Abstract
This is a study of forms loosening in German modern architecture. Through computer graphics form analysis, we have explored the design process of Hannes Meyer's (1889-1954) Federal School of the General German Trade Unions Federation (ADGB) (1928-1930). We then verified our conclusions with Meyer's own explanations. In Chapter 2, we have examined the formation of the psychological effects of the glazed corridor during the design process. In Chapter 3, we have clarified the formation of the method known as "dissolution into the landscape" through the analysis of landscape and architecture. Then in Chapter 4, we have explained that a "biological" concept is present in these two methods. Meyer loosened architectural form based on a "biological" concept and presented a new architectural methodology at the end of the 1920s.

Keywords: Bauhaus; Hannes Meyer; modernism; Germany; computer graphics

1. Introduction
Modernist architect Hannes Meyer (1889-1954), the radical functionalist, was also the second Bauhaus director (1928-1930). Director Meyer moved away from Bauhaus formality by introducing scientific methodology while simultaneously designing his most important work, The Federal School of the General German Trade Unions Federation (ADGB) at Bernau near Berlin from 1928-1930. The staggered form of the school comes from Meyer's concepts, each with its own theory, arriving from different departure points to loosen the formality of Modern Architecture. Discussing these problems as a single concept complicates analyzing them.

Past studies have concentrated on the psychological effects and relationship to the landscape, examining these theoretical backgrounds independently1. To understand the theoretical context in which Meyer's ideas were shaped, we need to consider Klaus-Jürgen Winkler's thesis on the biological concept of the ADGB School2.

During Meyer's design process, he considers biological concepts concerning psychological effects and landscape. The present study, in Chapter 2, analyzes the psychological effects in the glazed corridor with 3D-Computer Graphics (CG) representation and his explanation of the project. In Chapter 3, the dissolution in the landscape in teachers' houses was analyzed using the same method. In Chapter 4, the results of Chapters 2 and 3 were discussed on his theoretical background. Analyzing these different elements in his argument, I will show what each element signified in the "biological concept" for his method of loosening conventional architectural form.

This paper examines three plans, the competition plan (drawn April 1928, Fig.1.)3, the architectural application plan (drawn 16 August 1928, Fig.2.)4 and the execution plan (drawn 31 May 1930, Fig.3.)5.

2. Psychological Effects of the Glazed Corridor
2.1 Formal changes
The competition plan's corridor is characterized by its independence from the dormitory building, due to the shadow garden between the dormitory building and the corridor (Fig.4.). In that section, the corridor was attached to the dormitory building after the competition plan can be seen in the pergola that unifies the form of the glazed corridor and the shadow garden.

The architectural application plan's corridor is characterized by its independence from the dormitory building and the disappearance of the shadow garden (Fig.6.). In that section, the corridor was attached to the dormitory building after the competition plan can be seen in the pergola that unifies the form of the glazed corridor and the shadow garden.

The architectural application plan's corridor is characterized by its attachment to the dormitory building and the disappearance of the shadow garden (Fig.6.). In that section, the brick, concrete and glass block wall of the dormitory building appears because the corridor is attached to the dormitory. The roof and the northwest wall are still glazed. From the viewpoint of the corridor of the community building side (Fig.7.),
the lawn can be seen through the glass wall on the northwest side and the staggered walls of the dormitory building are seen directly through the glazed roof.

The execution plan is similar to the architectural application plan (Fig.8.). However, the former plan is characterized by a waterproof Ruberoid finished roof and a wood finished ceiling. In brief, only the northwest side wall is glass. From the standpoint of the corridor of the community building side (Fig.9.), the lawn can be seen through the only glass wall on the northwest side. On the southeast side, the staggered brick walls are viewed directly.

The changes made to the architectural form during the design process are represented in Table 1. In the end, the glass wall was restricted to only the northwest side where the lawn can be seen. Thus, the glass surfaces were gradually limited to the lawn side, and the dormitory building’s staggered form was gradually acknowledged inside the building.

2.2 Psychological effects

It has been speculated that these design changes occurred due to practical problems in the design process. However, in this paper, the author instead examines the relationship between the design changes and Meyer's ideological changes, especially vis-à-vis the psychological effects. Meyer's psychological effects could be categorized into two categories, based upon Meyer's own explanation of the building. The first is the psychological effect wherein man acknowledges social community through the impression caused by the space composition; the second is the psychological effect that causes man to relax upon viewing the landscape.

According to his explanation of the competition plan (1928), Meyer had the following intention for the glass corridor:

"[the] automobile approach [and] main entrance point to its underlying purpose. special entryways to the auditorium (conferences!) along the glass-covered walkway also permit quick orientation for the new entrant; orientation and access (without going astray) to each elemental part of the building: residential areas, sport, school."  

When comparing Meyer's intention with the formal analysis, it can be said that there is an effect of recognizing the composition of the building. In other words, this community becomes organized by making the glass corridor independent from each building and making the ceiling and both sidewalls glazed into a corridor.

In the explanation of the execution plan, the psychological effects of the glass corridor are described as follows:

"During rainy periods lasting several days good humor was preserved by ensuring there were plenty of things for the students to do and that their view of nature outside continually changed. It was with this in mind that the main glazed corridor was designed on an incline with re-entrant corners and glass walls affording a view of the school as a whole while other windows brought the beholder into contact with nothing but forest and nature."
Table 1. The Design of Corridor

| Plan                        | Relationship to Dormitory Building | Northwest Wall | Roof               | Southeast Wall                      |
|-----------------------------|------------------------------------|----------------|--------------------|-------------------------------------|
| Competition Plan            | Independent                        | Glass          | Wire Glass         | Glass                               |
| Architectural Application Plan | Attached                           | Glass          | Glass              | Brick, Concrete and Glass Block     |
| Execution Plan              | Attached                            | Glass          | Roof: Ruberoid roofing Ceiling: Wood | Brick                              |

Fig.4. Hannes Meyer and Hans Wittwer, Federal School of the General German Trade Unions Federation, Competition Plan, April 1928, (The Remarks were Written by Author)

Fig.5. Glazed Corridor of Competition Plan (CG)

Fig.6. Meyer, Federal School of the General German Trade Unions Federation, Architectural Application Plan, 16 August 1928, (The Remarks were Written by Author)

Fig.7. Glazed Corridor of Architectural Application Plan (CG)

Fig.8. Meyer, Federal School of the General German Trade Unions Federation, Execution Plan, 31 May 1930, (The Remarks were Written by Author)

Fig.9. Glazed Corridor of Execution Plan (Photo: Walter Peterhans)
If you contrast this explanation with the architectural form change, it is understood that the rugged walls of the dormitory building promote psychological effects that shape the school community's organization. Moreover, as already noted, the glass planes of the corridor were gradually decreased and limited to the northwest side in the design process. According to Meyer's explanation, this formal change had the result of forcing the eye of the beholder to rest only upon nature and the forest.

As mentioned above, the architectural form had been recognized through the use of glass in the competition plan; however this had changed gradually in the design process so that the psychological effects might become more pronounced. Consideration of the psychological effects of viewing nature through the window is the intent behind the competition plan. To illustrate this intention, the plan has arrows indicating the direction of the glance. As well, a student looking at the forest and nature through the window was drawn in those sections (Fig.10.). Therefore, changes to the glass corridor were likely made to gain the desired psychological effects.

3. Dissolution into the Landscape in Teachers' Houses

3.1 Formal changes

One feature of the teachers' houses in the competition plan is their layout, which makes the architecture abut the landscape (Fig.11.). As a result, the architectural volume reflected an inclination toward the landscape. In other words, geographical site features were incorporated in the planning layout.

The floor space of one unit of the teachers' house was increased in the architectural application concept, expanding the total length of the teachers' houses. However, the composition was unchanged from the competition plan idea. Four units of teachers' houses were arranged squarely around a central building (Fig.2.) and along an inclined slope (Fig.12.).

In the execution plan, the floor space of the teachers' houses was closer to that of the architectural application plan. However, the composition changed so that the architectural form flatly runs along landscape or contour lines (Fig.3.). In other words, there is an increased relationship between the geographical features and architecture after a synthetic consideration of that mutual relationship (Fig.13.).

As the analysis reflects, the special characteristics of those changes are represented in Table 2. Specifically, throughout the changes from the competition plan to the architectural application plan, although the scale of the units changed, the design concept remained the same. However, the design concept did change from the architectural application plan to the execution plan despite the unit scale remaining unchanged. As evidenced below, in paying attention to such features, we can see that the change in architectural form mirrors Meyer's evolving ideas about landscape.

| Change of plan from Competition plan to Architectural application plan | Scale | Design method | Character of change |
| --- | --- | --- | --- |
| different | same | The same design method is adopted regardless of the different scale. |
| from Architectural application plan to Execution plan | same | different | The different design method is adopted regardless of the same scale. |

Table 2. The Design of Teachers' House
of scale and internal composition. Meyer expressed the relationship between architecture and landscape in an explanatory manuscript for the execution plan as follows:

"It has always been the nature of such a 'school in the forest' to disparage any change in the structure of the landscape.... the naturally formed ridges on the bank of a small forest lake already contain multifarious building components for living, schooling, gymnastics, dining, and gathering."¹⁰

Thus, it is thought that the vertical composition was determined by an idea that put architecture on rolling landscapes. In other words, if the site contains a hill, the composition of architecture is arranged like steps along the landscape's incline.

"The school organism, as does each living entity, should offer the maximum possibilities for life. The value of each building is its efficiency rather than its appearance."¹¹

Meyer's formal intention confirms the change from competition plan to architectural application plan. The design intentions of the teachers' houses in the two plans were, namely, adaptations to the landscape.

In the execution plan, the teachers' houses were not simply laid along the landscape, but were more integrated into it. That is, a piloti-type concept using geographical features was adopted. In this way, architecture was formed to appear to be dissolving into the landscape. This theory is confirmed Meyer's following description:

"The landscape came right under the teachers' houses and these modern pile-dwellers could step down from inside the house into their covered portion of garden."¹²

Thus, the method known as dissolution into the landscape was formed in the execution plan.¹³

As mentioned above, it was an adaptation to the idea of putting architecture onto the landscape that was seen in the competition plan and the architectural application plan. It was by dissolution into the landscape that the design formed a closer relationship between the landscape and architecture. Thus, it was clarified that the changes in the teachers' houses in the design process was a move from "adaptation to the landscape" to "dissolution into the landscape." A more elaborate relationship to the landscape was achieved in this design process.

4. "Biological" Architecture

Two methods of "biological" architecture, its psychological effects and dissolution into the landscape, have been clarified in previous chapters. In this chapter, these methods are further considered within the context of Meyer's use of the term "biological." Afterward, the term "biological" is examined as a term that forms the basis of the two methods.

4.1 Psychological effects in "biological" architecture

Meyer wrote a famous text, "building" (1928), in which he used the term "biological" as follows:

"building is a biological process. building is not an aesthetic process. in its basic design the new dwelling house becomes not only a piece of machinery for living in but also a biological apparatus serving the needs of body and mind."¹⁴

Thus, it can be understood that the term "biological" contained both psychological and ergonomic components. This attention to the psychological aspects was characteristic of Meyer during this period. Afterwards Meyer wrote the text "Bauhaus Dessau" (1940) using the words "psychological" and "biological" as follows:

"It was our hope to give added depth and richness to architecture by an analysis of the social situation and a careful study of all biological factors, special attention being paid to the psychological factors involved in the way people organized their lives."¹⁵

In this text, there are two overarching themes: social situations and the biological factor. The psychological effects were a notable point contained within these concepts. Thus, it is understood that "biological" is, so to speak, a major premise of Meyer's architecture and the resulting psychological effects are a method that Meyer especially valued among the subordinate concepts.

4.2 Dissolution into the landscape in "biological" architecture

Meyer had the idea that it was necessary to form a close relationship to nature in this school.

"Nature's shapes are so wonderfully patterned because it balances the multitude of demands from its organisms. In our best structures, we must come close to nature."¹⁶

The problem was how to arrange the architecture, in a way that accurately translated its function in the landscape along the lake in Bernau's Forest. Meyer described this task as follows:

"The building itself represents an attempt to design the organism of a school collective in an unambiguous way. Just like a crab at the seashore, this innovative 'school system' is located on the sand in the Mark Brandenburg by a small forest lake. As a crab demonstrates that its separate parts are functionally correct, so the school's construction elements point to the various functions of school life: the facade of the living space is not turned to the sun through coincidence and peradventure; rather the dwelling's orientation is calculated according to a biological methodology that strives to achieve the greatest possible solar illumination for all living quarters in this northern German clime. No bed without sun!"¹⁷

Thus, Meyer called the layout method "biological." As well, he joined the landscape and its architecture through the "biological" concept.
4.3 The Loosening of form through biological knowledge

Meyer wrote about his methodology, using the term "biological," in his manuscript as follows:
"the segmentation of the school building in bernau strives to follow biological order. recognizing commerce, sun, wind, warmth, sound and light, ventilation and space-defining factors. the result is an edifice that works as a constructive shell."18

In brief, based on biological knowledge, Meyer dismantled the formal school system and created new architecture such as the Federal School of ADGB. This methodology that loosened formalities, one based on "biological" knowledge and research, was a key feature in Meyer's architectural education at Bauhaus. Meyer wrote in "bauhaus and society" (1929) as follows:

"its [new architectural theory of bauhaus] creative media are -deliberately employed- the results of biological research."19

Therefore, biological research can be considered the heart of Meyer's Architectural theory.

5. Conclusion

Thus, we have revealed the changes within Meyer's architecture at the end of the 1920s by analyzing the design process of the Federal School of the General German Trade Unions Federation (ADGB). In Chapter 2, we examined the formation of the psychological effects of the glazed corridor during the design process. In Chapter 3, we clarified the formation of the method known as "dissolution in landscape" through analyzing landscape and architecture. Then, in Chapter 4, we explained that the "biological" concept is present in these two methods.

In the mid 1920s, Meyer was known for his radical functionalism and his criticism of conventional formalism in modern architecture. By the end of the 1920s, his modified functionalism based on biological knowledge and analysis opened a new vista for modern architecture. At the close of the 1920s. Through his introduction and use of the "biological" concept beginning at the start of the new decade, Meyer significantly modified modern architecture and became an architect who helped propel modern architecture to the next stage.

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Endnotes

1 K. Michael Hays, Modernism and the Posthumanist Subject, The Architecture of Hannes Meyer and Ludwig Hilberseimer, Cambridge, Massachusetts, The MIT Press, 1995 (1st ed. 1992), pp. 120-147. Simone Hain, "Schicksal der Landschaft. Perspektiven oder Fluchten eines Architekten," In: Funktionalismus-Utopie und Wirklichkeit, Bernau, bauendal bundesschule bernau e.V., 1998, pp.20-37.

2 Klaus-Jürgen Winkler, "Über den Wert eines Baudenkals: Die ehemalige Bundesschule des ADGB in Bernau," in : Johans Geist, Dieter Rauch (eds.), Die Bundesschule des ADGB in Bernau bei Berlin., Arbeitshilfe des Brandenburgisches Landesamtes für Denkmalpflege Nr. 1, Potsdam, Potsdamer Verlagsbuchhandlung, 1993, pp.6-21.

3 Hannes Meyer, "erläuterungen zum schulprojekt" (1928), in: bauhaus, Zeitschrift für Gestaltung, 2/3, 1928, Nendeln, Kraus Reprint, 1976, pp.14-15.

4 The pictures of these drawings belong to Bauhaus-Archiv Museum für Gestaltung, Plan Nr. 609/36, 30, 25a, 23a, 29, 28a, 24a, 26a, 27a, 19a, 20a, 21a, 22a.

5 Werner Kleinerenschl, Magdalena Droste (eds.), Hannes meyer 1889-1954 architekt urbanist lehrer, Berlin, Ernst & Sohn, 1989, pp.194-195.

6 Winkler, "Über den Wert eines Baudenkals" op. cit., pp.12-13.

7 "auto-anfahrt, haupteingang ergeben sich zweiwickbedingt. sonderereingang zur aula (konferen!) und der glasgedeckte laufgang ermöglichen auch dem neueintretenden rascheste orientationsmöglichkeit und (ohne fehlgehen) zugang zu jedem gebäudeelement: wohnung, sport, schule." Meyer, "erläuterungen zum schulprojekt," op. cit., p.15. (original text was written in small letter)

8 Hannes Meyer, "Federal School of the General German Trade Unions Federation, Bernau near Berlin," in: Claude Schnait, Hannes Meyer, Teufen AR/Schweiz, Verlag Arthur Niggli AG, 1965, p.49.

9 Meyer, "erläuterungen zum schulprojekt," op. cit.

10 "der charakter einer solchen > schule im walde < ließ jegliche sinnwidrig erscheinen... die natürlichen bodenwellen am ufer eines kleinen waldees tragen die so verschiedenartigen bauglieder für wohnen, schulen, turnen, speisen und zusammensein." Hannes Meyer, "manuskriptfragment zur Bundesschule des ADGB," IV(4)-82|1- 47. This manuscript belongs to Deutsches Architekturmuseum, (original text was written in small letter)

11 "Wie jedes Lebewesen soll auch dieser Schul-Organismus ein Maximum an Lebensmöglichkeiten bieten. Entscheidend für den Wert jedes Bauwerkes ist sein Nutzeffekt und nicht sein Aussehen." Hannes Meyer, "Bauen und Gesellschaft. Bernau an der Spree," in: Deutsche Gewerkschaftsbund in Bernau bei Berlin, Manuskript, IV(4)-82|1-445. This manuscript belongs to Deutsches Architekturmuseum.

12 Meyer, "Federal School of the General German Trade Unions Federation, Bernau near Berlin," op. cit., p.49.

13 Hannes Meyer, "VORTRAGE IN WIEN UND BASEL 1929," in: Hannes Meyer, Bauen und Gesellschaft, Schriften, Briefe, Projekte, Lena Meyer-Bergner(ed.), Dresden, Verlag der Kunst Dresden, 1980, p. 59. Arieh Sharon, Kibbutz + Bauhaus, Israel, Karl Krämer Verlag Stuttgart and Massada Israel, 1976, p.31.

14 Hannes Meyer, "building" (1928), in: Schnait, Hannes Meyer, p. 95. (original text was written in small letter)

15 Hannes Meyer, "Bauhaus Dessau 1927-30" (1940), ibid., p.112-113.

16 "Weil die Natur in ihren Organismen den vielseitigsten Lebensansprüchen gerecht wird, sind ihre Gebilde so wunderbar gestaltet. In unseren bestem Bauwerken müssen wir der Natur nahekommen." Meyer, IV(4)-82|1-445.

17 "Das Bauwerk selbst stellt einen Versuch dar, den Organismus einer Schulkommune eindeutig zu gestalten. Wie ein Krebs auf dem Sand am Meer liegt dieses neustartige "Schulwesen" auf dem natürlichen bodenwellen am ufer eines kleinen Waldes tragen die so verschiedenartigen bauglieder für wohnen, schulen, turnen, speisen und zusammensein."

18 Winkler, "Über den Wert eines Baudenkals" (1928), in: bauhaus, Zeitschrift für Gestaltung, 2/3, 1928, Nendeln, Kraus Reprint, 1976, pp.14-15.

19 The pictures of these drawings belong to Bauhaus-Archiv Museum für Gestaltung, Plan Nr. 609/36, 30, 25a, 23a, 29, 28a, 24a, 26a, 27a, 19a, 20a, 21a, 22a.
der Schule die verschiedenen Funktionen des Schullebens: Nicht zufällig und von ungefähr ist die Hauptfront der Wohngebäude der Sonne zugekehrt, sondern ihre Wohnrichtung ist mit biologischer Methodik errechnet in dem Bestreben, die grösstmögliche Besonnung aller Wohnräume in dieser norddeutschen Gegend zu erreichen. Kein Bett ohne Sonne!" Ibid.

18 "die in bernau angestrebte zerrümmernng des schulhauses ist eine folge biologischen erkennniss. verkehr, sonne, wind, wärme, schall und licht lüftung und raumbildende faktoren. der bau als konstruktive schale ist deren ergebniss." Meyer, IV(4)(2)-82|1-447. (original text was written in small letter)

19 "ihre gestaltungsmittel sind - bewußt angewendet - die ergebnisse der biologischen forschung." Hannes Meyer, "bauhaus und gesellschaft" (1929), in: Hannes Meyer, Bauen und Gesellschaft, Schriften, Briefe, Projekte, op. cit., p.52. (original text was written in small letter)

20 k. von meyenburg, "kultur von pflanzen, tieren, menschen" (1927), in: bauhaus, Zeitschrift für Gestaltung, 4, 1927, Nendeln, Kraus Reprint, 1976.

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