points. Sixteen students, or 6.32 percent, score less than 18 points, which is equivalent to less than 60 points if converted to full score of 100 points. Fig. 6 shows the distribution of the frequency for the score of PIT according to the each class. The average score with standard deviation for the students in SC, CN, and AE is 23.9±3.9 points, 23.4±3.4 points, and 24.3±3.8 points, respectively. With regard to the average score of each class between the students in AE and those in CN, the significant difference is identified (level of significance $P < 0.05$). In the followings, the test results of each 3 classes are severally analyzed statistically.

3.3. Correlation of tests

The Figs. 7–10 show the distribution of the results for PIT and MCT-J. The correlation coefficient between both tests is 0.3413. The correlation coefficient between both tests in the class of SC, CN and AE are 0.2937, 0.4169 and 0.3560 respectively. The test results of PIT are correlated to MCT-J results to a little extent, but no-significant correlation between both tests is not identified ($P < 0.01$).

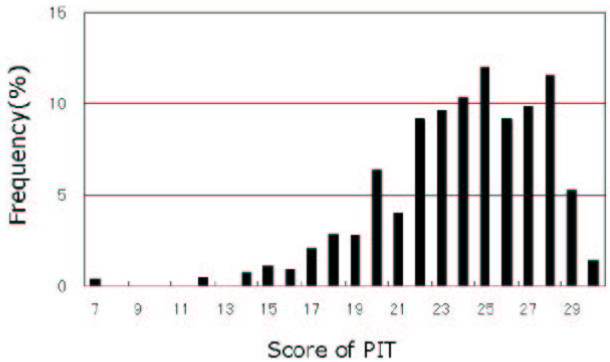

Figure 5: Distribution of PIT (all classes)

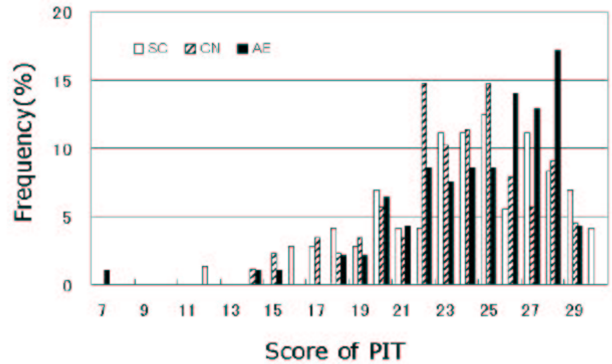

Figure 6: Distribution of PIT (each class)

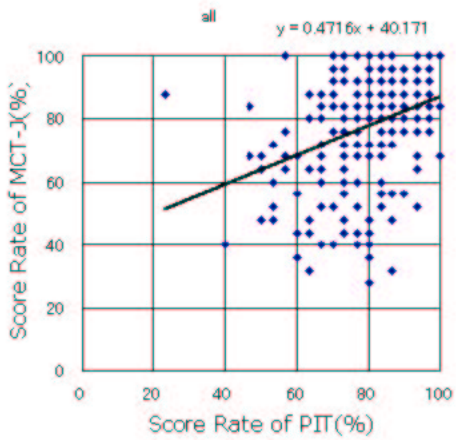

Figure 7: Correlation MCT-J, PIT (all classes)

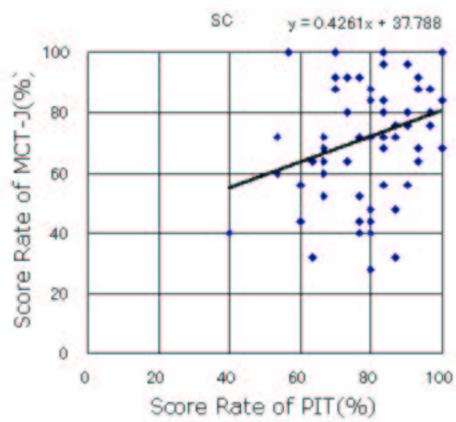

Figure 8: Correlation MCT-J, PIT (SC)

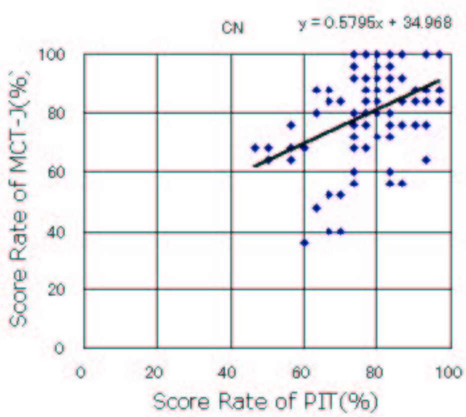

Figure 9: Correlation MCT-J, PIT (CN)

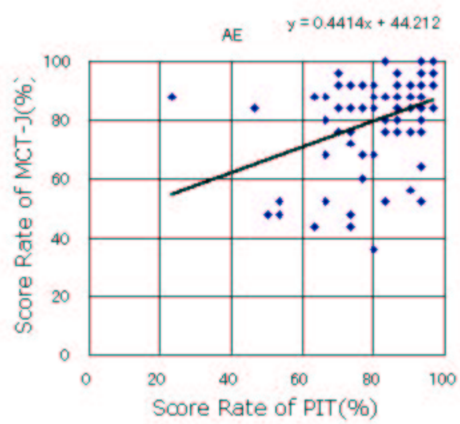

Figure 10: Correlation MCT-J, PIT (AE)

3.4. Visualizing the interior and exterior space

For all classes in the PIT, Fig. 11 shows the distribution of the frequency for the score rate (converted to full score of 100 points) of 20 problems on the interior space (referred to as interior problems), and those for the score rate of 10 problems on exterior space (referred to as exterior problems). The average score rate with standard deviation for interior problems is 83.2±12.4 and for exterior problems is 72.8±17.6, respectively. The significant difference is identified ($P < 0.01$) between the average score rates of the interior problems and those of the exterior problems. Figs. 12, 13 and 14 show the distribution of frequency for the score rate of the interior problems and the exterior problems by each class. In SC class, the average score rate with standard deviation for interior problems is 82.8±12.9 and for exterior problems is 73.8±18.2. In CN class, the average score rate with standard deviation for interior problems is 83.0±11.8 and for exterior problems is 68.9±16.9. In AE class, the average score rate with standard deviation for interior problems is 83.8±13.0 and for exterior problems is 79.5±17.5, respectively.

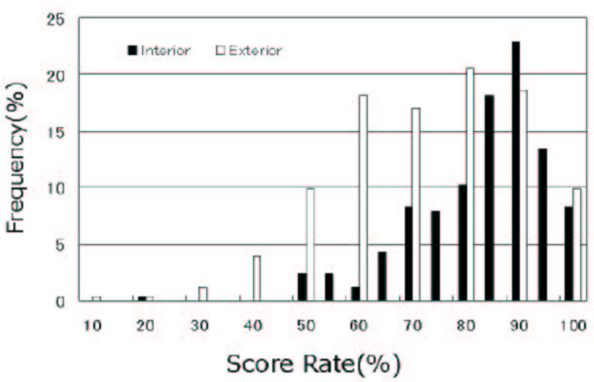

Figure 11: Distribution of PIT

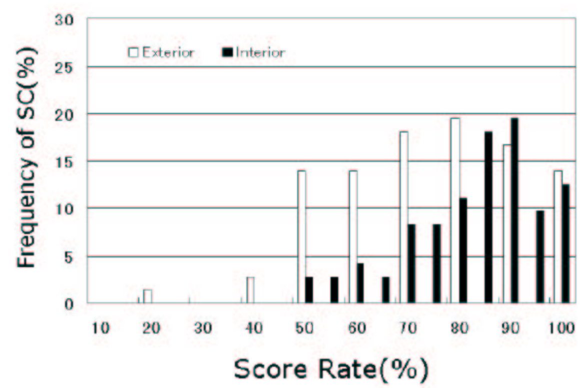

Figure 12: Distribution of SC

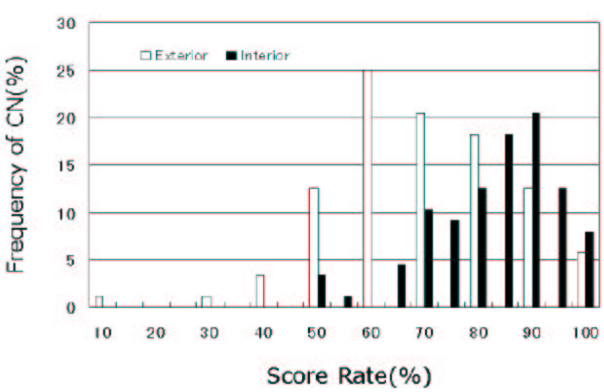

Figure 13: Distribution of CN

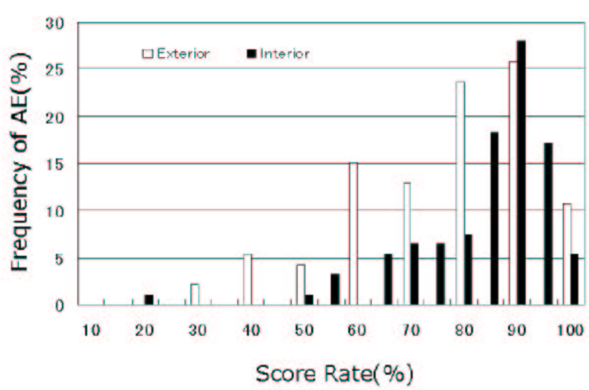

Figure 14: Distribution of AE

In each class, the significant difference is identified ($P < 0.01$) between the average score rates of the interior problems and those of the exterior problems. As far as the PIT applied in this experiment is concerned, it is more difficult to visualize the exterior space than the interior space.

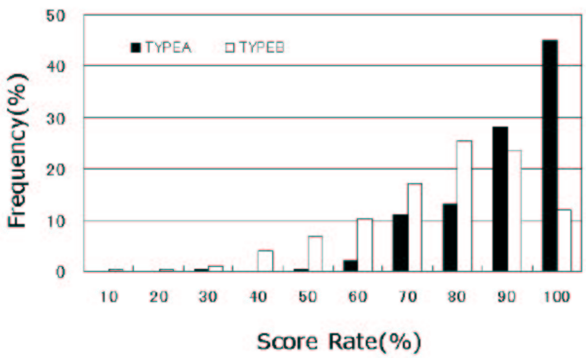

Figure 15: Distribution of PIT

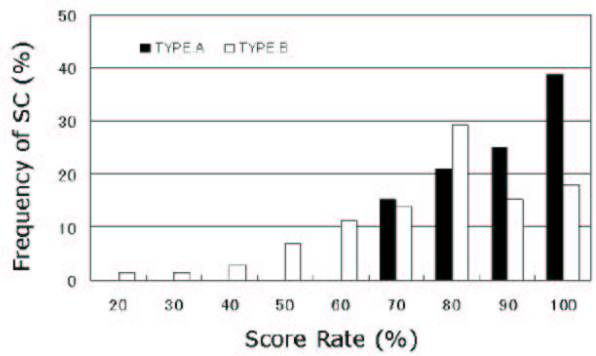

Figure 16: Distribution of SC

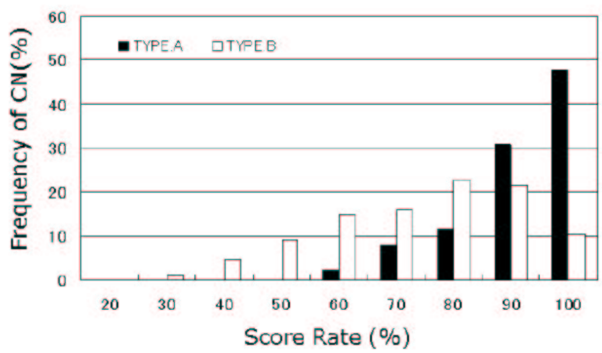

Figure 17: Distribution of CN

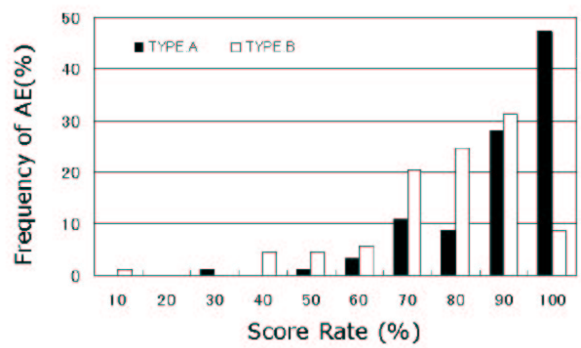

Figure 18: Distribution of AE

3.5. Visualizing the interior space in one floor and in two floors more

Fig. 15, on PIT, shows the distribution of score rate frequency for Type A problems on the interior space enclosed in one floor and that of Type B ones on the interior space open for two floors or more. The average score rate with standard deviation for problems of Type A is 90.0± 11.9 points, for problems of Type B is 76.4±17.2 points. Between the average score of these two types the significant difference is identified ($P < 0.01$). Figs. 16, 17 and 18 show the distribution of frequency for the score rate of Type A and Type B by each class.

In SC class, the average score rate with standard deviation for Type A is 88.8±11.0 and for Type B is 76.8±18.2. In CN class, the average score rate with standard deviation for Type A is 91.4±10.5 and for Type B is 74.5±17.1. And in AE class, the average score rate with standard deviation for Type A is 89.7±13.6 and for Type B is 78.0±16.3, respectively. In each class, between Type A average score rates and Type B ones, the significant difference is identified ($P < 0.01$). This suggests that the visualization of the interior space open for two floors or more is more difficult than that of the interior space enclosed in one floor.

4. Conclusion

PIT is developed to measure the visualization ability of the architectural space. To know the feature of visualization ability of architectural space, PIT and MCT-J [2] were applied to 253 students at the same time. The results are as follows.

1. As for MCT-J [2] applied for Osaka University students in this experiment, the distribu-

tion of the correct answer rate is generally lower than that of Tokyo University students, while the relative distribution giving the correct answer rate is in good similarity. As for MCT-J, the average score with standard deviation is 19.4±4.3 points (full score: 25 points). As for PIT applied in this experiment, the average score with standard deviation of PIT is 23.9±3.7 points (full score: 30 points).

2. The correlation coefficient between PIT and MCT-J is 0.3413. The test results of PIT are correlated to MCT-J results to a little extent.
3. As for PIT, the average score of the problems on interior space is higher than that on exterior space ($P < 0.01$). As far as PIT is applied in this experiment is concerned, it is more difficult to visualize the exterior space than the interior space.
4. As for PIT, the average score rate of the problems on the interior space enclosed in one floor is higher than the one open for two floors or more ($P < 0.01$). As far as PIT is applied in this experiment is concerned, it is more difficult to visualize the interior space with the atrium opened through two floors or more than the interior space enclosed in one floor.

The above results suggest the possibility to organize the objective test to assess the visualization ability of architectural space. To this end, the additional PIT(s) referring to the buildings other than the residence is to be conducted and the narrative question are on subject students' thinking process while working on the problems are to be conducted at the same time. The clarification of the process of reading/interpreting/visualizing the architectural floor plans and the space is left for future research.

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