

LEVELS OF EXPERTISE IN DESIGN EDUCATION

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ABSTRACT

Design ability and differences between novice and expert designers have been quite extensively studied in the field of design methodology. For example, design expertise got much attention in the latest Design Thinking Research Symposium held in Australia. Little attention, however, is paid to the *development* from novice into expert. At this moment, there is no theoretical basis for explaining and understanding the kinds of transformations the design student has to go through, and there is no theoretical basis for identifying the degree of design expertise of a designer at a certain moment. Also, little is known about how to stimulate design expertise development.

We propose to study the development of expertise in designing. This paper introduces a model of the development of design expertise, based on the general skill acquisition model of Dreyfus. Characteristics and limitations of the general model relevant for its application to the field of design are discussed. We will try to match the levels of expertise as they are identified in the model with some empirical data, consisting of a set of self-evaluations of a design student.

We could find some empirical basis for the model, but much more detailed empirical investigations are needed to reflect on the basic assumptions of the model. We therefore introduce a wider research programme that eventually should result in a stable description of levels of design expertise, a description of the transitions to higher levels of design expertise, and in ways to support design expertise development.

Keywords: design expertise, design ability, expertise development

1 INTRODUCTION

The core of design education as we know it now has traditionally been based upon 'design exercises'. It seems that most curriculum are built on the premise that you can (only?) learn designing by doing it. This 'learning by doing' is a powerful method, but it also has many disadvantages: it is very labour intensive for student and tutors, and easily involves a lot of repetitive work – which makes it pretty inefficient at times. And because of the complexity of design issues and the ill-structured nature of the student design problems, it is not even always clear what exactly is learnt by the student. Moreover, students cannot always express explicitly (in words) what it is they did learn. This makes it very hard for a design faculty that is working with a project-based design curriculum to explain the merits of their project-based approach, and to justify the way to meet the learning goals. This problem becomes ever more pressing as design teaching is migrating from the vocational level to the universities. Several university-based design schools have been developing their own criteria for what they see as an academic level of design work [1,2]. But both the project based 'learning by doing' method of

design teaching and these sets of criteria for the ‘academic level of design competencies’ miss a solid theoretical underpinning. In this paper we will set out to explore a model that endeavours to describe different levels of design expertise, and the development of design expertise in students and designers.

2 DESIGN ABILITY

The goal of design education is to let the students attain a certain level of design ability. But what IS this design ability?. In his important paper, ‘The Nature and Nurture of Design Ability’ [3], Nigel Cross describes the particular competencies that characterise what it means to be a designer. Based on an extensive study of design methodology literature, he names a set of eight basic ‘core features’ of design ability:

... designers...

- produce novel, unexpected solutions
- tolerate uncertainty, working with incomplete information
- apply imagination and constructive forethought to practical problems
- use drawings and other modelling media as means of problem solving.
- resolve ill-defined problems
- adopt solution-focussing strategies
- employ abductive/productive/appositional thinking
- use non-verbal, graphic/spatial modelling media.

The paper goes on to reflect on the nature and role of design education:

..In general education it is particularly important that teachers have a fundamental understanding of the abilities that they are seeking to develop in their students. In tertiary, professional education, teachers can get by as long as their students are reasonably competent enough to enter their profession at the end of their course. In professional education the distinctions between education and training are perhaps less clear-cut than they are in general education, ...

This latter statement may suggest a reason why most of the literature we can find about design education stops short after providing a general idea of what it is that possibly constitutes a designer. There is an assumption that the ‘learning by doing’ model that is customary in professional training will take care of the actual development of each and all of these abilities. With the professional education of designers moving into the university, this clearly is not enough anymore. There are novel pressures on design faculty to explain and justify their teaching methods in terms of a general university education – that is, in terms of the kinds of testable knowledge that general education provides.

As design teachers, we will argue that this cannot be done, and that it is unwise to even try to use this model of general education to evaluate design teaching. But what is the alternative? How does design education then actually work? This means that we have to be able to explain, justify and develop our methods for design teaching much more explicitly. To do this, we need more than a general model of what constitutes an able designer, and we need to be clear about the development of the design ability from novice to expert levels. In the next section we will introduce a general model for skill acquisition that might help us to describe the development of design expertise.

3 A MODEL OF THE DEVELOPMENT OF DESIGN EXPERTISE

To explore the development of design abilities and the levels of design expertise we now turn to a number of papers and lectures by Hubert Dreyfus [4,5]. We have selected this work as a basis for our work on design expertise because of all the models of expertise development that are currently used in education studies, this one is special in that it takes the development of skills as the starting point for a model of learning and expertise development (this in contrast to other, more knowledge-oriented models). This skill-based model could thus be close to the way design is learned in design education and design practice. Alternative models of expertise development might also yield interesting insights into design, and they will be considered later on in this research project.

Dreyfus, in his skill-based model, distinguishes seven distinct levels of expertise, corresponding with seven ways of perceiving, interpreting, structuring and solving problems:

1. **novice:** A novice will consider the objective features of a situation, as they are given by the experts, and will follow strict rules to deal with the problem.
2. **advanced beginner:** For an advanced beginner the situational aspects are important, there is a sensitivity to exceptions to the 'hard' rules of the novice. Maxims are used for guidance through the problem situation.
3. **competent:** A competent problem solver works in a radically different way. He selects the elements in a situation that are relevant, and chooses a plan to achieve the goals. This selection and choice can only be made on the basis of a much higher involvement in the design situation than displayed by a novice or an advanced beginner. Problem solving at this level involves the seeking of opportunities, and of building up expectations. There is an emotional attachment, a feeling of responsibility accompanied by a sense of hope, risk, threat, etc. At this level of involvement the problem solving process takes on a trial-and-error character, and there is a clear need for learning and reflection, that was absent in the novice and the beginner.
4. **proficient:** A problem solver that then moves on to be proficient immediately sees the most important issues and appropriate plan, and then reasons out what to do.
5. **expert:** The real expert responds to specific situation intuitively, and performs the appropriate action, straightaway. There is no problem solving and reasoning that can be distinguished at this level of working. This is actually a very comfortable level to be functioning on, and a lot of professionals do not progress beyond this point.
6. **master:** With the next level, the master, a new uneasiness creeps in. The master sees the standard ways of working that experienced professionals use not as natural but as contingent. A master displays a deeper involvement into the professional field as a whole, dwelling on success and failures. This attitude requires an acute sense of context, and openness to subtle cues. In his/her own work the master will perform more nuanced appropriate actions than the expert.
7. **visionary:** The world discloser or 'visionary', consciously strives to extend the domain in which he/she works. The world discloser develops new ways things could be, defines the issues, opens new worlds and creates new domains. To do this a world discloser operates more on the margins of a domain, paying

attention to other domains as well, and to anomalies and marginal practices that hold promises for a new vision of the domain.

This admittedly is a general model of the development of expertise, developed to cover many fields. In the next section we will discuss some characteristics and limitations of this model that might be relevant for its application to the field of design. Then we will further investigate the appropriateness of the model for describing the development of design expertise by trying to apply it to a set of empirical data.

4 DISCUSSION

As a first qualification of the model, it is important for the understanding of this model to realise that the levels of expertise should not be taken as characterisations of a complete person. The levels can co-exist within a single design project: designers can simultaneously display the rule-following behaviour of the novice in some parts of their work, while displaying the interpretation and reflection that characterise higher levels of expertise in other parts of the design project.

Most of these 'levels' are intuitively recognizable to anyone involved in teaching design. But we should be careful in taking these levels of skill acquisition as a blanket model for the complete development of a designer. Learning design doesn't just involve skill acquisition, it also involves the learning of declarative knowledge, and the building up of a set of experiences that can be directly used in new projects. These experiences become a repertoire of earlier solution that can be applied by the designer. They could be seen as a store of 'frames' (in Schön's terminology [6][7]), as 'design prototypes' [8], or as 'design gambits' [9].

And it is important to realise that this model of the development of expertise has been built up by Hubert Dreyfus over a number of years, as a reaction to different influences. There might be discontinuities in the model because of that. The first three steps in the model, from 'novice' through to 'beginner' and 'competent', have been developed in connection with Dreyfus's early investigations into the claims and limits of Artificial Intelligence [10]. This work has later been more strongly connected to a fundamental treatise on mental representation, referring to the work of Merleau-Ponty [11]. The last two steps in the model, from 'expert' to 'master' and 'world discloser', have been inspired on the existential 'anxieties' as they have been described by Heidegger.

Having said this, the general set-up and the descriptions of levels of expertise that are defined in the model DO spark intuitive recognition by designers and those involved in the teaching of design students. Apparently this description of the development of a designer in terms of skill-acquisition potentially does describe an important part of the advent of a designer. It could be a useful tool (though by no means the only one) for us as design teachers to describe the development process we want to stimulate and foster in our students.

This model of the development of design expertise needs to be developed further, and should eventually be validated by empirical research. In the next section we will take a next step in the development of the theory by trying to match the levels of expertise as they were identified in the model to a set of empirical data. This is an informal check, not an 'official' empirical study to validate the model of design expertise. This informal check should be seen in the context of an exploration to see whether the model as it is seems to reflect design reality, and to get inspiration for the further development (and detailing) of the design expertise model.

5 LEVELS OF EXPERTISE IN DESIGN EDUCATION

A set of empirical data is used to explore the descriptive value of the model of design expertise development in design education. The set of empirical data consists of self-evaluations of a student at the faculty of Industrial Design at Eindhoven University of Technology. In this design curriculum, that is solely project-based, students have to describe their own learning progress in 'self evaluations', which are commented upon by design teachers. These 'self evaluations' are a critical part of the design curriculum in this faculty: no marks are given, but the students are assessed on the basis of the learning progress they report in these self-evaluations. In the self evaluations the students are asked to reflect on their development in nine basic competencies: 'ideas and concepts', 'integrating technology', 'user focus', 'social and cultural awareness', 'multidisciplinary teamwork', 'market orientation', 'visual language', 'design and research processes' and 'self directed learning'.

We will try to see if the statements in the self-evaluations support the kinds of levels and transitions that are being described in the expertise development model. For this very first exploration, we will just take the self-evaluations that one student produced in the first three years of his study (encompassing 10 big design projects and about 25 'assignments'), this is approximately 90 pages of text. We will now present some quotes from these self-evaluations, categorized as expressions of the student being at a 'novice', 'advanced beginner' and 'competent' level, or signifying a transition between these levels. The data has been processed by the second author, who is not involved in education at the Industrial Design faculty at the TU Eindhoven.

novice-level:

... I think (it is) an excellent tool in the idea generation process, definitely when you're evolving from a concept to a product...

... What I still miss is some more theoretical background on form (theory of forms). I know there are certain rules in graphical design...

... It strikes me that I never put any effort in learning how to handle requirements while they are a fundamental part of the design process...

transition from novice to advanced beginner:

... The things I'm learning are changing; at first you really learn project related things. Every project you found out a number of specific things and you wonder how to ever learn all things. But the last periods I'm beginning to see the bigger lines, how all those things relate to each other. You draw connections between things you've seen earlier and new things you see in projects...

advanced beginner:

...I can hardly believe that for all these different design problems (there is) one process (that) is the most effective...

... Another thing I would like to experiment with is how this method will work on different sort of project...

transition from advanced beginner to competent:

... For me as designer it's important that are different ways to look at the interface problem so that I can select & follow the appropriate principle for each individual project...

competent:

... Most of the times when you apply a certain method you will have to adapt it so that it will fit your project...

As a very preliminary conclusion from this first confrontation of the expertise development model with empirical reality, we can say that we can actually find an empirical basis for these levels of design expertise, and that there is also evidence that the transitions from level-to-level really take place. The deeper questions that arise from the development of this model of expertise, like: ‘Are these the only levels that can be distinguished? (or are there intermediate steps that should be distinguished in the model?)’, ‘How do the transitions between de levels actually take place’?, really require a much more mature and rigorous model, and a much more serious set up of the empirical research. For now, there is not enough detail to really reflect on the basic assumptions of the model of expertise development in design. A more detailed longitudinal study needs to be set up to do this properly. We need to actively follow a couple of students in their education, tracing their development from the actual work that they are doing. In this way we would not have to depend on the students being able to verbalise these points in their self-evaluation, and wait until they do so. A proposal for an extensive research project is currently in the making.

6 CONCLUSIONS

The classic remark, at the end of almost every scientific paper, is that ‘more research is needed’. That is putting it very mildly, in this case: we have the feeling that we have hardly begun. This paper (and undoubtedly others at this conference) opens up a whole field of design studies, concentrating on describing and defining the properties of the designers and their development in design training and practice. For our study, more theoretical ground can also be found in educational research [12] and in the field of educational psychology, for example [13] and [14].

There are several directions for the further development of this design expertise development model. We can distinguish four main directions for research: (1) there is a lot of width to be gained by mapping the development of designers on all different design abilities (every level of expertise). The research field that is opened by these papers can be visualised as a matrix, with the rows containing the different levels of expertise and the columns being the different design abilities. With Nigel Cross’s eight basic abilities and the seven levels of expertise from the model by Dreyfus, this adds up to 56 fields of detailed design research. (!)

We should explore (2) the different kinds of reflection and problem solving that take place on every level of expertise. For instance, the kind of problem that is perceived by the designer at the first level of expertise (how can I use my methods?) is quite different from that on the second level (when should I use this particular method/rule of thumb?). The reflection that takes place on the novice-level deals with the rules themselves, the reflection for the advanced beginner centres on the applicability of a rule in a specific design situation.

This knowledge about the specific processes of problem solving and reflection that take place at different levels of expertise can help us define and study the transitions (3) that link the different levels. What does a designer need to learn to get from one level to the next? How can he/she do that? What problems stand in the way of learning the next set of skills? It has been observed before [15] that the acquisition of design skills is not a gradual process, but that it goes in leaps and bounds. But how does that work? What are the conditions in which leaps can occur? Which type of reflection is most suited? [16]

A fourth stream of research (4) should be focussed on the aspects of design learning that might not be captured so easily in this skill-based learning model: the development of

the declarative and process-knowledge of the designer, and the acquiring and use of 'design prototypes'.

If we can get a grip on the development of design expertise, this could lead to a number of new developments in design education. A model like this would enable us to more precisely target the position and learning possibilities for every student, at every point in their studies. Design exercises could be made much more specific, opening up the possibility for a much more efficient learning process. Design methods and design tools could be provided to the design student at exactly the right time to foster the next step in their development. The model of design expertise could actually lead to the development of new, more specific methods and tools. The effectiveness of support depends very much on the levels of learner expertise. Instructional techniques that are highly effective with inexperienced learners can lose their effectiveness and even have negative consequences when used with more experienced learners. This phenomenon is called the expertise reversal effect [17].

The designer has more or less been the 'missing person' in design research. If we can capture the most salient aspects of design thinking and the development of design expertise in a model like this, design studies will become a much richer field of enquiry.

REFERENCES

- [1] Meijers A.W.M., van Overveld C.W.A.M., Perrenet J.C., *Academic Criteria for Bachelor and Master Curricula*. TU Eindhoven, Eindhoven, The Netherlands, 2003.
- [2] Eekhout M, Wetenschappelijk Ontwerpen. Eekhout M (ed) *Ontwerpmethodologie*, Bouwtechnologie-Faculteit Bouwkunde TUDelft, Delft, 1998.
- [3] Cross N.G., The Nature and Nurture of Design Ability. *Design Studies*, Vol. 11 No 3, 1990, pp.127-140.
- [4] Dreyfus H.L., *From Socrates to Artificial Intelligence: The Limits of Rule-Based Rationality*. Unpublished lecture notes of the first 2003 Spinoza Lecture at the University of Amsterdam, 2003.
- [5] Dreyfus H.L., *Can there be a better source of meaning than everyday practices?* Unpublished lecture notes of the second 2003 Spinoza Lecture at the University of Amsterdam, 2003.
- [6] Schön D., *The Reflective Practitioner: How Professionals Think in Action*. Basic Books, New York, 1983.
- [7] Dorst K., *Describing Design*. Ph.D. Thesis TU Delft, TU Delft, 1997.
- [8] Gero J.S., Design Prototypes: A Knowledge Representation Schema for Design. *AI Magazine*, Vol. 11(4), 1990, pp.26-36.
- [9] Lawson B., Schemata, Gambits and Precedent: Some Factors in Design Expertise. Cross N.G., Edmonds E., (eds) *Expertise in Design*. Creativity and Cognition Studios Press, Sydney, Australia, 2003, pp.37-50.
- [10] Dreyfus H.L., *What Computers still can't do*. MIT Press, Cambridge MA, 1992.
- [11] Dreyfus H.L., Intelligence without representation – Merleau-Ponty's critique of mental representation. *Phenomenology and the Cognitive Sciences*, Vol. 1, 2002, pp.367-383.
- [12] Visscher-Voerman I., *Design approaches in training and education: a reconstructive study*. Ph.D. Thesis Universiteit Twente, Twente, The Netherlands, 1999.
- [13] Ericsson K.A. and Smith J. (eds.), *Towards a general theory of expertise: Prospects and limits*. Cambridge University Press, Cambridge, 1991.

- [14] Ericsson K.A., Krampe R.Th., Tesch-Romer C. The role of deliberate practice in the acquisition of expert performance. *Psychological Review*, 100(3), 1993, pp.363-406.
- [15] Dorst C.H., *Understanding Design*. BIS Publishers, Amsterdam, 2003.
- [16] Reymen I.M.M.J., Research on design reflection: overview and directions. Folkesson A., Gralén K., Norell M., Sellgren U., (eds) *Proceedings of the 14th International Conference on Engineering Design*, 2003, pp.33-35.
- [17] Kalyuga S., Ayres P., Chandler P., Sweller J. The expertise reversal effect. *Educational Psychologist*, Vol. 38(1), 2003, pp.23-31.

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