# Visual Abstraction as Key Competence for Critical Thinking

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## *Abstract*

*Abstraction is a fundamental intellectual competence that enables the human mind to analyse and comprehend concepts in order to creatively develop new solutions. The ability to translate abstract spatial concepts into equally abstract sculptural artefacts, which is acquired in the context of architectural design and needs to be practised throughout life, can also be transferred to contexts outside of architectural practice. With this main objective in mind, intellectual hypotheses from the humanities, for example from archaeology, can also be represented visually without abandoning their scientific content. The way often practised in the games and film industry of subverting such content with lifelike fantasy worlds is not without alternative. On the contrary, by means of abstraction, the critical thinking of science can also be transferred to the artistic artefact. The methods used to achieve this goal will be presented using samples of visualisations of a number of important heritage sites, developed in close collaboration with major cultural institutions such as the German Archaeological Institute (DAI), Cologne Cathedral administration or Bern Minster Foundation. Essentially, the scientific hypothesis is translated through the two skills adopted from traditional architecture: modelling and photography. Firstly, genuinely new, abstract forms are designed. In the second step, these are projected as if the abstract forms were built architecture. This essential second step can therefore be termed virtual photography. In conclusion, artistic creativity promotes competencies and skills to cope with the uncertainties of the 21st century by practising imagination and critical thinking conceptually and visually through art, as effectively taught in our architectural courses.*

**Keywords:** *Design, Composition, Modelling, Perspective, Projection, Photography*

## 1. Introduction

If scientific statements about the past express certain aspects with high certainty but others with very low certainty, the overall statement can be described as uncertain. A statement such as ‘a building stood at a defined location’ is, in itself, a clear and certain statement. But if nothing is known about the appearance of the building, in other words, if its appearance is completely uncertain, then the knowledge about this building is uncertain. This circumstance has to be kept in mind when translating verbal statements from the historical sciences of archaeology, building research and art history into images. Drawings, especially sketches, are common examples of such translations, which suggest certain things but leave others undefined. But sketches are only drawings and do not allow for many of the possibilities inherent in three-dimensional models.

Fig. 1. Sanctuary of Trajan in Pergamon

Quite apart from mass calculations, strength analyses and other structural simulations, even the simplest three-dimensional models allow spatial sketches to be verified for consistency in a single virtual model. Even if such models are abstract, and indeed abstract to the same extent as verbal hypotheses, they can be viewed from different angles and compared with the familiar representations such as ground plans, elevations, sections and even perspectives. They are, in a sense, three-dimensional sketches. Since their visual perception is itself

achieved through the image, the viewpoint and direction of view when viewing the virtual model are decisive for its interpretation. In the sciences, visual imagination is usually at the beginning of the process, which is then verbalised. From the sum of the verbal expressions in conjunction with eventual hand sketches, an abstract model can then be created, which does not necessarily have to be consistent at first. But any contradictions that arise are clearly revealed by the model and encourage further scientific reflection or research until one or more models are created that correspond to the scientific assumptions. The initial hypotheses are formulated by archaeologists, building researchers and art historians, while architects are responsible for translating them into abstract forms. As such, the authors have developed a method of visualising uncertainty that goes beyond mere modelling to include the visualisation of the model itself. This is because the visualisation or projection of the model is just as important and decisive for perception and interpretation as the model itself. Both influence the evaluation by the historical sciences and their intradisciplinary exchange, as well as their communication to the public. Ultimately, ideas about the past world arise from the experience of physical reality. And so, a form of projection inspired by documentary photography serves to maximise the comparability and comprehensibility of the spatial structure despite its abstraction. To emphasise this correlation, the authors refer to this form of model projection as virtual photography. Last but not least, this form of representation not only adequately conveys the content itself, but also provides an adequate picture of science, namely that it is not unambiguous, but rather multi-layered and contradictory, and can change into its opposite when premises change. The following examples of cooperative projects illustrate some of the key aspects of modelling abstraction and virtual photography.

**2. Ancient metropolis of Pergamon around 200 CE**

As in all the following illustrations, the abstraction in Fig. 1 concerns polychromy. Architecture is not only material, but also, especially in antiquity, polychromatic. But knowledge about polychromy itself is just as difficult to obtain as certainty about its materiality. The precise distribution of colours on the building is usually completely unknown. In contrast, the form, or geometry, can generally be assessed with much greater certainty. To counteract misinterpretation of supposedly white buildings, the images are consistently rendered in black and white, just like traditional black-and-white photographs. An additional note in text form or a polychrome representation of polychrome architecture that has been preserved – in the case of ancient architecture from Pompeii, for example – can unmistakably clarify that ancient architecture was polychrome, but the monochrome representation allows for a relatively high degree of certainty in the statement. The absence of stone joints is equally clear in the statement about materiality. The buildings were, of course, constructed from individual stones, in this case white marble. But although many fragments have been preserved, enough to allow a detailed visualisation that is scientifically justifiable, not all of them have been preserved. And in those places where the form allows for a well-founded continuation and multiplication of the fragments' shapes due to the formal repetition characteristic of classical antiquity, the actual division into individual stones is completely unknown. Instead of showing the preserved fragments and completing them without joints or with speculative joints that are purely imaginative, the geometry of all joints has been omitted in the interest of consistency, thus subtly but clearly expressing that this is only a representation of a hypothesis about the geometry of the architecture.

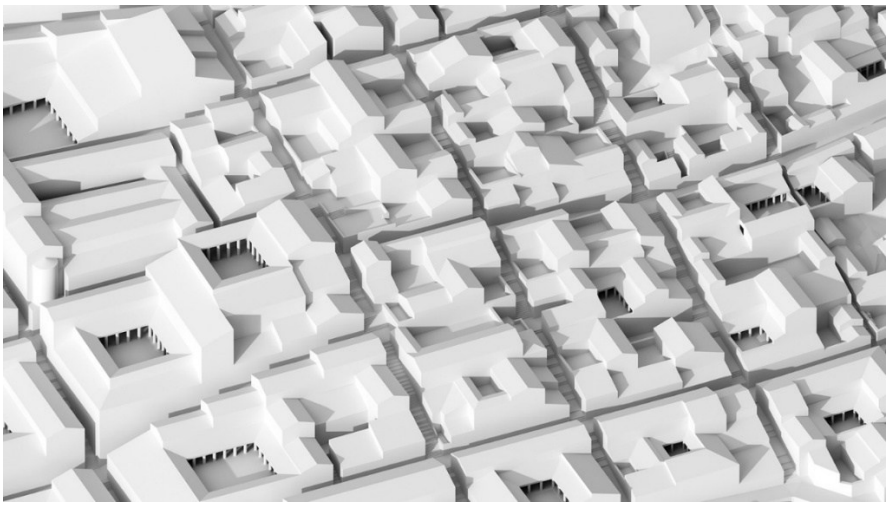

Fig. 2. Eastern slope of Pergamon

The abstraction in Fig. 2 takes this a step further and shows the building structure as a diverse, non-repetitive arrangement of buildings and building parts. Beyond the pure absence of materiality and stone joints, entire building complexes are limited to an arrangement of buildings in order to illustrate nothing more than the compositional principle according to which the buildings were arranged. According to archaeological assumptions, which in turn are based on excavation findings of better-preserved housing patterns, the factors influencing the arrangement are proximity to central buildings such as markets and baths, proximity to the main road, a serpentine road with a constant gradient that was most likely built to allow the palaces to be erected on the mountain plateau, proximity to the city wall and, last but not least, the slope of the hillside. The aim was not simply to find the ideal layout, but to strike a balance between an ideal solution and variability, because it was the archaeological consensus that the building complexes were not arranged as evenly as in the early Hellenistic period such as in Priene further south.

The project was realised as part of the TOPOI (The Formation and Transformation of Space and Knowledge in Ancient Civilizations) Cluster of Excellence funded by the German Research Foundation (DFG) which was led by the two Berlin universities Freie Universität and Humboldt-Universität and also includes the German Archaeological Institute (DAI), the Collection of Classical Antiquities in the Pergamon Museum Berlin of the Berlin State Museums of the Prussian Cultural Heritage Foundation, and the Konrad Zuse Centre. It culminated in the first monographic exhibition on the ancient metropolis of Pergamon. Out of this, a permanent cooperation developed between the authors and the Istanbul department of the DAI, which is responsible for the excavations in present-day Bergama. [1-4]

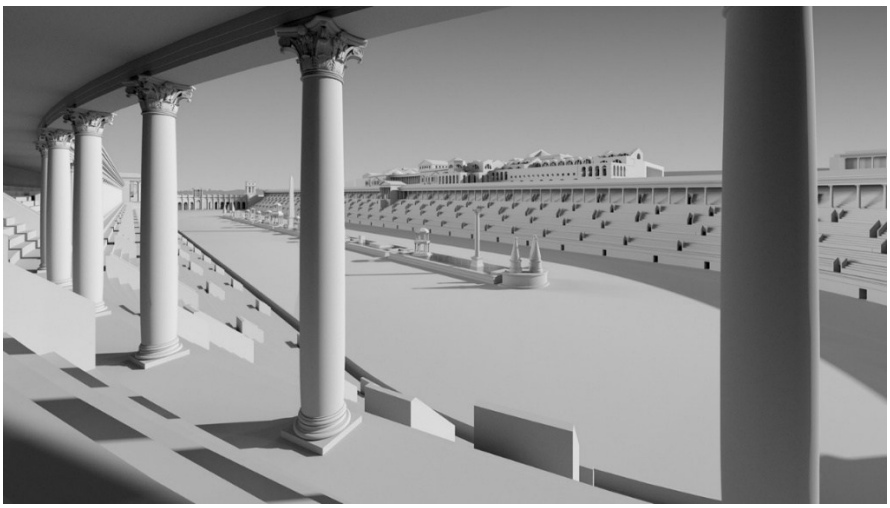

Fig. 3. Circus Maximus and Imperial palaces on the Palatine hill

Fig. 4. Courtyard behind the major audience hall of the imperial palaces on the Palatine hill

**3. Imperial palaces on the Palatine hill in ancient Rome**

The abstraction in the Palatine project is at first glance quite similar to that of Pergamon. However, the focus here was on several successive construction phases. This is because the Roman emperors apparently kept their palace in a state of perpetual construction. Why this was the case is somewhat debated, but one hypothesis suggests that the constant building activity was intended to demonstrate power and wealth. The changes to the imperial palaces were therefore performed on the side of the hill that was frequently seen by many citizens and residents of Rome, namely from the Circus Maximus. The statement about the visual impact of the structural changes from phase to phase was therefore that they were embedded in the spectacle of the games. The scenographic combination of circus and palace backdrop therefore played a decisive role in the search for a suitable vantage point for a perspective that expresses precisely this relationship, as shown in Fig. 3. An additional aspect of abstraction compared to Pergamon is the landscape. Subtly in the background, the outline of a row of trees suggests a landscaped context in the middle of the city.

The interior of the palaces was characterized by a succession of representative courtyards, which were basically similar in design, so that their dramaturgy was derived primarily from the act of walking through them. Fig. 4 shows an example of the visual relationships that the courtyards, arranged one behind the other, offered visitors. But the visual connections were not only on the central axis, but also on the colonnades on the sides. A new aspect of abstraction here is the hint of a water surface. This isn't shown by the usual wave patterns, but only by the water's own characteristic relationship between reflection and refraction. Actually almost a mirror surface, the reflection diminishes as the viewer approaches. This effect is based on the physical phenomenon and prevents the surface from being misunderstood as a full mirror. The nevertheless completely undistorted geometric reflection corresponds to the abstraction of the materiality, but at the same time does not contradict the natural effect of water on windless days.

The project was realised as part of decades of research by the Architecture Department of the above-mentioned DAI in Berlin on the occasion of the final exhibition of the TOPOI research cluster, also mentioned above. This exhibition also took place at the Pergamon Museum in Berlin, but in addition to the imperial palaces, it also showcased various other projects of the research cluster. This project was funded by the DAI. [5-7]

**4. Cologne Cathedral and its predecessors**

The building structure in medieval Cologne is both less stable and more homogeneous. Much more than a general statement about the typical building volume with average building lengths, widths, roof pitches, and overall heights, as well as the layout of the streets that have largely been preserved to this day, could be defined as a starting point. Nor did pronounced variability, as in the case of the sloped construction in Pergamon, appear particularly likely. The high density of buildings and the associated limited

visibility within the city make a pedestrian perspective from street level almost impossible. Fortunately, when the Hildebold Dome shown in Fig. 5 was completed, the Romanesque churches arranged in a ring around medieval Cologne were already erected, so that a perspective could be taken that, from both a scientific and architectural point of view, was essential and could also have been taken at the time depicted, namely from the church tower.

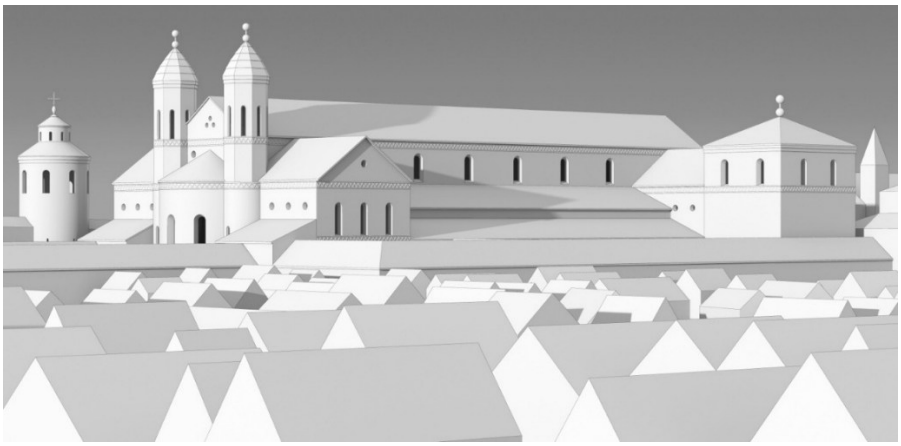

Fig. 5. St. Hildebold Cathedral around 1024 CE

Fig. 6. St. Maria ad Gradus, Cologne Cathedral and Hildebold Cathedral around 1320 CE

The relevance of a viewpoint is essential because architecture shapes and influences the perception of its users. The abstraction of the church is based on a medieval representation, a dedication image in the Hillinus Codex, on which the elevations of the church are unfolded, making the church appear considerably flatter. Nevertheless, ornamental patterns typical of the period can be recognised, which are reproduced here in an idealised form, as far as this is justifiable from an art-historical point of view.

This circumstance applies at all times, and it can be assumed that the planning of architecture is always consciously or unconsciously shaped and influenced by this spatial perception. In order to perceive architecture appropriately, even in an abstract, scientifically uncertain state, and thus to be able to interpret it scientifically and architecturally properly, projection from a realistic position in space is essential. This principle is a central component of what the authors refer to as virtual photography. It means that, regardless of the degree of abstraction, the geometry is photographed as if it were built, in other words, as part of physical reality. Fig. 6 shows the state of Cologne Cathedral when the Gothic choir had already been built and the Hildebold Cathedral was still half standing. To the east of the choir is another church. In order to make the three churches comparable, the abstraction of the Gothic choir is more extensive than necessary. This is because its geometry remains largely unchanged to this day. It would therefore have been possible to reproduce it more precisely based on the original. But based on the findings, this is not possible for the other two churches. So, the Gothic choir was idealised by modeling components that were apparently intended to be repetitive as identical and shapes that were apparently based on simple geometry as exactly symmetrical and regular. This way, the three churches are more similar in terms of abstraction and therefore made comparable.

The project was realised in close cooperation with the cathedral administration and the then master builder as an update of earlier illustrations of the construction phases of Cologne Cathedral and its predecessor buildings on the occasion of the construction of the new access building to the tower ascent and the archaeological zone below the cathedral. The entrance to the archaeological zone is located exactly in the centre below the two west towers and shows the accompanying film by the authors on a screen as a permanent installation. The project was financed by the Ministry of Science of the State of North Rhine-Westphalia. [8,9]

**5. Bern Minster**

The visualisation of the construction phases of Bern Minster was developed in parallel with detailed building research, which allows the construction of the church to be traced down to individual stones. For this reason, the construction phases show some concrete construction joints with some individually identified stones. But again, to keep the representation focused on geometric principles, components that were apparently intended to be identical were also modelled identically. For example, the pillars on the choir shown in Fig. 7 are based on exactly the same profile. To create comparability between the central church, the predecessor church, which is still intact at this point, the cathedral platform and the rest of the town surrounding the church, all buildings were modelled in as much detail as possible, within the limits of scientific uncertainty. Only the secular residential buildings below the platform and behind the church were abstracted even further, as although some of the buildings have been preserved, others have been so heavily altered that their appearance can no longer be reconstructed. Similar to the stone joints in ancient architecture, the entire façade was therefore dispensed with here, while some characteristics of Bern's urban texture were highlighted. On the one hand, the individual buildings vary in width and height, and on the other hand, they have an almost uniform, pronounced roof overhang, which is a result of the weather and heavy snowfall, and, at least in the upper town, they are almost uninterrupted by arched arcades at street level. This photograph was again taken from an actual viewpoint, namely from the opposite bank of the river, which runs through a deep valley.

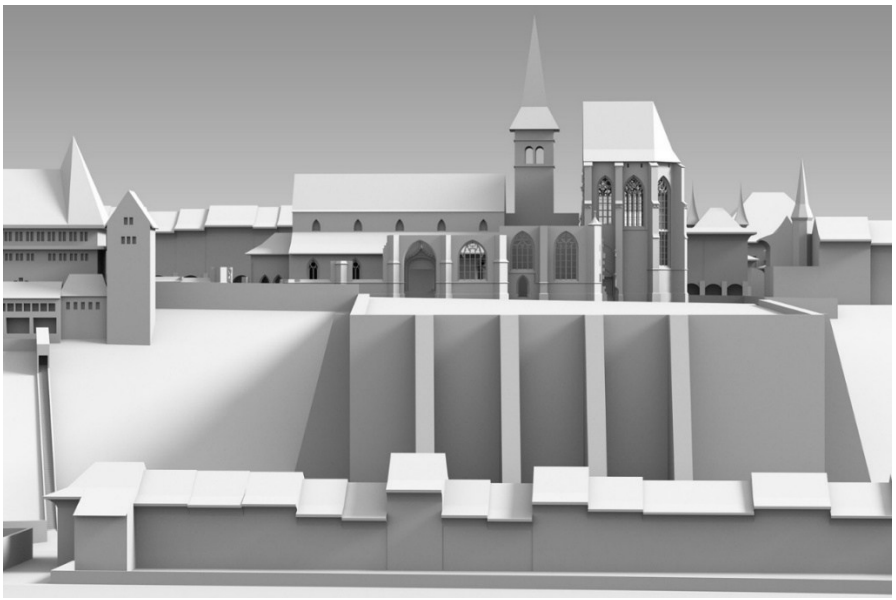

Fig. 7. Bern Minster, its predecessor church, its platform and the surrounding city, 1438–1440 CE

Figure 8 finally shows the conclusion of the architectural research of the first century of Bern Minster, as it appeared within the cityscape before the completion of the spire. As with the Hildebold Cathedral, the viewpoint here is chosen so that the church appears in the midst of the dense buildings, not behind the cathedral platform as before, but above the roofs of the city texture, seen from the skylight of the new town hall on the opposite side of the upper town.

Fig. 8. Bern Minster, its predecessor church, its platform and the surrounding city, 1529–1588 CE

The project was realised in collaboration with the Münsterstiftung (Cathedral Foundation) and the Institute of Art History at the University of Bern on the occasion of a major monographic publication on the first hundred years of the Bern Minster's construction.

Due to the early announcement of the parallel development of a three-dimensional virtual model of the cathedral, its predecessor church and the urban surroundings, various authors were able to influence the visualisations of the model and use them as illustrations for their own academic contributions. The authors' work is published in the book in 48 images in 7 articles by 4 authors. [10]

## 6. Conclusion

It requires extensive experience in architectural design to adequately translate uncertain ideas from others into images of spatial models. It is precisely the core competence of architects to translate the client's ideas, as uncertain, ambiguous or contradictory as they may be, into a consistent model that nevertheless comes as close as possible to the client's vision. Non-architects are not practised in this. It takes a radically different approach to refer to reference buildings, to express that one building or another should – in the case of planning – or would have – in the case of history – resemble one building or another, or to find a visual expression that illustrates principles, that gives the uncertain idea itself a visual appearance. What architects usually develop for and with clients can be transferred almost one-to-one to cooperation with humanities scholars, except that it is not planning intentions but hypotheses about the past. The central requirement, however, is the ability to design new forms and appropriate projections, that is, to produce abstract models and virtual photography.

**Acknowledgments**

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**References**

1. R. Grüßinger, V. Kästner, A. Scholl, and Staatliche Museen zu Berlin, Eds., Pergamon - Panorama der antiken Metropole: Accompanying book to the exhibition; An exhibition of the Antiquities Collection of the Berlin State Museums (Imhof, Petersberg, 2011).
2. E. Laufer, D. Lengyel, F. Pirson, V. Stappmanns, and C. Toulouse, "Die Wiederentstehung Pergamons als virtuelles Stadtmodell," in Pergamon - Panorama der antiken Metropole: Accompanying book to the exhibition, R. Grüßinger, V. Kästner, A. Scholl, and Staatliche Museen zu Berlin, Eds. (Imhof, Petersberg, 2011), pp. 82–86.
3. L. Petersen, R. von den Hoff, Albert-Ludwigs-Universität Freiburg, and Staatliche Museen zu Berlin, Eds., Skulpturen in Pergamon: Gymnasion, Heiligtum, Palast; Catalogue accompanying the exhibition of the same name, Archaeological Collection of the University of Freiburg in cooperation with SMB Staatliche Museen zu Berlin (Druck Verlag Kettler, Bönen, 2011).
4. J. Lang, H.-P. Müller, F. Pirson, Antikenmuseum, Deutsches Archäologisches Institut, and Brandenburgische Technische Universität Cottbus-Senftenberg, Eds., Pergamon wiederbelebt! die antike Residenzstadt in 3D: Special exhibition by the University of Leipzig's Museum of Antiquities in collaboration with the German Archaeological Institute (DAI), Istanbul Department, and the Chair of Visualisation at the Brandenburg University of Technology (BTU) Cottbus-Senftenberg, April–Juli 2018 (Antikenmuseum der Universität Leipzig, Leipzig, 2018).
5. R.-P. Märtin et al., Eds., Jenseits des Horizonts: Raum und Wissen in den Kulturen der Alten Welt; Exhibition of the Cluster of Excellence 264 TOPOI - The Formation and Transformation of Space and Knowledge in Ancient Civilizations - in cooperation with the Berlin State Museums, Prussian Cultural Heritage Foundation, Pergamon Museum (Theiss, Stuttgart, 2012).
6. U. Wulf-Rheidt, "Die Paläste der römischen Kaiser in Rom – megalomane Bauprojekte oder normale kaiserliche Bautätigkeit?," in Jenseits des Horizonts: Raum und Wissen in den Kulturen der Alten Welt, R.-P. Märtin, Ed. (Theiss Verlag, Stuttgart, Germany, 2012), pp. 108–123.
7. B. Kelly and A. Hug, Eds., The Roman Emperor and his Court c. 30 BC–c. AD 300: Volume 2: A Sourcebook, vol. 2 (Cambridge University Press, Cambridge, 2022). doi:10.1017/9781009063814.
8. B. Schock-Werner, D. Lengyel, and C. Toulouse, Eds., Die Bauphasen des Kölner Domes und seiner Vorgängerbauten = Cologne Cathedral and preceding buildings (Verl. Kölner Dom, Köln, 2011).
9. S. Klösges and E. Metternich, Eds., In aeternum cantabo: Zeugnisse aus 1300 Jahren kölnischer DomMusikGeschichte: Exhibition marking the 150th anniversary of the Cologne Cathedral Choir in the Archdiocesan and Cathedral Library of Cologne (Kölner Dommusik, Köln, 2013).
10. B. Nicolai and J. Schweizer, Das Berner Münster: Das erste Jahrhundert: Von der Grundsteinlegung bis zur Chorvollendung und Reformation (Schnell & Steiner, Regensburg, 2019).