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# TRANSFORMING TO EXPERT
## *On the Role of Experiential Knowledge in Architecture*

This paper deals with the question on how architectural knowledge can be detained respectively how it can be conveyed. It approaches this topic by discussing the highly complex subject of knowledge in architecture in general and experiential knowledge in architecture in particular. Thereby the role of experiential knowledge in transforming layman to expert is of special interest.

Core of this contribution forms the discussion of the question in how far the engagement with exemplary architectural objects, often referred to as referential objects or precedents has the potential to convey architectural experiential knowledge. The discussion of this question is based on the prevailing view that exemplary architectural objects are to be regarded as a rich source of experiential knowledge. A second aspect of this argumentation is grounded on the common argument that designers often and regularly make use of referential objects during design. This argument is repeatedly put forward by system developers of knowledge based computer systems in supporting their chosen strategy in creating these systems. The paper investigates in how far the engagement with referential objects by architects and student architects during architectural design is actually aimed at learning from these objects and supporting their design process by the experiences made by others. One Result of this conference contribution is the classification of the different types of usage and situations in which it is made use of precedents in architecture.

The reflections of this paper are undertaken before the background of a critical discussion of a paradigm of Artificial Intelligence applied to the domain of

architectural design. They integrate knowledge of various disciplines such as design theory, architectural computing, cognitive sciences and IT.

**Background**

Background for the reflections in this paper forms a critical discussion of CBR (short for Case-Based Reasoning) applied to architectural design (Case-Based Design, short CBD). CBR is a paradigm of Artificial Intelligence, which stands for the reuse of past experiences in solving current problems or interpreting new situations. The term CBR describes both a model of the cognitive processes involved in problem solving or interpreting as well as a conceptual method for developing knowledge based computer systems.[1] CBR is based upon Roger Schank's 'Dynamic Memory Theory'[2] and theories on analogical reasoning[3]. CBR can be seen as a form of analogue reasoning[4] and draws upon the notion of inter-domain analogies.[5] One major difference between CBR and other approaches in AI to model expert knowledge lays in the fact that CBR relies (but not exclusively) on instance knowledge of concrete (e.g. problem solving) episodes, retained in cases, rather than on generalized knowledge in form of rules or models, derived from them, as is the case in traditional expert systems (such as Rule- or Model-based Systems). A case thereby is a contextualized piece of knowledge, an interpreted representation of a real experience including all details that make this experience special.[6] To formalize case knowledge Kolodner defines three major components of case description. These are: Description of the problem / situation of the problem, the description of the solution and the outcome of the solution, the result.[7] The last component should contain information on what happened after the solution has been carried out, whether the outcome was a success or failure, includ-

1 Kolodner, Janet L.: "Improving Human Decision Making through Case-Based Decision Aiding". In: *AI Magazine*, 12(2) 1991, pp. 52–68. Kolodner, Janet L.: *Case-Based Reasoning*, Morgan Kaufman Publishers, Inc., San Mateo 1993.

2 Schank, Roger C.: *Dynamic Memory - A Theory of Reminding and Learning in Computers and People*, Cambridge University Press, Cambridge, Mass. 1982.

3 Aamodt, Agnar and Plaza, Enric: "Case-Based Reasoning: Foundational issues, Methodological Variations, and System Approaches". In: *AICom - Artificial Intelligence Communications, IOS Press*, 7(1), 1994, pp. 39–59.

4 Ibid. Heylighen, Ann: *In case of architectural design - Critique and praise of Case-Based Design in architecture*, doctoral Thesis, Faculteit Toegepaste Wetenschappen, Department ASRO, K.U. Leuven, Leuven, Belgium 2000.

5 Aamodt and Plaza, see note 3.

6 Kolodner, Janet L. (1993), see note 1.

7 Kolodner, Janet L. (1991); Kolodner, Janet L. (1993), see note 1.

ing explanations for success or failure. This last component is of special interest for the further discussion in this paper.

**Knowledge in architecture**

One of the prevailing arguments for applying CBR to architecture is its classification as 'weak theory domain'. Weak theory domains are, beside the prevailing complexity of problems to be solved, which can be classified as 'wicked problems'[8] or as 'mean problems', characterized by the fact that domain knowledge is vague and inconsistent[9] as well as highly individual. In literature the terms 'knowledge' and 'skill' or 'theoretical' and 'practical knowledge', also described as 'Knowing-by-Doing', 'Knowing-in-Practice', 'Knowing-in-Action', are frequently cited in discussions on the question of which types of knowledge constitute the body of architectural knowledge.[10] Whereas theoretical knowledge can be conveyed academically through lectures and textbooks, practical knowledge necessary for designing has to be gained by experience.

**Experiential knowledge in architecture**

As one of the indicators for the fact that making architecture heavily relies on experiential knowledge can bee seen that celebrated and distinguished architects often are of certain age. Collecting experience takes time. Chris Jones and Brian Lawson word as follows:

*Design seems to be an activity that requires a certain level of maturity to be practiced well.*[11]

*… nobody can be a good designer without the right experience.*[12]

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8 Rittel, Horst W. J.: "On the Planning Crisis: Systems Analysis of the 'First and Second Generations''. In: *Berdiftsokonomen*, 8, 1972, pp. 390–396. Rittel, Horst W. J. and Webber, Melvin M.: "Planning Problems are Wicked Problems". In; Cross, Nigel (Eds.): *Developments in Design Methodology*, Chichester, New York, John Wiley & Sons, 1984, pp. 135–144.

9 Kolodner, Janet L. (1993), see note 1.

10 Schön, Donald: *The design studio: An exploration of the traditions and the potential*, RIBA Publications, London 1985. Akin, Ömer: "Case Based Instruction Strategies in Architecture". In: *Design Studies*, 23(4), 2002, pp. 363–435. Lawson, Brian: *What Designers Know*, Architectural Press, Imprint of Elsevier, Oxford 2004. Lawson, Brian: *How Designers Think*, Architectural Press, Oxford 2006. Paparizou, Elena and Protzen, Jean-Pierre: *To Rescue the Designer from Epistemic Freedom and other Challenges*, *International Engeneering and Product Design Education Conference, 2–3 September 2004*, Delft, Netherlands.

11 Lawson, Brian: "Schemata, gambits and precedent: some factors in design expertise". In: *Design Studies*, 25(5), 2004, pp. 443–457.

12 Jones, J. Christopher: "The State of the Art in Design Methods". In: Moore, Gary T. (Eds.):

One characteristic of knowledge based on experiences is its implicit or tacit nature. This means that it can hardly be externalized. This is named as one of the reasons for the fact that educating architects heavily relied (and still does in some ways) on the so called 'Apprenticeship of Learning'[13] or 'Master-Apprentice Model'[14] respectively. Young architects spent years of apprentice with well-known colleagues to learn by observing and helping out in smaller tasks. The worldwide omnipresent studio setting in architectural education shares aspects with this approach to convey knowledge from experts to novices in the way that an experienced architect and designer, the professor, is there to lead the students design process and to offer assistance if needed.

**Novices and Experts – differences in knowledge and skills**

*The accumulation of experience is a vital part of the transformation to expert*[15]

Experts hold generalized, a priori knowledge, gained by own experiences, which puts them in the position to apply this knowledge to a class of similar tasks.[16] Novices instead do not hold a comparable repertoire of design experiences and therefore do not have relating concepts at disposal. These concepts or schemes[17] are used by the designer in problem solving. The studio in architectural education is meant to bridge this gap and to form a platform for students to gain missing architectural concepts. In studio students are asked to work on design tasks which directly relate to problems they will actually have to work on later in life. Thereby they are put in the position to collect design experiences from which they can draw in future when confronted with similar problems. What they do there is learning by doing rather than learning by being told. There are some problems related to this approach to education: The first relates to the fact that it is a matter of

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*Emerging Methods in Environmental Design and Planning*, 1973, pp. 2–8. Lawson, Brian (2004), see note 10.

13 Cross, Nigel: "Designerly Ways of Knowing". In: *Design Studies*, 3, 1982, pp. 221–227.

14 Lawson, Brian (2204), see note 10.

15 Cross, Nigel: "Expertise in design: an overview". In: *Design Studies*, 25, 2004, pp. 427–441.

16 Liebich, Thomas: *Wissensbasierter Architekturentwurf - von den Modellen des Entwurfs zu einer intelligenten Computerunterstützung: ein Weg zu den Entwurfsgrammatiken and zur multiplen graphischen Repräsentation*, Fakultät Architektur, Stadt- und Regionalplanung, Hochschule für Architektur und Bauwesen, Weimar 1993, S. 62.

17 Ball, Linden J., Ormerod, Thomas C., et al.: "Spontaneous analogising in engineering design: a comparative analysis of experts and novices". In: *Design Studies*, 20(5), 2004, pp. 495–508. Oxman, Rivka: "Design by re-representation: a model of visual reasoning in design". In: *Design Studies*, 18, 1997, pp. 329–347.

**In studio students are asked to work on design tasks which directly relate to problems they will have to work on later in life. However, it is a matter of chance whether they learn things of importance as well as whether a fruitful knowledge transfer takes place.**

chance whether students learn things of importance as well as whether a fruitful knowledge transfer takes place between teacher and student. If knowledge transfer takes place it still remains uncertain whether the student is able to translate this knowledge so that it can fertilize the own design work. Main obstacle of the studio setting is that it is not, can not and sometimes does not want to be a fairly close simulation of the real world of architectural practice and thus of related problems.[18] Therefore it is not possible for students to learn everything necessary to know during studio as a matter of fact. It is essential for them to learn also from the experiences of others.[19] It requires additional ways and means to convey experiential knowledge in architectural education. This statement is, to anticipate, often quoted by CBD researchers as one more argument for applying CBD systems in architectural education. But first let us reflect on what is regarded as sources of knowledge in architecture in general and experiential knowledge in particular.

### Sources of experiential knowledge in architecture – processes and products

As sources of architectural knowledge in general are regarded the knowledge of methods and the knowledge of their results.[20] This corresponds to a differentia-

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18 Cuff, Dana: *Architecture: The Story of Practice*, Massachusetts Institute of Technology, Cambridge 1991. Lawson, Brian: *How Designers Think*, Architectural Press, Oxford 2006. Heath, Tom: *Method in Architecture,* John Wiley & Sons. Ltd. 1984. Akin, Ömer: "Case Based Instruction Strategies in Architecture". In: *Design Studies*, 23(4), 2002, pp. 363–435.

19 Richter, Katharina and Donath, Dirk (Eds.): "Towards a Better Understanding of the Case-Based Reasoning Paradigm in Architectural Education and Design – A Mirrored Review", *Communicating Space(s) [24th eCAADe conference proceedings] 6-9 September 2006*, Volos, Griechenland 2006, pp. 222–227.

20 Tzonis, Alexandre and White, Ian: "Introduction". In: Tzonis, Alexandre,White, Ian (Eds.): *Automation based creative design*, Amsterdam 1994, Elsevier Science B. V. Richter, Katharina and Donath, Dirk: "Augmenting Designers Memory – Revisal of the Case-Based Reasoning Paradigm in Architectural Education and Design". In: Gürlebeck, K., Könke, C. (Eds.): *Electronic Proceedings of the 17th International Conference on the Applications of Computer Science*

tion between process and product as sources of design knowledge as for example put forward by Cross.[21] Accordingly as sources of experiential knowledge in architecture are mentioned:[22]

- Experiences gained through designing (as e.g. undertaken in design studio),
- Experiences made through the observation of others while designing ( as e.g. in the Master-Apprentice Model).

Time and again, and, importantly, not exclusively in the context of CBD, the built design product is named as a rich source of experiential knowledge in architecture, sometimes even put on the level of it. Two types of experiences based on the final product of a design process can be differentiated:[23]

- Experiences gained through studying buildings in situ, and
- Experiences gained by browsing through architectural magazines, journals, books, the internet for images, drawings, texts of existing buildings.

**References in architecture**

One of the main arguments put forward by CBD researchers for applying CBR to develop architectural design support systems is the thesis that architects during design and especially in its early phases regularly and extensively make use of exemplary architectural objects, often also called precedents, references, referential objects, or sometimes even cases. In most cases researchers take this thesis as rational to define a description of the final product of design, the built and/or published architectural object, as major source of knowledge in their systems to provide them for reuse.[24] To once again remind ourselves: CBR is originally all about reusing experiences made in the past e.g. in problem solving. One question appeared in this context to be critical and that is whether architects really engage with references during design for the purpose of decoding experiential knowledge encoded in/through these objects. Therefore a closer look had been judged essential

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*and Mathematics in Architecture and Civil Engineering*, Weimar 2006.

21 Cross, Nigel: "Designerly Ways of Knowing". In: *Design Studies*, 3, 1982, pp. 221-227. Cross, Nigel: Designerly Ways of Knowing, Birkhäuser. Basel, Boston, Berlin 2007.

22 Heylighen, Ann: "Exposure to Experience: On the Role of Experience in Architectural Design Education". In: Scotford, M. , Marbadi, J.-F. *et al* (Eds.): *Research in Design Education*, Raleigh, NC, Herber Center for Design Excellence, College of Architecture and Environmental Design, 1998, pp. 148–151. Taha, Dina: *A Case Based Approach to Computer Aided Architectural Design. MONEO: An Architectural Assistant System*, PhD - Thesis, Graduate School, Faculty of Engineering, Alexandria University, Alexandria 2006. Cross, Nigel (2007), see note 21.

23 Taha, see note 22..

24 for a further discussion of this aspect and related problems, see: Richter, Katharina and Donath, Dirk (2006), see note 20.

to investigate the actual role references play during architectural design. At first a definition of the term reference had to be developed. Prefixing it has to be said that it is on purpose that the term 'precedents', which is often used in literature in this context, is avoided here, since it implies additional meaning (the notion of celebrated masterpiece or authoritative exemplar[25] – which is not of any help here.

References in architecture are: Built and/or published architectural objects or certain aspects or parts of them, which are studied in situ or by means of different media and which are consciously consulted/used by designing architects and students to support their design process.

Among others the interpretation of several research studies aiming at the investigation of different aspects of the use of reference in architecture[26] has been conducted to support the hypothesis, that the purpose of using exemplary architectural objects during design is not necessarily connected to the idea of reusing past design experiences to solve current design problems. The definition of the term design experience here has been put in relation to what is defined by the cognitive model of CBR as an experience, a. o. expressed by the tripartite nature of a case (see above).

**Classification of the use of references in architectural design**

Through the interpretation of the aforementioned studies it was made possible to classify the situations in which designing architects and students access references and the purpose of this engagement into five distinct categories:

- The engagement with exemplary architectural objects is first and foremost conducted to trigger ideas. It showed potential to activate an intense memory scan for own experiences from the past to use in the current design problem solving.
- References as sources for design constraints.

The engagement with references during architectural design holds the potential to function as a reminder of aspects, design problems, design constraints etc. one has not been thinking of yet but which found consideration in other projects.

- References as means for communication.

25 see e.g. Goldschmidt, Gabriela: "Creative Architectural Design: Reference Versus Precedents". In: *Journal of Architectural and Planning Research*, 15(3), 1998, pp. 258–270.

26 Heylighen, Ann and Verstijnen, Ilse M.: "Exposure to Examples, Exploring Case-Based Design in Architectural Education". In: Gero, J. (Eds.): *Artificial Intelligence in Design '00*, Kluwer Academic, Dordrecht 2000, pp. 413–432. Heylighen, Ann and Verstijnen, Ilse M.: "Close encounters of the architectural kind". In: *Design Studies*, 24(4), 2003, pp. 313–326. Heylighen, Ann and Neuckermans, Herman: "Are architects natural Case-Based Designers?" In: *The Design Journal*, 5(2), 2002, pp. 8–22. Akin, Ömer (2002), see note 18; Taha, see note 22.

**The engagement with referential objects by architects and student architects during architectural design is not very much aimed at learning from these objects and supporting their design process by the experiences made by others.**

The study showed that in architectural practice as well as in architectural education objects of reference are indeed frequently used to externalize own design ideas and to mark off these ideas from preceding ones.

- References as means for design evaluation.

The study revealed indications that architects use exemplary architectural objects to make design decisions based what has already been approved in the past.

- References as source for explicit information.

This last category can further be divided in

- Reusing experiences made in the past and

This means that by that is that indeed sometimes exemplary objects are used to learn from them. They are e.g. used to predict costs of the designed object in comparison with other similar ones.

- Reusing solutions generated in the past.

Sometimes even the task of designing architecture, which often is driven by the demand to "produce" originality, relies on the reuse of solutions generated in the past for cost and time saving. This happens especially during later phases in the design process.

The order of these categories has been chosen regarding the increasing explicitness of information absorbed by architects by engaging with references. It has also to be noticed that these categories mirror the progress of the design process from preliminary design to construction documentation. Especially the last category requires a fairly good understanding of the project; ideas must have become precise for using references being fruitful for the process. One has to be aware that this classification can and does by no means want to be called complete. Reason for that lies a.o. in the narrow scope of available relating literature.

Another aspect of interest in context of this paper is the role which references play in architectural education, in 'transforming to expert'. Exemplary objects are of great importance in conveying architectural knowledge to students. They are used to illustrate concepts and to communicate ideas in design studio, to convey explicit architectural knowledge in theory oriented subjects, to pass on different

views on architecture as well as for architectural analysis. Students during design studio use, more or less successful, references in the above mentioned categories. It has to be noticed that to bridge the gap of experiential knowledge between novices and experts stemming e.g. from the incomplete simulation of architectural daily routine in design studio, as explained above, the material on objects of reference available can not be called sufficient and effective. To meet this lack the conduction of so called case studies, studies of products and processes, are a common means in architectural education.

**Discussion**

Although limited, as mentioned, the conducted study on the use of reference in architectural design indicates that situations and purposes of the use of reference in architectural design can further be grouped into two large groups which are:

- The use of references for indirect problem solving and
- the use of references for direct problems solving.

The engagement with references by designing architects and students of architecture is only secondarily undertaken for the purpose of extracting resp. using experiential knowledge encoded by these objects. This is especially true for the early phases of design – the main focus of CBD researchers in architecture.

The engagement with referential objects by architects and student architects during architectural design is not very much aimed at learning from these objects and supporting their design process by the experiences made by others. Besides available material on exemplary objects in architecture is by no means sufficient being to help support this strategy.

This finding is of great interest for a discussion of the CBR paradigm in architecture. It uncovers a predominant misunderstanding by CBR researchers of the role which references actually play in architectural design. This misunderstanding concerns two aspects. On the one hand it uncovers the misinterpretation of the term reuse which is, following the underlying theory of CBR inappropriately applied (only) to the final product of the design process, the designed solution – and on the other hand it shows the inappropriate emphasize on references as containers for experiential knowledge, when the mentioned argument put forward by developers would actually be oriented at the underlying theory of CBR. The two large groups of use of reference in architecture pointed out by this study are of high importance for a further discussion of the CBR paradigm in architecture which is not aimed at here and has to be discussed elsewhere.