

Generation of non-functional architectonic spatial forms with geometric transformations

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Abstract – In the academic progression of architectural attitude and design competence it is important to give particular attention to the exploration and creative experimentation with spatial forms. In addition to the analysis of historical and contemporary architectural examples, significant role is given to modelling exercises which guide design students in a tentative way to the planar and spatial operation of compositional principles. During this process, a series of personal experiences develop the recognition and confident application of planar and spatial compositional tools and the ability to create tension or to maintain balance. These tools - albeit exerting their effects during subjective experience - are largely based on physical laws and operate according to the principles of visual (possibly tactile) perception, so their understanding and conscious application is a rational goal. In the analysis of architectural compositions, the relationship, location, size, juxtaposition or overlapping of forms - in other words their geometric relationship - is perhaps the primary factor, nevertheless the effects of materials, colours and textures cannot be ignored either. One of the distinctive characteristics of architectonic models is their ability to highlight certain pre-defined properties; in the case of forms made of homogenous materials for example, an enhanced attention to geometry, plasticity, and the impact of light and shadow. The focus of this paper is form-evolution generated through geometric transformations; a process during which a simple plane figure and subsequently a body is transformed (sliced, dragged, distorted, added or subtracted, etc.) resulting in architectonic compositions featuring architectural proportions and characteristics. These form-experiments are intentionally aimed at the generation of "non-functional" spaces, so the goal of the creation is not actual buildings, but rather the composition of pure spatial and volumetric relations in a philosophical sense, which, nevertheless, can provide the conceptual basis (in terms of form, mass, and spatial structure) for subsequent architectural outputs.

Keywords – Geometric Transformation, Architectonic Composition, Modelling, Experiencing Through Experimentation, Architectural Education

I. INTRODUCTION

The author of the paper is an architect, theatrical set & scenic designer, and lecturer of architecture at the Department of Graphics, Form and Design of

the Budapest University of Technology and Economics. He is the instructor and course director of the course 'Transformations'. His design and research activity gravitates around space creation,

spatial theories, and the complex relationships between space and body movement.

II. MATERIALS AND METHOD

Academic architectural education methodology for the development of theoretical and practical skills in spatial and volumetric creation. Geometric transformation-based experimental modelling techniques for traditional planar and traditional spatial compositions, as well as for the digital construction of virtual spatial models and their subsequent construction using traditional materials.

III. RESULTS

The methodology developed by the author, and its introduction in academic architecture education contribute to the advancing of creative skills in spatial and mass formation through the application of geometric transformations in planar and spatial composition, help understand and appreciate certain spatial theoretical considerations, and increase consciousness in creative decision making in the complex process of architectural design.

IV. DISCUSSION

The form-evolution generated through geometric transformations is a process during which a simple plane figure and subsequently a body is transformed (sliced, dragged, distorted, added or subtracted, etc.) resulting in architectonic compositions featuring architectural proportions and characteristics. These form-experiments are intentionally aimed at the generation of "non-functional" spaces, so the goal of the creation is not actual buildings, but rather the composition of pure spatial and volumetric relations in a philosophical sense, which, nevertheless, can provide the conceptual basis (in terms of form, mass, and spatial structure) for subsequent architectural outputs (Figure 1).

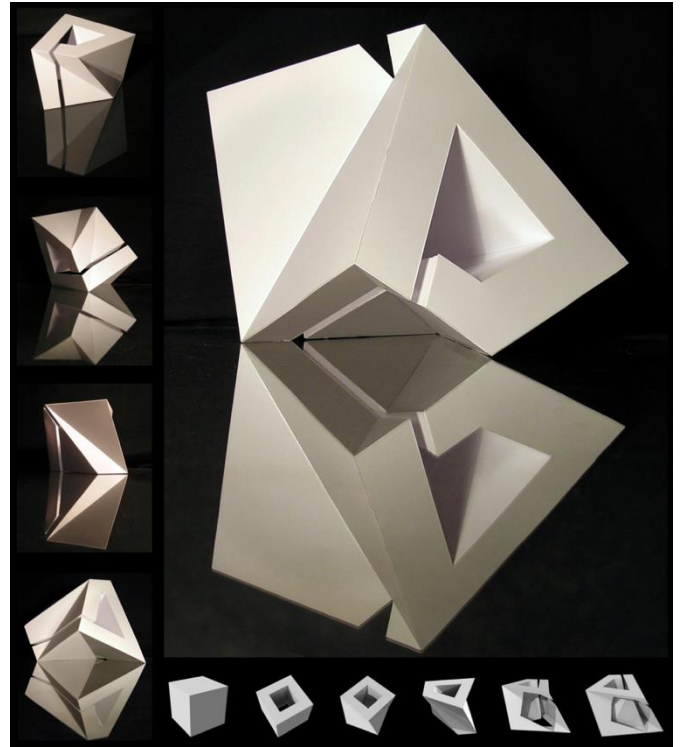


Fig. 1 "Non-functional" transformed space (B. Molnár) [1]

The construction of planar and spatial compositions provides an opportunity to make experimental measurements of the compositional balance or tension established through the position and relationship of the forms, and to record the results (Figures 2 – 5).

As a first approach in the analysis of a planar composition, one would try to locate a visual point of equilibrium which (just as a geometric centroid) represents a distinct position, buttressed at which point, the composition would not 'tip over'. If, however, one was to actually determine – on an experimental basis - the resultant centroid of the ensemble of forms in the composition and compare it with the centre point of a frame carefully moved around the composition until a sense of visual balance is found, one would find that these two points - in the vast majority of cases - do not overlap. This suggests that there are other factors (colour, contrast, shape, spatial depth, and even the relation of the position itself to the vertical) which may inflict a dissonance between the physical and perceptual equilibrium. Balance of course does not presuppose symmetry. Symmetry in fact would reduce the contrasting psychological forces and perceptual inductions involved in the composition. The analysis of the observations made with the involvement of multiple participants shows that the

recognition of the compositional effects and the tensions as well as the balance / imbalance created by them, is almost unanimous. Therefore, the interpretation of the visual effects is not subjective, i.e. not independent of physical and visual laws. The individual realization of this proves that a conscious analysis is possible, and can be developed, and also suggests ways to raise the conscious application to a higher level.

The planar and spatial composition exercises presented in this paper demonstrate the experimental creative process, which achieves the desired compositional effect through a series of geometric transformations. By slicing, dragging, and overlapping the initial forms, planar and spatial elements are created. The densification and dispersion of the elements create accents and energy centres which overthrow the previous static balance, leaving temporary imbalance before exposing interesting situations of dynamic balance.

however did not come with the spread of Newtonian physics but is determined by the much more deeply rooted essence of our physical world.

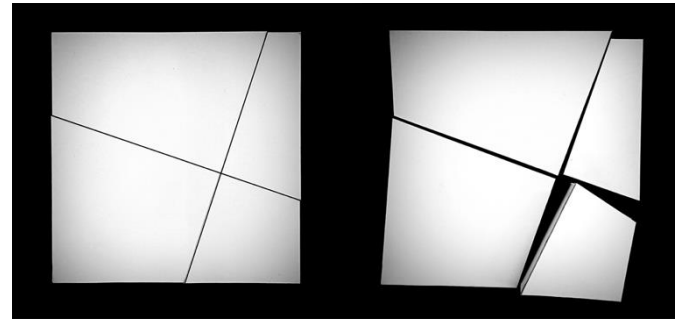


Fig. 4 Relief-like 3D composition A (Mark Vitek)

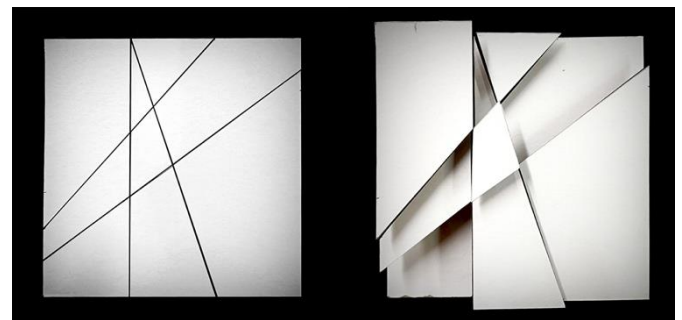


Fig. 5 Relief-like 3D composition B (Mark Vitek)

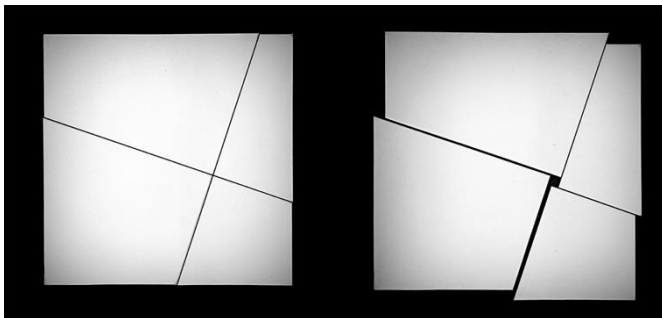


Fig. 2 Planar composition A (Mark Vitek)

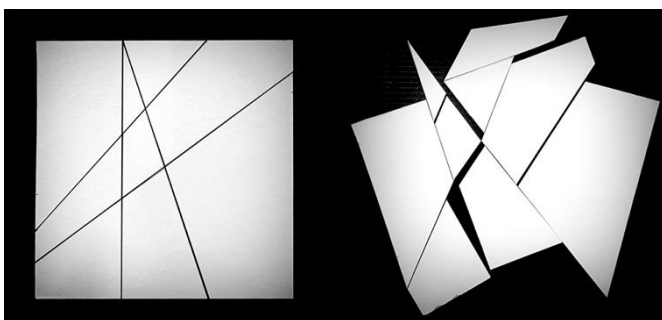


Fig. 3 Planar composition B (Mark Vitek)

Space is asymmetric due to the force of gravity: the potential energy of masses positioned higher is greater than those at lower position. Heavier elements ‘strive’ downwards, while lighter ones ‘strive’ upward. Consequently, the different spatial positions are dynamically unequal. This knowledge

In this relation, Herbert Langfeld suggests the following experimental example as demonstration: “If one is asked to bisect a perpendicular line without measuring it, one almost invariably places the mark too high. If a line is actually bisected, it is with difficulty that one can convince oneself that the upper half is not longer than the lower half.” [2]. This means that if one wants the two halves to look alike, one must make the upper half shorter. (Above a certain viewing angle, of course, perspective foreshortening can become an influencing factor.) An early manifestation of this experience in Roman architecture is the decreasing height of columns and increasing lightness on upper levels of trabeated structures. But one could look even further in the past. Plato refers to similar techniques in sculpting and painting: “for artists were to give the true proportions of their fair works, the upper part, which is farther off, would appear to be out of proportion in comparison with the lower, which is nearer; and so, they give up the truth in their images and make only the proportions which appear to be beautiful, disregarding the real ones”. German architect Fritz Schumacher discusses the same concept when stating: “Since grasping the sum of an architectural work is tied to

the connection of the optical and motor performance of a person, the creator must regulate both in an equal manner.” [3].

The same geometric transformations used to create simple planar or relief-like three-dimensional compositions are then also applied in space, on regular bodies. Cropping, dragging and rotation this time can be carried out in all directions. The additional spatial dimension increases the complexity of the compositional effects and thereby increases the complexity of the exercise. The masses and the spaces emerging in between prompt associations with architectural forms, and provide an opportunity to observe proportions, plasticity, the contrast of shadow and light, and to study the spatial behaviour of shapes, planes, and edges as they turn at the corners. These observations can also provide with actual insights to design. Insights which can be summoned in need for new types of relationships between forms and spaces in future architectural situations. The variation possibilities of columns created by splitting a cube in two perpendicular directions are already surprisingly numerous. At the same time, the variety of spatial compositions that can be constructed with the resulting forms and their richness of possibilities are practically inexhaustible (Figure 6).

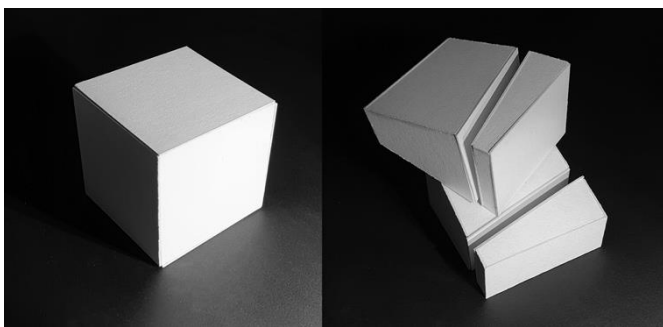


Fig. 6 Transforming the cube (Kata Zsitva)

Departing from the ordinary horizontal and vertical directions common in historical architecture, with the introduction of oblique angles in slicing one can further increase the degree of compositional freedom. Changing a single rule opens up the possibility to create dynamic, intuitive spatial compositions. Inserting additional steps in the series of transformations break yet more boundaries in variability and scale, and these experiments have an impact on the development theory of form. The removal of a part

of the faces of the solid bodies resulted from the slicing and incisions, and the interlinking and combining outside and inside spaces, lead to a more advanced level of experimental spatial construction, in which geometric construction, the practice of architectural space formation and the philosophical questions of theoretical space come together in harmony.

In addition to traditional modelling techniques, the possibilities offered by digital technology should also be considered.

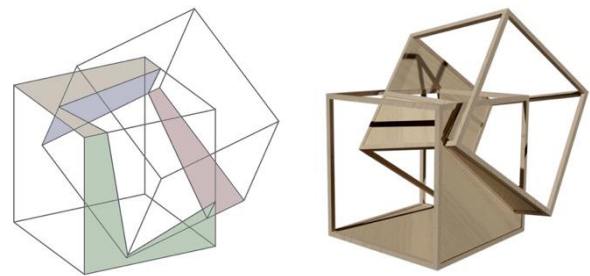


Fig. 7 Virtual and traditional modelling (Ákos Pintér)

Digital tools allow the otherwise complicated and lengthy construction processes of spatial distortion, rescaling, twisting or subtraction of bodies and spatial forms to be performed in real-time, making the result of a transformation visible in an instant. Intermediate results, recorded in fine-tuned – even parametrized – stages, and work phases can be created in a virtual reality, the ample interpretation, evaluation, and application of which are crucial part of the skill set of designers of contemporary forms (Figure 7).

Rebuilding work-in-progress virtual models from real materials greatly increases and substantiate the experience, therefore, the digital search process for experimental forms concludes with the creation of a tangible physical model.

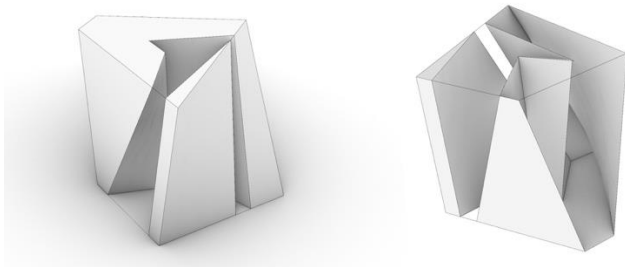


Fig. 8 Virtual modelling and rendering (L. Verzsényi-Lukács)

Converting the complicated virtual spatial form into a planar template (practically a folding pattern) is an excellent descriptive and thought-provoking instrument of geometric transformation and dimensional theory. Breaking down a complex form into a plane with the ability to fold it back into a composition of spaces and masses in a few quick movements provides any designer of spaces or spatial objects with rich source of inspiration, an opportunity that must be seized and developed into further sub-tasks and artistic creativity.

Thus, through experimentation and the modelling of spatial transformations students of architecture and design gain basic insights which can also lead to theoretical findings, therefore the consciously structured series of exercises leap far beyond mere spatial modelling, contributing to compositional experiences and theoretical discoveries as well. The ability to connect the satisfaction of the functional requirements of a space with its philosophical or transcendent dimensions develops creativity (Figure 8).

Generative design provides the possibility of creating shapes in real time. The generative design is actually a design of a making process, which finally can produce countless solutions for one – for example - geometrical task [4].

With the unfolding of modernism in architecture more and more spatial theories emerged, as the development of technology provided additional opportunities for innovative experiments in spatial relationships and floor plan systems. These include, among others, Frank Lloyd Wright's open living spaces, the 'Raumplan' (design of spaces) concept of Adolf Loos, which understands the interior of buildings as spatial organisms, or Mies van der Rohe's contiguous flow of spaces (Barcelona Pavilion, 1929). In his 1924 publication 'Towards a Plastic Architecture', Doesburg first proposed the idea that new architecture is based on the four-dimensional spatiotemporal concept of modern natural science.

These two different attitudes also exist in the creative attitude of spatial design. One perceives the space as an independent substance, assigns its own constructive and proportion systems, internal energies, relationships, and structure to it, and interprets the building, the body, as a shell around it. The other interprets the space based on its functional attributes and shapes it as an organic vessel designed for living.

V. CONCLUSION

The elementary geometric transformation-based planar and spatial composition exercises improve the understanding of how compositional effects operate in plane and space and help mastering them through examination, modelling and the evaluation of results.

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REFERENCES

- [1] F. Sebestény, "Space and Motion, theoretical and experimental investigation of the connections, practical application in architectural education" Thesis for: Doctor of Liberal Arts, PTE, 2012.
- [2] H. S. Langfeld, *The aesthetic attitude*. New York, USA: Kennikat Press, 1920.
- [3] F. Schumacher, *Das bauliche Gestalten*. Leipzig, Germany: Gebhardt, 1926
- [4] Tibor Pálóczi and Péter Lassu, "Digital by nature. The cephalopods and the algorithms" *Periodica Polytechnica Architecture*, vol. 49. No. 1 pp. 86–91. 2018.