DEVELOPMENT OF TEACHING MATERIALS TO SUPPORT SPATIAL IMAGINATION IN ARCHITECTURAL DESIGN EDUCATION

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Abstract

The purpose of this study is to create teaching materials to assist spatial imagination in architectural design education and to clarify the characteristics of a student's virtual space imagination. It is helpful to consider the implementation method of a space matrix sheet. In architectural design, it is important not only to draw a planar drawing but also to imagine the scene as a 3D space, the activities of people living there, and the atmosphere of the space. Early-stage students in architecture often connect spaces simply by creating each desired space independently, thus resulting in functional failure and not forming a sequence of rich spaces. Therefore, in university-level design education, educators often have to emphasize functional contradictions and advise students to create a sequence of spaces, thereby wasting time. In this study, for a student housing design exercise, we developed a spatial-imagination sheet with which to create a space by making students conscious of connecting the space according to the scene, and we tried it in a design education class. Specifically, we made the students rank the initially designed spaces in order of importance. We then created a space matrix sheet for the image by combining of spaces and allowing the students to write the scenes that they imagined on that sheet. By analyzing the scenes that students wrote on the spatial-imagination sheet, we confirmed the effect. As a result, the following points were clarified. Students with high design evaluations created many scenes, particularly ones such as "seeing" and "thinking." It was found that active virtual acts induced a continuous image. When using the space matrix sheet, by actively imagining an image of active virtual acts, it becomes possible to visualize the space continuously. This approach helps in the construction of the sequence. The upper group made it easy to "see" inside orientation from the surrounding space by setting "others" in the main space. Therefore, when making early-stage students use the space matrix sheet, setting "others" in the space to be visualized makes it easier to connect the spaces.

Keyword Design method, Design education, Esquis, Scene, Teaching material

1. Introduction

1.1 Purpose

In this study, we developed teaching materials to aid in thinking about the interconnection between design spaces. We experimented with architectural design exercises for students, and clarified the characteristics of thestudents' imagination of space. It is also helpful to consider the implementation method.

1.2 Background

In architectural design, various design conditions (e.g., climate, the environment around the building site, the lifestyle of the family, requests made by the family) are analyzed repeatedly by trial and error as part of the design proposal. Generally, because houses are small relative to the entire design site, a designer will often choose a design plan at the beginning of a design. In design education for students, we work on designing individual problems while worrying about them individually. At that time, the designer imagines the virtual space as a real space while drawing a sketch, and chooses the space to determine the design of the space. In addition to the inspiration of the designer, it is necessary to be able to imagine space realistically, to experience many different spaces, to sense the scale of spaces, and to imagine life scenes. In particular, in designing an attractive space, it is important to be able to imagine living scenes and spatial sequences. Early-stage students tend to be interested in the functions, designs, and overall shapes of individual spaces, and one often observes

that they design without being aware of connecting spaces. Therefore, it is important for educators to use teaching materials that allow students at the initial stage of design education to think about interconnecting design spaces.

1.3 Position of past research and this research

In the research on the initial design method, various models were proposed aiming at the rationality of production. R. D. Watts (1966) [1] proposed a spiral model that goes from abstraction to concretion while repeating “Analysis” “Sysnthesis” “Evaluation” “Realization”. Also Donald Alan Schön (1983) [2] explains, based on a case example, experts such as architects, industrial engineers, urban planners and others developing a unique practical epistemology through dialogue with the situation in actual work . Among them, a teacher with a technique (artful) needs difficulty as a child’s disadvantage when a child learns how to read, as a disadvantage of “how to teach a teacher”, teachers trouble students He says something must be found. He also stated that he must do small experimental work on the spot then in the classroom. Furthermore, this research that we have to practice small experimental research at the moment in the classroom at that time also gives students a challenge and teaching materials in architectural design education, observes, records and analyzes the situation. Based on that consideration, it aims to make educational programs and teaching materials better. Akin (1984) [3] and Eckersley (1988) [4] performed design experiments by using protocol analysis. Despite having relatively few subjects, they attempted to clarify the units that can recognize the drawing and to model the design action and knowledge structure. In recent research, G.Goldschmidt(2014) [5] developed a linkography for a method for notation and analysis of the design process. She clarifies the design and suggests how the designer creates ideas, creates ideas, and puts them together in meaningful ways. She shows that there is logic in the creative process. Linkography shows how networks are connected by analyzing protocols obtained in design exercises. Also in Japan, In research on the architectural design process, Sakatani and Monnai (2015) [6], which was influenced by Donald Alan Schön and G.Goldschmidt analyzed the thinking process by describing the contents (protocols) of dialogs of students as subjects of experiments. By focusing on the dialog in the design process, they analyzed the collaborative design process. This paper shows the features that create new ideas while referring to not only the designers themselves but also the ideas generated by dialog partners. In design experiments Wada (1999, 2009) [7,8] involving our previous practitioners and students, we analyzed contents focusing on scenes such as emotions and scenes that designers feel when proceeding with design tasks. From there, the thinking content of the practitioner was observed extensively, such as how to use space, size, detail, atmosphere, and environment. By contrast, the thought contents of students include many functions and atmospheres of space (e.g., its size) with relatively few actual details. It is clear that there exist a few elements to make the space realistic. In the present research, we prepared teaching materials to aid in thinking about the connection between design spaces and created a housing design exercise to test students. From the analysis results, we clarify the characteristics of the student’s spatial image. We then discuss how to improve the created teaching materials and how to implement them.

2. Research method 2.1 Survey method

This research involved a housing design exercise for the sophomores (29 students) of the architectural course of the Polytechnic University of Japan. The theme of the design challenge is a “two-generation home with music as a hobby.” The students were instructed to use a sheet of paper (Table 1), and no limitations were placed on their use except for the date and number of the schedule. In the intermediate presentation of design issues, students were requested to use a single-line planar view, an elevation view, and a cross-sectional view. The students used their drawings to present their own house designs. After the presentation, the design space was arranged in descending order of importance to the students. Thereafter, we tried a space matrix sheet that visualized two spaces from two directions by using eight designed spaces. This sheet is called a spatial matrix sheet. Furthermore, after the presentation of the final work, students of the same grade undertook mutual evaluation of their work (Fig. 1). An example of a student’s design work is shown in Fig. 2. Each student designed a two-story house, which was evaluated on a four-level scale. The evaluations from the other students were collected, and the average was used as the student’s evaluation. The four levels (and their numerical equivalents) were “good” (4), “somewhat good” (3), “somewhat bad” (2), and “bad” (1). Although it was fellow students who evaluated the works, we confirmed

that their scores correlated with those of the two educators who graded the final presentations ($r = 0.8551$, $p < 0.05$).

After the presentation of final work, the sketches and space matrix sheets were collected. In the analysis, 23 students were excluded from the data (Fig. 3). In this study, we compared the characteristics of the space image of the first-graders with those of the group with the highest evaluation of their work (Group A) and the group with the lowest evaluation of their work (Group B).

Design education period	Apr. –Jun. 2017
The theme of design challenge	Two-generation home with music as a hobby
Design condition	Flat area in the suburbs of Tokyo Usage area: Residential area Site area: 225 ㎡ Building coverage: 50% Floor-area ratio: 100% Total area: 120 ㎡～ 150 ㎡ Structure: wooden
Submitted drawing and model	Design purpose Plans on each floor by hand drawing(1/100) Elevation view 2 surface / section 1 surface(1/100) Indoor perspective Model(1/50)
Collected design information	Esquis sheet Spatial image using space matrix sheet Final work Design evaluation by the students of the same grade Design work evaluation by 2 faculty teachers
Design education object	architectural course of the Polytechnic University of Japan (Sophomore,29 students)

Table 1 Outline of design education

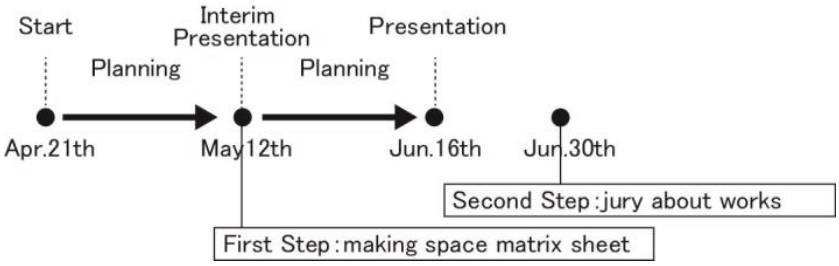


Fig. 1 Process of architectural design education

2.2 Classification of Acts in Virtual Space

We used the matrix sheet to practice connecting spaces together. Fig. 4(a) and (b) shows the space matrix sheets written by students in Group A and B, from which we extracted scenes. In this research, we define a scene as a feeling that a designer has in a virtual space, and life emulated and acts done by the designer himself or others in that virtual space. Here, we distinguish the sequential scenes as one act or scene and treat each scene as one virtual act. This extracted virtual behavior is shown in Fig. 5 and is classified into the four types: “seeing,” “thinking,” “behaving,” and “moving” (virtual behavior classification).

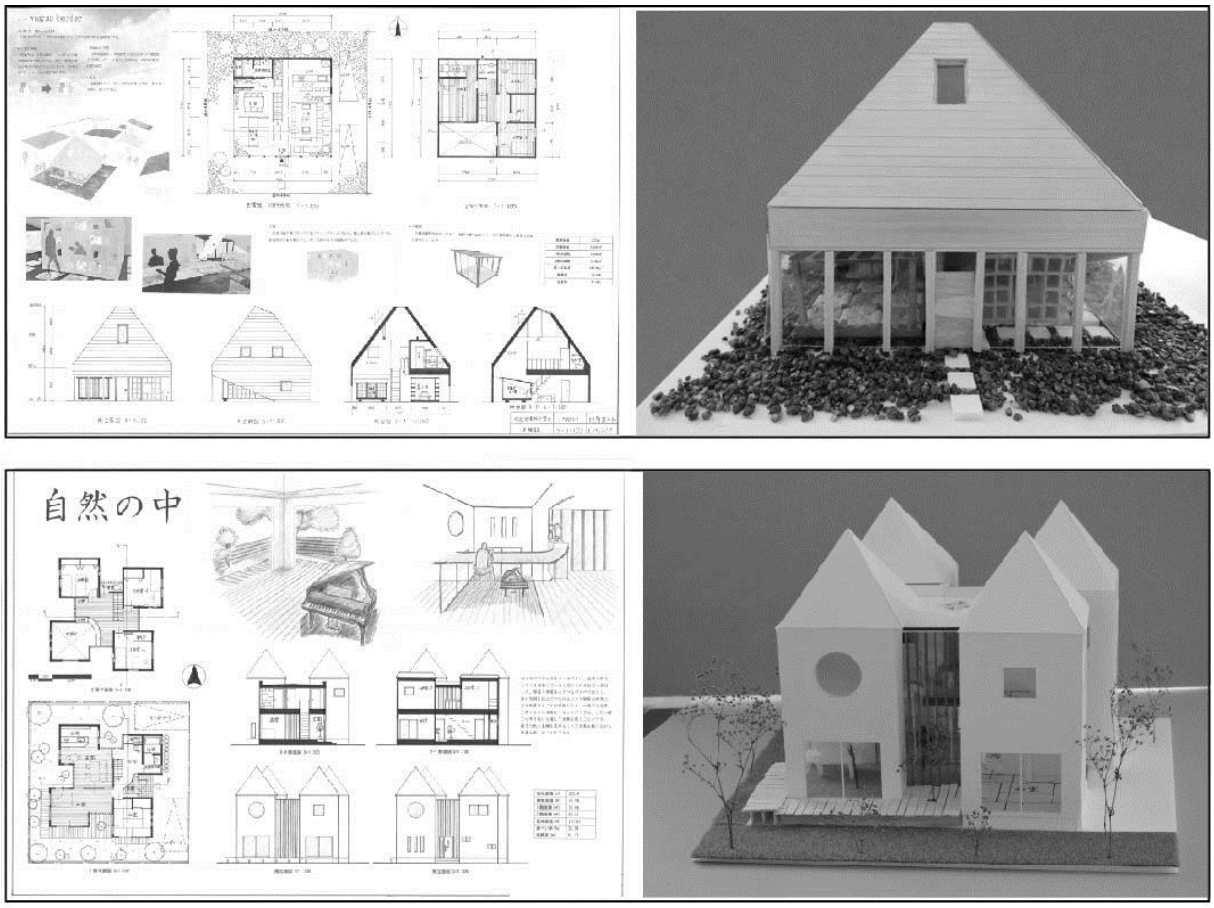


Fig. 2 Student design works

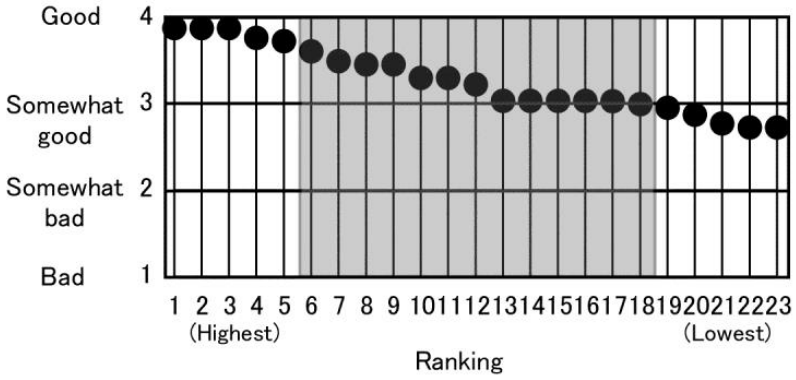


Fig. 3 Rank of evaluation and student to be analyzed

Connection of space (direction of consciousness)

High ← importance → Low

No. Name

Space name / How to use	1 Studio	2 Kitchen	3 Living	4 Dining	5 Japanese style room	6 Child room	7 Couple's bedroom	8 Garden	9 Bathroom	10 Toilet
1 Studio	Where to listen to records	Cooking with listening music	Talking with listening music	Eating with listening music	Listening music	Cut off noise (study and sleeping space)	Seeing some speakers from garden area	not closer to listening area		
2 Kitchen	Kitchen and studio are better not to be too close.	Cook	When kitchen and living room are near, it is easy to put out tea etc.	Kitchen and living room should be nearby	LDK and Japanese-style room are often used together	It is better for kitchen to be visible from child's room		connection by window between kitchen and garden area is a little less		
3 Living		Living room and kitchen should be nearby	Discourse and relax	Living and dining should be nearby				Can see garden area from living room		
4 Dining		Dining and kitchen should be nearby		have a meal				Can see garden area from dining room.		
5 Japanese style room		It is better to be near as customer comes	Japanese room and living room should be nearby	Japanese style room and dining room should be nearby	To relax			Can see garden area from Japanese style room.		
6 Child room						Space used by individuals	The couple room and the child's room can deal with disasters closer	Can see garden area from children's room.		
7 Couple's bedroom						The couple room and the child's room can deal with disasters closer	Space used by individuals	Even if it is sunny, it does not have much problem		
8 Garden			Living room is better to be seen from garden area	Can see dining from garden area				Common place It is better to see from inside		
9 Bathroom									Relaxing place	
10 Toilet									Toilet and bathroom should be summarized	

High ↑ importance ↓ Low

Group A (Highest)

Connection of space (direction of consciousness)

High ← importance → Low

No. Name

Space name / How to use	1 Studio (music room)	2 Dining	3 Kitchen	4 Living	5 Garden	6 Child room	7 Couple's bedroom	8 Guest room	9 Bathroom(2F)	10 Lavatory(2F)
1 Studio (music room)	It is better not to hit the sun so much as there are instruments	Seeing nature form studio	Seeing from the window	Easy to acces from rooms	Keep to some distance	Connect with door				
2 Dining		Block the line of sight from neighbor	Can see from the Dining		There is a door near the courtyard nearby	Can see from the window				
3 Kitchen			Sunny		Not too far					
4 Living				Easy to go to living room from any room						
5 Garden					Unobtrusive	It is not too close.				
6 Child room						To put an instrument The sun is not hit	Not too far	Not too far		
7 Couple's bedroom							Sunny			
8 Guest room								Sunny		
9 Bathroom(2F)									Sunny	
10 Lavatory(2F)										The sun is not hit

High ↑ importance ↓ Low

Group B (Lowest)

Fig. 4 Example of filling space matrix sheet

3. Results and discussion

3.1 Characteristics by Virtual Act Classification

To clarify the characteristics of the virtual acts imagined by Groups A and B, the number of types for each virtual-act classification is shown in Fig.6. The number of virtual act types of Group A was about twice of that of Group B. “Behavior” was the most frequent in both Groups A and B, and “moving” was the least frequent. By contrast, “thinking” had a big difference between Group A and Group B. The Group A imagined more virtual acts than Group B. The reason why “behaving” is the highest for both groups is considered as follows: When thinking about the virtual space, it was easier to perform the virtual act by projecting the designer in one space than the virtual act between the two spaces. Furthermore, it is considered that the smallest “moving” between Groups A and B is different from “seeing” and “thinking” because it could adapt only to the adjacent space. In “thinking,” there was a difference between Groups A and B, and the following two reasons are conceivable:

1 Group A visualized the virtual space as if it were the real space than Group B.

2 We interconnected noncontiguous spaces with virtual acts.

3.2 Characteristics of the same and unique virtual act

Among the virtual acts extracted, common actions were extracted from multiple students, and specific actions were extracted from only one student. Fig. 7(a) and (b) show the numbers of types in terms of common actions and specific actions. The numbers for Group A were approximately twice those for Group B for both common actions and specific actions. Furthermore, the common behavior “behaving” was the largest among Groups A and B. It may be easy for the designer to perform “playing” and other activities in one space. The number of types of distinctive actions of “thinking” was three times higher in Group A than in Group B. To compare the contents, Table 2 shows the specific actions of “thinking” of Groups A and B. From there, the “thinking” of Group B is expressed such as “the sound echoed,” “come to hear music,” and so on. It was only a virtual act according to the contents of the design theme. However, the “thinking” of Group A included images of feelings received from the space and the grasp of the space, such as “feeling a wide space” and “feeling nature.” Group A performed a virtual act while feeling the virtual space which was to be designed rather than group B, who performed in a real space.

	Code	Virtual Acts
	Seeing	(Visual) See, Watch, etc.
	Thinking	(Spatial recognition) Think, Feel, Want to do, etc.
	Behaving	(Behave in space(rooms)) Rest, etc.
	Moving	(Moving) Transfer, Gather, Turn, etc.

Fig. 5 Classification of virtual acts

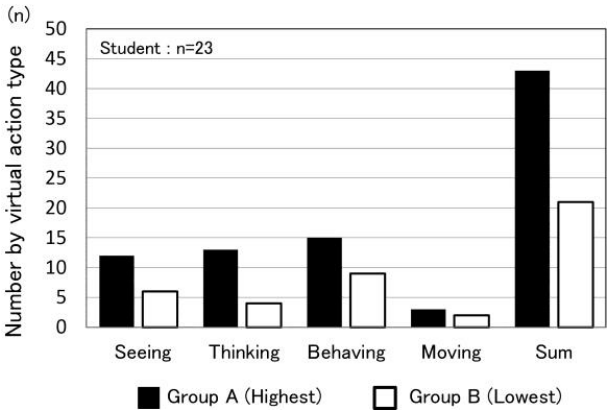


Fig. 6 Number of virtual acts

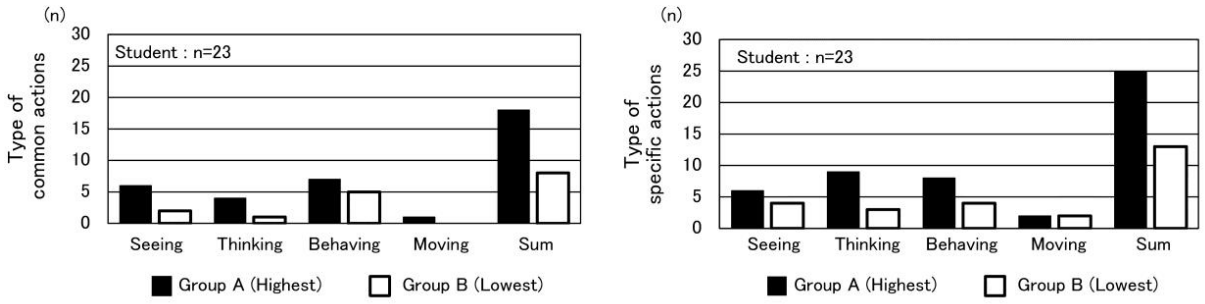


Fig. 7 Type of common actions and specific actions

3.3 Relationship between active virtual acts and consecutive images.

The virtual acts of Group A include passive acts such as “audible” and “sound resonates,” as well as spontaneous virtual acts (active acts) such as “talking” and “calling people.” Therefore, by focusing on active acts, the active acts of Groups A and B are shown in Table 3. In addition, a continuous image is also shown in the figure. There was an active act in “seeing” and “thinking” only in Group A. By confirming a continuous image, we found that everything contained active acts. These results show that active acts induced a continuous image. In Group B, the setting of “others” was small in the main space. It is considered that this group makes it easier to “see” inward from the surrounding space, centering on these “others” by setting the “others” in the main space. By contrast, in Group B, there is no central space when imagining space. These facts influence the process and the sequence of space when designing a work.

3.4 Image to main space

To clarify the characteristics of the way of how to connect the most important space (main space) to other space , the image direction is made inward (inside orientation) and outward (outside orientation) (Fig. 8). Furthermore, Fig. 9 (a) and (b) shows the virtual actions of other people (others) who performed virtual acts while imagining a connection of the space. Group A has more connections between the main space and other spaces than Group B. Among the students of Group A, the designer performs many “behaviors” in the main space and sets “others” to connect the space. Furthermore, Fig. 10 shows the numbers of inside orientations and outside orientations and the numbers set by others. There were many virtual acts of the inside-orientation type of “thinking” in both Groups A and B.The main space was a hobby room related to music. Therefore, it is considered that virtual acts on the perception of sound concentrate from the surrounding space to the main space. In Group A, there were many inside-orientation “seeing” and “thinking” that set others in the main space (Fig. 11).

Group	Active (Thinking)		
Group A (Highest)	Feeling a wide space	Feel nature	Uunderstand coming someone instantly
	Listening exercised music	Cut off noise	playing music in the studio with relaxed
	Try to hear the play	Have open-minded	Feel having open-minded
Group B (Lowest)	Connect with sound	Come to hear music	The Sound echoes

active acts

Table 2 Active acts (Thinking)

	Rank	Connection with spaces				
Group A (Highest)	1	**Cooking with listening music**	**Talking with listening music**	**Eating with listening music**	**Listening music**	Cut off noise study and sleeping
		Seeing some speakers from garden area	not closer to listening area			
	2	Can have open-minded and feel nature by **playing** and **see garden** in studio	**Can play with** having open-minded by opening ceiling, feeling a wide space	Can change large room by putting off screen in living room **during playing**	**Can listen music from deck and garden**	**Can watch at performance**
		Can see and hear the play with reading books at 2nd floor	Can Listen and watch at music			
	3	Listening exercised music	Watching at exercised music	Listening music	Watching at music	**Watching at perfomance**
		Can see family with practicing the music	**Can see guests**	**Can see outside with playing the music**		
	4	**Try to hear the play called peple in living room**	**Have open-minded by playing to garden**	**Children get down after starting to hear music**	Uunderstand coming someone instantly	Exist the space from non-looked directly
		Can see playing music in the studio with relaxed	**Can see playing music in the studio**	**Can see playing music with eating**	Seeing stage from the entrance directly	
	5	Reach the light in the courtyard	Seeing each other through the windows	**Can play non worried about others**	**Can see a figure playing music**	Not hearing music from music room
Group B (Lowest)	19	**Can see having with family from studio**	**Can see cooking from studio**	Hearing sound in guest room	Seeing couple from studio's garden	Seeing childroom from studio
		Hearing music from studio	Seeing garden from couple-room			
	20	**Can see having with family with playing**	**Can not see rooms directly**	Seeing rooms through the fixed windows	Seeing the stage from the front position	Seeing the stage
	21	Seeing nature form studio	Seeing from the window	**Easy to acces from rooms**	Keep to some distance	Connect with door
	22	The sound echoes	Connect with sound	Near to the space	Neighborhood	
	23	Come to hear music	Come to hear having with family	Seeing family	**Can grasp family's state**	

Highlighting Word···Active Acts ···Continuous Image

Table 3 Continuous space connection

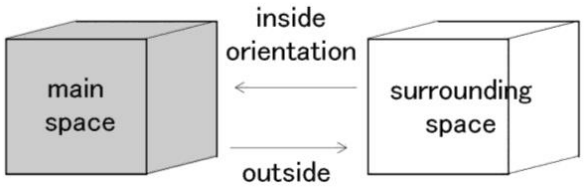
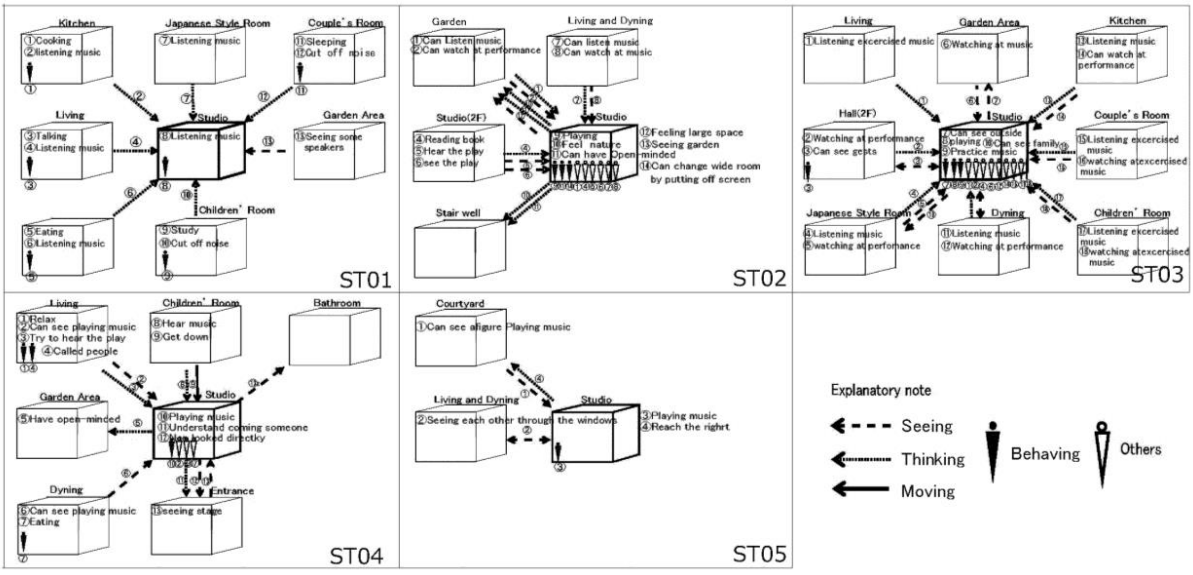
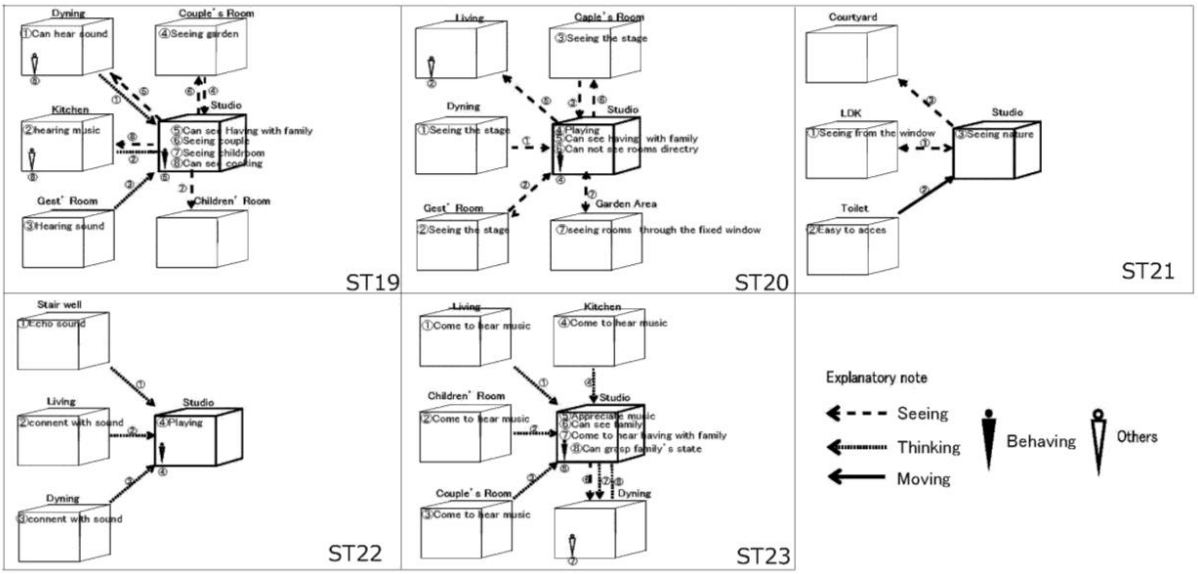


Fig.8 The way of connecting the main space and the image direction



(a) Group A (Hghest)



(b) Group B (Lowest)

Fig.9 The virtual actions that set others when imagining

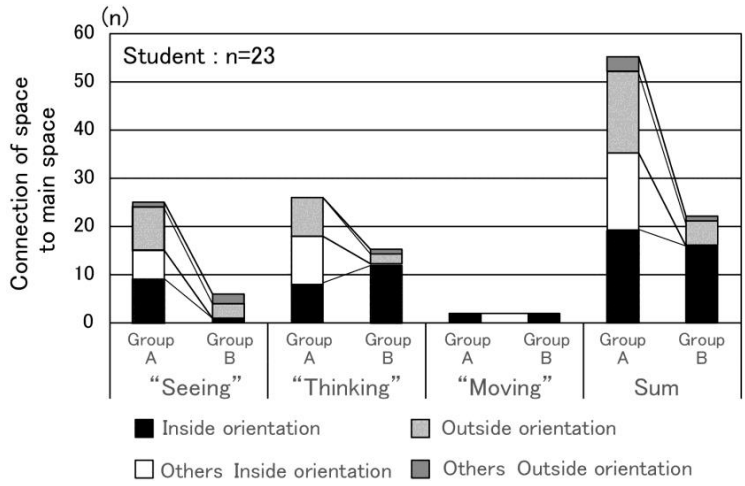


Fig.10 Relationship between setting of others and direction connecting space

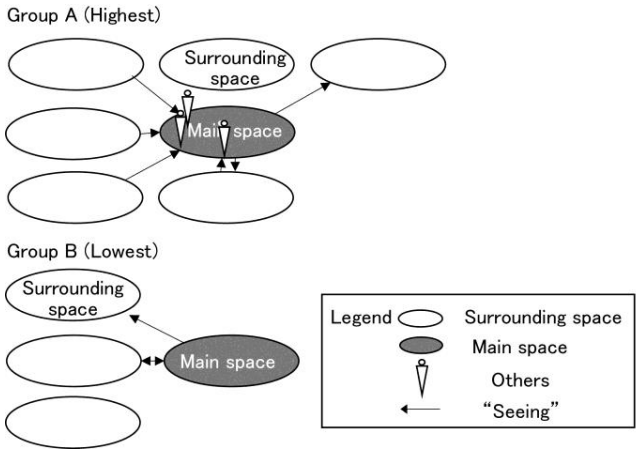


Fig.11 Main space and virtual acts

4. Conclusion

As a result of analyzing students' virtual acts and analyzing Groups A and B, the following points were clarified:

1 The number of differences of the type of virtual act imagined by Group A was more than twice that of Group B. Therefore, it is important to write many virtual acts on the space matrix sheet.

2 Students can now do the following by using the space matrix sheet.

1) Students can "behave" in one space. 2) Students can use "seeing" or "thinking" to create images connecting

multiple spaces.

3) However, students cannot imagine “moving.” “Moving” affects flow lines and sequences. Therefore, when using the space matrix sheet, it is necessary to advise the user to use “moving” in two spaces.

3 It was found that active virtual acts induced a continuous image. When using a matrix sheet, by making an image of active virtual acts, it becomes possible to visualize the space continuously. This process helps in the construction of the sequence.

4 We found that active acts induce continuous images. When using the space matrix sheet, by making the act actively consciously imagine, it becomes possible to visualize the space continuously. This process helps in the construction of the sequence.

5 Group A made it easy to “seeing” and “thinking” inside the orientation from the surrounding space by setting “others” in the main space. Therefore, when making early-stage students use the space matrix sheet, setting “others” in the space to be imaged makes it easier to connect the spaces.

6 In this research, teaching materials were created to help the students at the initial stage of design education notice the connection of the space. In the future, the following teaching materials will be necessary:

1) Teaching materials to help in continuously imagining many spaces.

2) Teaching materials for self-checking design contents by virtual acts

5. Acknowledgments

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