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Making the design process in design education explicit: two exploratory case studies

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Abstract

The aim of design education is that students learn to think and act like designers. However, the focus in the design studio is mainly on the design product, whereas the 'why and how' of the design process are barely addressed. A risk of learning by performing real-life tasks without addressing the skills involved, that is, without receiving appropriate support and guidance, is that learners are overwhelmed by the complexity of the tasks.

To make the design process explicit, a conceptual framework is developed in earlier research. This paper reports a first evaluation how articulation of basic designerly[1] skills with the help of a conceptual tool is perceived by students and teachers and whether it changes students' conceptions of the design process and their self-efficacy. In two exploratory case studies, questionnaires give insight. The first is a short intervention in which student's perception is measured. In the second case study the design process was addressed *in* the design studio. It measured changes in student's conceptions and self-efficacy. Also, insight is provided in teacher's perception of working with the framework.

The results of these exploratory studies indicate a positive effect. The teachers involved perceived the framework as a structuring factor during the tutoring sessions, for both teacher and students. Students did perceive explanation of the design process as being helpful. A change in students' design conceptions and an increase in self-efficacy is seen.

Key words

Design process, generic elements, framework, design education, architectural design.

Introduction

The aim of design education is that students learn to think and act like designers; they have to acquire the reasoning processes of professionals (Collins, Brown, & Holum, 1991; Van Merriënboer & Kirschner, 2018). For experienced professionals reasoning processes are not split up in separate steps. They constitute an undivided unity of automatic, unconscious actions based on common practice and routine, interspersed with conscious moments of reflection and exploration. For learners the complex, interwoven set of skills is (largely) unknown and unobservable. It has to be acquired by practicing while frequently doing 'whole'

[1] Cross, N.G. (2007). Designerly ways of knowing. Basel, Boston, Berlin: Birkhauser.

tasks (Van Merrienboer & Kester, 2008). To guide students in this 'journey in the unknown', it is helpful to address the design process explicitly.

However, in the architectural design studio[2] students seem to learn mostly by practicing design tasks without explicit articulation of the actions and skills involved. Research in architectural design education (Van Dooren et al., 2019) has shown that tutoring appears to be primarily a matter of discussion on the level of the design product at hand. Teachers talk with students about all kinds of aspects involved in the design product in relatively detailed terms: such as the position of rooms, the form of the building, the view and the composition of the facade, and all other kind of aspects. If they refer to the design process, they do so almost solely as a kind of side remarks or footnotes. The 'how and why' of the basic design process are barely addressed.

A risk of learning by performing real-life tasks without addressing the skills involved, that is, without giving appropriate support and guidance, is that learners are overwhelmed by the complexity of the tasks (Van Merriënboer & Kirschner, 2018, Sweller, Van Merrienboer & Paas, 2019). Students are asked to perform skills, that are still unknown to them. In the context of a working memory with limited capacity and a lack of adequate cognitive schemas and conceptions in their long-term memory, students tend to focus mainly on the specific design project at hand without a learning process taking place. Articulation and instruction of the professional reasoning processes, more in specifically the design process, will help students to develop effective conceptions.

Reasons for barely addressing the design process in the design studio, may be the lack of a commonly shared vocabulary and lay person conceptions on design education (Van Dooren et al., 2019). Teachers, being experts performing their skills for a large part implicit, talk with students in the same way they talk with colleagues in the design office and in the way they remember from their own education as a student. They are not used to talk about the design process and if they refer to it, they use their personal notions. Not being trained as teachers, they also seem to think that students (only) learn by discovering the designerly skills themselves (Van Dooren et al., 2019). Guidance in the form of leading questions and well-designed learning tasks regarding the skills that students are supposed to develop does not seem desirable in this view.

To be able to make the design process explicit and to have a common base for communication, a generic framework has been developed (Van Dooren et al., 2014). Five elements have been distinguished to explain the design process in relation to all kinds of design situations at hand, and to guide and train students in the development of design skills. These two main goals may include other goals, such as the comparison of personal design approaches and the articulation of the design processes in the context of teamwork.

This paper presents the results of two exploratory case studies, in which the framework is used to make the design process explicit and to guide and train students in specific essential

[2] The research in this paper focuses on architectural design, but for reasons of readability, regularly the shorter notions 'designing' and 'design process' are used. At the same time, the results of focusing more on the design process in design education and the generic elements may be recognizable for other design disciplines as well (Van Dooren et al., 2014).

design skills. The aim of the *first case study* is to investigate how first and third year Bachelor students perceived the articulation of the design process. The *second case study* gives insight in the results of working with the framework in two Master design studios. How did the teachers perceive the use of the framework in the tutorials and did students' conceptions of the design process and their self-efficacy change as a result of using the framework?

In the remainder of this introductory section, information about (the relation between) students' self-efficacy, their design conceptions and the way teachers articulate the design process will be given. Then, the framework is briefly introduced. The section ends with the main research question, the sub-questions and an introduction on the research method. The following two sections each present and discuss an exploratory case study. Finally, overall conclusions are drawn and discussed.

Self-efficacy and design-process conceptions

Students' self-efficacy, their design process conceptions and the way in which teachers make the design reasoning processes explicit and help students to acquire adequate design skills are related to each other.

The design process conceptions are the mental models and cognitive strategies, which describe how to perform tasks and how to reason. There may be large differences between effective sophisticated conceptions of professional designers and intuitive or lay person conceptions used by novices (Van Merriënboer and Kirschner, 2018). Students and lay persons tend to consider designing as a process of solving 'the problem', posed by conditions and criteria, presented by the client, site and program analysis. Observing the typical behaviour of novice design students and comparing it with their conceptual drawings of the design process, made by these students, Newstetter and McCracken (2001) concluded that the drawings were prophetic for the design behaviour of students. The design process was mainly represented in two ways: in linear flow charts and as a creative process, with an emphasis on brainstorming, intuition and imagination. These conceptions could be recognised in the behaviour characteristics they observed: (1) coming up with good ideas without evaluation, (2) coming up with solely one idea without considering alternatives, (3) working in a linear, serial process without iteration, (4) working on the idea and the component level without moving between these levels, and (5) ignoring constraints and context (environment and user). The sophisticated conceptions of professional designers include designing as an ill-defined, open-ended, complex, personal and culturally influenced process. The process unfolds in a process of experimentation. Conditions and criteria are discovered during the process of exploring and reflection. Designing is a matter of coming up with inferences and profound testing of possible solutions (Cross, 2007; Lawson, 2006; Lawson & Dorst, 2009; Schön, 1983, 1985, 1987). If teachers show and articulate their sophisticated design-process conceptions, students' ability to perform the design process may increase and their self-efficacy may rise.

Self-efficacy, the perceived belief in the personal ability to perform, is caused by and affects different cognitive, motivational and affective processes. Sources of self-efficacy are mastery experiences, experiences provided by social models, social persuasion and the reduction of stress reactions (Bandura, 1994). In principle, if students are able to master challenging tasks, not too easy, but still realistic in relation to their prior knowledge and experience, their self-

efficacy will increase. Their ability to perform challenging tasks will increase and their stress level may decrease. Main teaching issues to increase the ability to master challenging tasks are the behaviour and articulated way of thinking of the teachers and the way in which they help students acquire skills that enable them to deal with new tasks.

A framework for design education

In the past decades, research has been conducted on the reasoning processes of design experts. Researchers have used different terms to describe the different basic skills, such as conjecture and analysis (Hillier, Musgrove & O'Sullivan, 1972); primary generator (Darke, 1979); imposition of an order, naming and framing, reflection-in-action, conducting experiments, and a web of moves (Schön, 1983, 1985, 1987); a co-evolution of solution and problem spaces (Lawson, 2006; Cross, 2007; Lawson & Dorst, 2009), and ideation and evaluation (Goldschmidt, 2014). These terms are regularly overlapping each other.

To help teachers and students discuss the design process, an overview is needed which is relatively simple to remember and easily to use. Therefore, the body of knowledge is brought back to as few elements as possible, five basic design skills present in any design process. The elements are interwoven with each other. There is no fixed step-by-step sequence; the emphasis on the elements depends upon the kind of project, the designer and the design discipline. The five elements are certainly not meant as a prescription or recipe for design, they are only meant to articulate the 'designerly' reasoning processes and to help in designing adequate design courses, to guide and train students in the main design skills.

For each of the elements (see Figure1) a short description is given:

1. *Experimenting* is a process of *exploring and reflecting.* Exploring refers to a process of being open and alert, coming up with alternative options in a rational and associative manner. Reflection refers to the process of testing, of analysing and evaluating the possible solutions, looking for (un)intended consequences of the provisional solutions and looking for the option that best fits the design situation at hand. Experimentation is studying different options, in a fractal-like process of diverging and converging.

2. *Guiding theme* or *quality* stands for the 'emergence' or imposition of a focus, an inspiring direction, something to hold on to in an almost endless field of possibilities and to help in creating coherence and significance in the design result. The guiding theme is the personal 'answer' of the designer, influenced by culture and profession. The qualities develop during the design process, from vague and abstract to a concrete elaborated solution fitting the situation at hand.

3. *Domains* consist of all *aspects and scale levels* designers have to address in the design result, such as space, material, function, the direct context of the site, and a broader socio-cultural context. Designers have to make statements and choices and they have to deal with a lot of knowledge and information - such as criteria, rules, preferences and cultural habits - in and across the domains. Aspects influence each other, choices in one domain can be made with knowledge about other domains.

4. The *frame of references* is the common professional and personal *library of knowledge* and experience in the minds of designers, consisting of ideas and qualities and abstract and proven rules of thumb, principles and patterns. In these 'knowledge chunks' different domains come together (for example in a spatial type structural or circulation aspects are already embedded). Consciously or unconsciously, designers explore and test these 'knowledge chunks'; they use, reject and transform them in the situation at hand.

5. *Laboratory* is the (visual) language designers use to experiment. The most important physical "designerly language" is *sketching and modelling.* The visual functions as an extended working memory, complementary to the language of words and notions. With the help of different visual means, the process of "designerly" thinking, of exploring and reflecting on options and discovering new insights, unfolds.

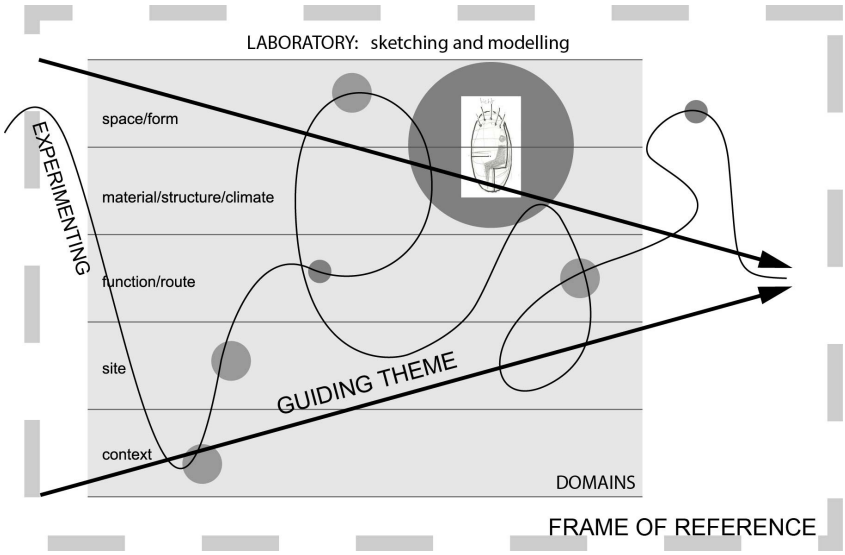


Figure 1. The five generic elements in the design process: (1) experimenting, (2) guiding theme, (3) domains, (4) frame of reference and (5) laboratory (van Dooren et al., 2014)

Questions and method

In the research presented here, the main question is how articulation of basic designerly[3] skills with the help of a conceptual tool is perceived by students and teachers and if it changes students' conceptions of the design process and their self-efficacy.

To answer the main question, four sub questions will be answered in two case studies (Harland, 2014; Burke Johnson, Onwuegbuzie & Turner, 2007). The *first case study* explored the perception of students: (1) how did first and third year Bachelor students perceive the value of the framework as a conceptual instrument to gain understanding of the design process? The *second case study* focused on students and teachers in two master design studios. This study explored the change in students' conceptions and self-efficacy: (2) Did first

[3] Cross, N.G. (2007). Designerly ways of knowing. Basel, Boston, Berlin: Birkhauser.

year Master students acquire more sophisticated conceptions? and (3) Did addressing the design process increase their self-efficacy? Finally, the teachers involved were questioned about their perceptions: (4) Do teachers perceive the framework as a supportive tool to make the design process explicit, for themselves and for their students?

Both case studies include each an intervention, a questionnaire and statistical analysis. An overview is given in Fig. 2.

In the *first case study* the perception of Bachelor students was measured. It is expected that students' conceptions and self-efficacy may change if teachers address the design process intensively, more specific during a longer period in direct relation to the design process at hand. Therefore, the *second case* study included a more profound test of the framework in the design studio. Two relatively small groups of students were involved in the intervention: almost without and with a few years design experience. Also the teachers involved were asked whether the framework was perceived as useful. In addition to the research, informal anecdotal information is given from students involved in the master studios.

	first case study: Bachelor
content	lecture, text and reflection
participants	380 first year + 240 third year BSc students
perception	survey + analysis value of making design process explicit and reflection on personal design process

	second case study: Master design studios
content	lectures, text and reflection + tutorials and training
participants	7 academy, 8 university MSc students, respectively without and with design experience + 3 teachers
perception teachers	survey: value framework for tutoring and for students
conceptions students	survey + analysis: five notions, a visual representation and imagine a house
self-efficacy students	survey + analysis: statements concerning understanding, trust,…

Figure 2. Overview of the two case studies.

Case study 1: students' perception (first sub question)

Participants and setting

All architectural students involved participated in a first or a third year 'academic skill' course in the Spring semester of 2017. The students followed a BSc Architecture study at a Dutch university. Almost all of them came directly from high school in the Netherlands.

The first-year students (N=380) fulfilled a 'one-day' assignment, a short reflection written on the day of the lecture without further guidance. The third-year students (N=240) worked on a 'two-weeks' assignment; they were guided by 20 teachers, selected to teach research and writing and having different teaching experience in general and in these courses specifically.

The information for students and teachers consisted of an English text about the five generic elements (Van Dooren et al., 2014) and one lecture, which provided a short overview of the generic elements (by the first author). On the basis of the framework, students were asked to write a reflection on their personal design process in a parallel running design project.

The first year students' response rate was 29%, the third year students' response rate was 30%.

Material, procedure and analysis

Questionnaires concerning the first sub question were distributed in September 2017. Figure 3 shows the questions which focused on reflection on the personal design process (1.1), and more specifically with the help of the framework (1.2 and 1.3), the value of making the design process explicit in a text and lecture (1.5), and having knowledge of the design process (1.6). The main goal was to get information on students' perception. But because there seemed to be a relative large difference between the assessments given by the first and third year students, it was tested with the Mann-Whitney U test for two independent samples.

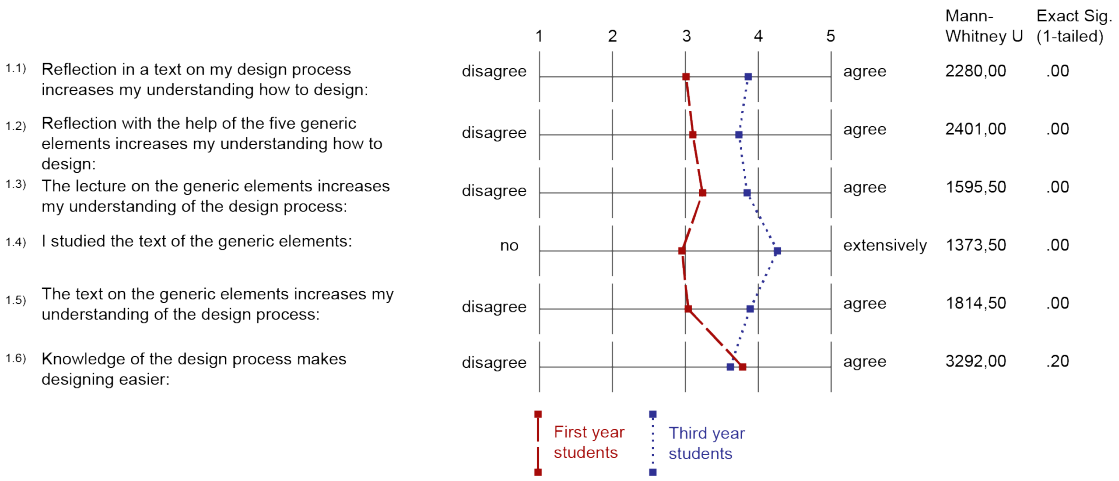


Figure 3. students' perception of making the design process explicit and Mann-Whitney U test for differences in assessment by the first / third year students

Results

Figure 2 shows the results. Five out of the six statements have been assessed significantly different by the first year and third year students ($p < .001$). Addressing the design process (in text, lecture and reflection) is perceived neutral by first year students and significantly more positive by third year students. Both groups are equally positive on 'knowledge makes the design process easier'.

Discussion

Making the design process explicit with the framework of the five generic elements as a conceptual tool (first sub-question) has been perceived neutral to positive.

There may be several causes for the distinction in outcomes between the first year and third year students. The most obvious reasons may be the difference in duration of the assignment (one day versus two weeks) and the difference in design experience. Third year students may be more in need of getting to grips with the design process and they had more time to study than first year students.

The *first case study* investigated the perceptions of making the design process explicit by a relatively short 'study and reflection' task in a separate course, parallel to the design studio. However, designing is learned in the design studio, during the whole design project. Therefore, the data collection for *the second case study* takes place in the design studio: the design process is made explicit in direct relation to the successive preliminary design products of the students.

Case study 2: teacher perceptions and students' change in conceptions and self-efficacy (second, third and fourth sub question)

Participants

All students involved studied architecture and participated in one of two Master design studios in the Fall semester of 2017. The studios were given in two different Dutch design schools, an academy and a university. The *Academy Project* is a mandatory MSc 1 studio. Eight students had started their Master with no or relative little design experience. They had different backgrounds: primarily building sciences and in a few cases civil engineering or art. This MSc 1 is the first studio in a four year part time study, in which students always work in design offices parallel to the design studios. The *University Project* is an elective MSc 2 studio, part of a two year full time MSc Architecture. Six out of seven students already completed a full time three year architectural design BSc at the same university, one student completed a building engineering BSc background. This elective MSc 2 included a ten week long apprenticeship as assistant-teacher in a first year design studio for Bachelor students. The language spoken in both the academy and university project was Dutch.
The teaching staff consisted of four teachers, including the first author. The other three were selected because they had a more than average interest in being more explicit about the design process. The teachers worked partly individually, partly in couples in the design

studios. They differed in experience in teaching in general and specifically in supervising these projects.

Setting

In the Academy Project the students had to do one design assignment and in the University Project students had to do three relatively short design tasks. Goal of both design studios was to learn to (1) experiment by sketching and modelling as the basic 'designerly' skill, (2) work with a guiding theme or qualities, (3) see the relations between the different architectural aspects or domains, and (4) recognize (spatial) patterns in reference projects and explore them in a project at hand (frame of references).

The framework was addressed in several ways. First, information on the generic elements was given in a text (Van Dooren et al., 2014) and in lectures, given by the first author in the first weeks of the projects. After an overview lecture, the elements were discussed more in depth in three other lectures. Secondly, during the design tutorials the teachers referred to and explained the basic 'designerly' skills as best as possible in relation to the design situation at hand. Table 1 shows examples of how the design process was addressed in the tutorial dialogues. Both, leading questions and learning tasks, were used during the individual dialogues and during group tutorials. Thirdly, all students had to present their design process on a poster and write a reflection about it, in the order of the elements.

Table 1. Examples of leading questions and learning tasks referring to generic elements, referred to in direct relation to the design at hand.

generic element	examples of leading questions, asked by teachers	examples of learning tasks, instructions given by teachers
Experiment	what happens if….? / which experiments did you have done? / what implications did you discover? / which one do you prefer? / which experiments should be done next?	come up with few different options / looking for the similarities and differences / testing an experiment in other domains
Guiding theme	what kind of identity or quality do you want to achieve? / is this […] the meaning you want to give the design? / which means are related to the chosen quality?	come up with different qualities for this particular design situation / come up with alternative options and architectural means to express the chosen quality'
Domains	what does this decision (e.g. a spatial order) mean for other aspects (e.g. the structure)? / in which domains(s) do you have or wish to do experiments as a next step? / what does the theme or identity mean for this aspect?'	look for implications of a choice in one domain in other domains / study the architectural means in the different domains to express the chosen theme

Frame of reference	what happens if you do it like […] ? / which projects do you like and which values or qualities do they express, in specific for your design? / what does this [... e.g. spatial] pattern mean for the other aspects?	come up with the patterns in these projects / experiment in the design situation at hand with these patterns
Laboratory	how do you test these possible solutions, in a sketch, model,…? / which visual mean do you need? / what did you discover by making a model?	make an abstraction / study the possible options by making different sketches and models / explore this option in plan, section and perspective

Material and procedure

Table 2 shows the questions concerning the change in students' conceptions (second sub question), the change in students' self-efficacy (third sub question) and the teachers' perceptions (fourth sub question). To gain insight in the change in students' conceptions and self-efficacy, a questionnaire was handed out before, directly after, and 2-4 months after the project (pre, post and delayed post). The change in conception of the design process, was measured in three questions. The change in self-efficacy was measured with a set of 8 statements that had to be scored on a 4-point scale (completely false / barely true / somewhat true / completely true). To gain insight into the experiences of the three teachers involved (apart from the first author), they answered three open questions after the design studio.

Table 2. questionnaires in reference to addressing the design process in the design studio: teachers' perception and students' change in conceptions and self-efficacy (pre, post and delayed post).

Subject		Questions
students' conceptions (third sub question)	Q 1	What are the first five notions you think of regarding the design project?
	Q 2	Make a visual representation of the design process with the help of the words from the previous question.
	Q 3	Imagine, you get the assignment to design a free standing house. Explain in short how you would approach this task (max. 100 words).

students' self-efficacy (fourth sub question)		To what extent do you agree or disagree with the following statements at this moment:
	s 1	I have enough understanding of the design process to be able to design.
	s 2	I trust myself that to effectively approach unexpected events while designing.
	s 3	I have enough insight and skills to integrate different aspects in a design.
	s 4	While designing, I always see multiple solutions.
	s 5	When I get stuck in the design process, I know in most cases what to do.
	s 6	I know I'm able to apply generic design principles and basic skills.
	s 7	I know that I'm able to become an excellent designer.
	s 8	Although it can be difficult, I have fun in designing.
teachers' perceptions (second sub question)	q 1	Does the framework help in tutoring students? If so, how / why?
	q 2	Do you have the impression that it helps students? If so, how? (if possible with examples of students)
	q 3	Other remarks?

Analysis

The process of coding, counting and analysis of *students' conceptions* is done by two researchers. The codes were defined, based on the five elements and study of the data. The final decisions were taken by the main researcher (first author).

Regarding the *first five notions you think of regarding the design project* (student's perception Q 1) eight codes were distinguished. Two codes for separate aspects and actions (D1, space, form, function, and E1, exploring, deciding) and five codes for the elements as comprehensive notion: (D2, domains; E2, experimentation; G, guiding theme; R, frame of reference; L, laboratory) and one code for all other notions, regularly more personal perceptions (P; stress, complex). The differences between the codes were tested with the Cochran Q test for k-related samples with a binary variable. Before the test the scores were transformed into binary variables (0 - 1 / item named or not named).

In reference to the *visual representations of the design process* (students' perception Q 2), five codes were distinguished, gradually increasing in complexity: (1) linear steps, (2) linear steps with one feedback loop or parallel lines in one step, (3) steps with several loops or parallel lines, (4) zigzag, parallel lines, network like, and (5) complex combinations of zigzag, parallel lines, including guiding theme lines.
With respect to *the descriptions given imagining a real situation* (students' perception Q 3), the stories were analysed in idea units. Three codes were distinguished: (a) the number of elements mentioned in combination in one idea-unit, (b) the process as elaboration or

experimentation, and (c) the emphasis on preconditions, including client, site analysis and program.

The internal consistency of the eight *self-efficacy* statements (s1-s8) is tested with Cronbach's Alpha coefficient. A reliable scale is shown for the second and third measurement (Cronbach's Alpha > 0.8); it was relatively low but still acceptable for the first measurement (Cronbach's Alpha = 0.67).

Results

Change in students' conceptions (second sub question)

The data collected from the questionnaires provide insight into the change in students' conceptions of the design process, seen from three different perspectives: the first five notions you think of regarding the design project (Q1), visualisation of the design process (Q2), and the imagination of a real situation (Q3).

In Table 3 *the notions named* (Q1) are presented in relation to the elements of the framework. Specifically, four groups of notions show a significantly different distribution of the measurements pre and post the project ($p < .05$): a decrease in separate aspects, such as space, function, site (D1) and separate actions such as exploring and investigation (E2), and an increase in the more comprehensive notions domains (D2) and frame of references (R).

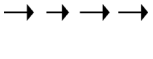
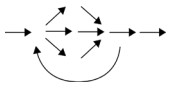
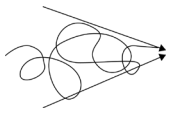
Table 3. Numbers of notions named by students per measurement reflecting their conceptions on the design process and significant results on Cochran's Q tests.

	CODE	NOTIONS	Pre	Post	Delayed post	***Q***	***df***	***p-value***
DOMAINS	**D1**	partial notions, separate aspects, such as space, user, material, context, site, form,…	24	8	14	8	2	.02
	D2	comprehensive description, such as domains or aspects	0	7	7	9,8	2	.01
EXPERIMENT	**E1**	partial notions, specific actions, such as develop, investigate, discover, (connecting) ideas, study, analyzing, di/converging, reflection, iterate, compare, (dis)advantages,	15	7	6	*3,5*	*2*	*.27*

	E2	comprehensive notions, such as experimenting.	1	13	9	18,67	2	.00
GUIDING THEME	**G**	comprehensive notions, such as concept, vision, direction, (guiding) theme	6	9	12	*4,91*	*2*	.10
REFERENCES	**R**	comprehensive notions, such as (frame of) references, case studies,	2	9	10	11,4	2	.00
LABORATORY	**L**	comprehensive notions, such as sketching, modelling, drawing, laboratory	9	9	6	*0,75*	*2*	*,90*
PERSONAL GENERAL, PERCEPTION	**P**	observing, input, collaboration, creative, logic, design, learning, presentation, flexible, divers, creative, designing, fail, critical and honest, keep positive, stress	18	12	11	*1,56*	*2*	*.59*

Table 4 shows the *change in the visualisation of the design process* (Q2). A shift can be seen in the number of students from naming more simple, step-by-step visualisations before the project towards criss-cross and complex visualisations after the project. The Chi-square test shows a significantly different distribution of the measurements of how students visualise the design process (chi-square=15,85, df=8, $p < .05$).

Table 4. Visualisations of the design process: a shift in the number of students from naming more simple towards more complex visualisations.

abstraction of patterns					
	1. Linear steps	**2. Steps / feedback loop / parallel lines**	**3. Steps / more loops +/parallel lines**	**4. zigzag/ parallel lines/ network like**	**5. zigzag/ parallel lines/ network like/ incl.**

					guiding lines | complex
pre	2	5	4	2	2
post	0	2	2	5	6
delayed post	0	0	3	3	9

Figure 4 shows some examples of student visualisations. All four selected students start with a more linear sequence. The academy students A2 and A3 show in their visualisations 'having ideas' as parallel actions in one step, which then are worked out in the next steps. The visualisation of university student U6 is the most linear one, U5 is the most complex one. Post and delayed post the project almost all visualisations show higher complexity. The visualisation of student A2 shows delayed post a more criss-cross symbol. In the visualisations of student A3 the linear sequence is still there but now in an iterative loop. The visualisations of U5 and U6 are more complex and criss-cross and show more resemblance to the framework: student U6 refers almost literally and student U5 comes up with a personal interpretation of the framework.

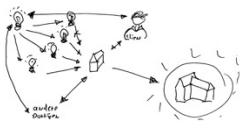
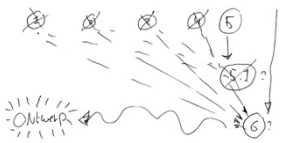
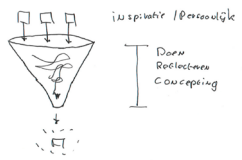
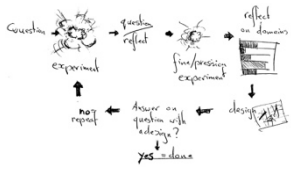
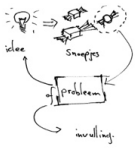
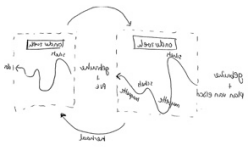
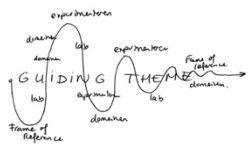
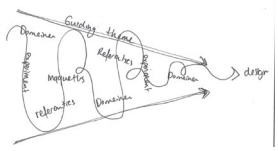
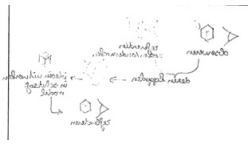
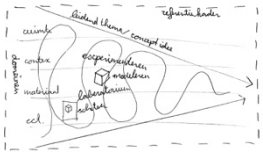
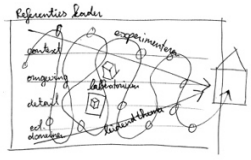
	Pre	Post	Delayed post
A2			
A3			
U5			
U6			

Figure 4. Examples of visualisations of the design process of four students, measured pre, post, and delayed post (Q2).

In reference to *the imagination of a real situation* pre, post and delayed post design studio (Q3), the stories seem to change in conception from simple towards more complex, 'from problem solving towards designing'. Table 5 shows examples of the same students as in Figure 3 (Q2). Before the project the design seems to be directed by client / program and site analysis. After the project client / program and site analysis are still important, but other actions are also mentioned such as essence, experimenting and alternatives (student A2). A second parallel tendency concerns the notion elaboration. Before the project the design process seems to be mostly a matter of elaboration (of one or more ideas), after the project refining is still mentioned but more in combination with developing a theme and testing on domains (student A3). And finally, directly after the project the idea units include more actions and skills in direct relation to each other. Student U5, for example, says: *"At the hand of references and personal ideas slowly a 'guiding theme' will emerge, or at least the start of it"*. And U6: *"Also I should look into houses of buildings in reference to my guiding theme. These might be inspiration to experiment further in the different domains."*

Table 5. Examples of descriptions imagining a real situation (question 3).

Student	Pre	Post	Delayed post
A2	"Firstly discussing with the client, based on the 'right' questions, to collect starting points. Then looking over site, context, orientation and so on. // Then discussion about the design with the client for remarks. When needed modify."	"Discussion with client to achieve 'true wishes'. //Coming up with the essence. Followed by a frame to direct the process.// Experimenting with aspects such as form, site, material and context. // Then showing alternatives to client to reflect and develop."	"Discussion with the client, to get to know him (personality, character, interests, preferences).// From here trying to come up with a guiding theme, with conditions connected to it. // Next all information trying out in different sketches and models. // Reflection together with the client."
A3	"Check my limitations: budget, environment, size. Think about primary goal(s) and list them. Think about secondary goal(s) and list them. // Sketch a number of designs. Ponder which feels to fit the	"Investigate the site. What are the values. How can I use them? // Start sketching designs. See what works with your site and "ambition". // Develop a guiding theme.//	"Visit the site. What kind of experience I want? // Experimenting. // Some elaborate, reflect on domains and elements. // Repeating this until time ends or project is finished."

	goals the best (could be multiple). // Refine the design to make it practical while maintaining the essence. Finished."	Find references which work for your design. // Start testing your design on the domains and reflect. // Refine your design or alter your design accordingly. // Repeat till finished/ out of time."	
B5	"I should start with an investigation of the site […] requirements users, looking at their living style […] From this investigation you achieve the most important design themes or improvements, together the starting points. // With these starting points, you sketch and model. // First on larger scale, but also ideas on a smaller scale can be imported. // In between you look if the provisional design fits the user. // Probably you have to make more versions. Iteration till a fitting design."	"I should start with exploring qualities in the site and task to come up with a guiding theme. // Then experimenting by sketching. Firstly, testing functionality and spatiality, e.g. in different plans. // The choice is made with the guiding theme at hand: does it fit? //References may help in generating new ideas, to experiment further. // Working in different scales, making variants, making provisional choices working in a different domain. Coming back on previous decisions. // Through the whole process the guiding theme serves as a kind of test frame, to come up with a coherent whole."	"I would start with looking into the domains: what spatial area is needed. // At the hand of references and personal ideas slowly a 'guiding theme' will emerge, or at least the start of it. // Next experimenting will provide alternatives in the five domains. // The experiments fitting the theme, atmosphere and the requirements are feasible to do further experiments. // This proceeds until the point that design and theme are a whole."

B6	"Starting with investigation of the site, what kind of existing materials, culture, and so on. For whom, what are the requirements or interests. // Next to that searching for other references for inspiration. /Then, mostly the first sketches will unfold. // If I get stuck, I often make a small model or repeat investigation. The sketch or model I reflect to the self-imposed requirements or starting points."	"I would start with coming up with the kind of house I want to make: atmosphere, impact,… next to that I should look for references, which direction I want to go (guiding theme). // Then I would start with sketching and making a lot of alternatives, look if they fit in the guiding theme. // Then elaborating through the different domains, until a consistent, good elaborated design is developed."	"First I should investigate the environment and the context of the site. // From here a guiding theme may rise; or a fascination could be for me the guiding theme, which I will use to experiment. // Also I should look into houses of buildings in reference to my guiding theme. These might be inspiration to experiment further in the different domains. // Finally, testing in reference to the theme a final design is worked out."

This last effect, the combinations of design elements, is also presented in Table 6. The overall Chi-square test over the three measurement moments shows a significant difference in combined elements just after the studio (chi-square= 16.77, df=3, $p < .01$). Also the decrease in combined elements from the second to the third measurement moment is significant (chi-square=9,25, df=3, $p < .05$). So the increase in the combined elements is only present just after the studio and does not last.

Table 6. Number of idea units with a combination of elements mentioned imagining a real situation per measurement (Q3).

	Pre	**Post**	**Delayed post**
1 element	42	25	41
2 element	13	30	16
3 element	0	5	4
4 element	0	1	0

Changes in students' self-efficacy (third sub question)

After the project the self-efficacy of the students (see Figure 5) has significantly increased and the effect remains till at least 2-4 months after the project. ANOVA with Repeated Measures

shows significant differences between the average self-efficacy scores (F = 21.54; df = 2.13; p < .01). Paired t-tests showed significant differences between the first and the second measurement (t=-4.79, df=14, p<.01) and between the first and the third measurement (t=-6.72, df=14, p < .01). It is interesting to see that self-efficacy did not drop after 2-4 months (see Figure 4).

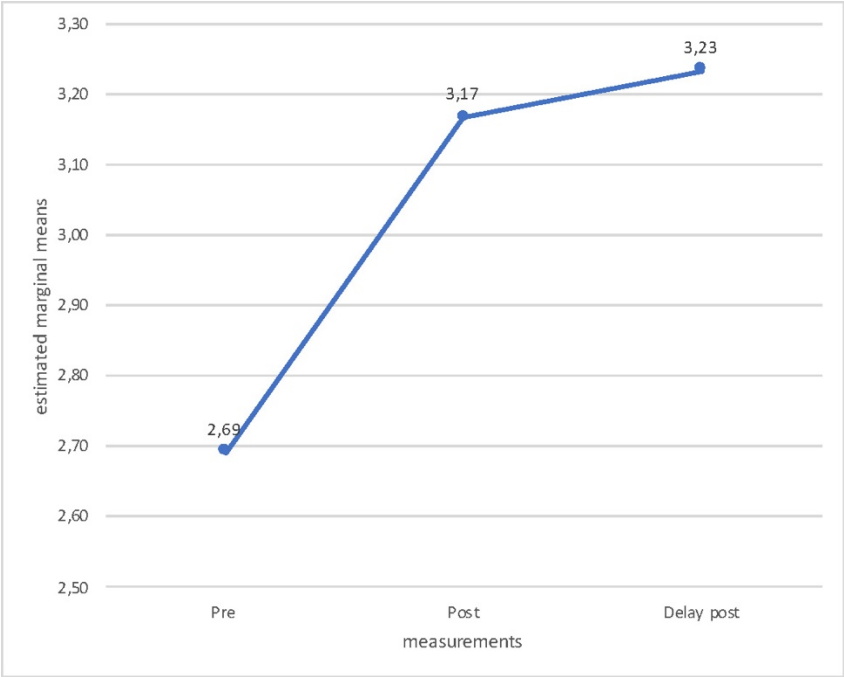


Figure 5. Increase in self-efficacy students pre, post and delayed post project

Teachers' perceptions of using the framework (fourth sub question)
Each three teachers involved (apart from the first author) perceived the framework elements as a structuring factor during the tutoring sessions, both for teachers and students. Teacher 2 compared the framework with a map: the discussion with the student improves if you have an overview of all areas and know which area is the discussion topic at a particular moment.

Teacher 1 mentions that it is almost a list you have in mind, with the kind of things which may be discussed with the student. When a student gets stuck, he literally goes over the list together with the student to show how you may act in situations like these. Teacher 3 asserts that it helps in formulating concrete tasks for students, such as experimentation. When a student gets stuck, he is more able to see possible reasons, such as not enough references, no clear theme, or no experimentation.
The teachers had the impression that the framework directly helped the students to decrease anxiety and uncertainty and to get to grips with the design process. Students' pleasure and understanding seemed to increase and they felt that they were allowed to make mistakes.

As extra remark teacher 1 mentioned that it helped when working with a student on a design you do not like as a teacher. He continues: *"I'm used to teachers with a judging attitude, from their opinion about right or wrong, attractive or unattractive. This method gets around this.*

That is clever, because as a human being you tend to the 'right or wrong' attitude very easily." Teacher 3 mentioned that his personal fun in designing and design tutoring has increased.

Spontaneous student' remarks

Not only the results of the questionnaires, also spontaneous remarks made by the students confirm the assumption of teachers that the framework may be helpful for students. In the University project, some of the students used a representation of the generic framework more or less literally. Questioned why, they concluded that the scheme was very helpful, therefore they worked with it the whole studio period. And one of the students participating in the Academy Project reported similarly in an email. He wrote that he started with the wish to be an architect, but almost without understanding of what designing meant. His first design studio in the Academy project was a struggle, also with the scheme and text. After the first design studio during the next two design studios, he related most of his actions to the scheme to understand the process. In the fourth project the scheme was solely implicit somewhere at the back of his mind and his understanding of the design process had increased, which was also illustrated by his grades (from sufficient to good).

Discussion

The second case study indicates positive results. Regarding the *conceptions of students* (second sub-question) we see to a certain extent a move from layperson conceptions towards sophisticated conceptions of the design process. The layperson conceptions consist of (1) a linear design process, frequently with a feedback loop, (2) having ideas (without testing) or having one idea and elaboration, (3) the client as a source of feedback, and preconditions in general such as brief and site analysis as source for solutions, and (4) a relatively high number of separate aspects, such as space, site, form, and partial notions such as investigation. Students may see the design process as coming up with ideas as a kind of solutions, as 'logical' implications of the design task and its conditions, more specific of 'what the client wants'. In this conception the designer seems to solve the problem, put forward by the client. The more sophisticated conceptions consist of (1) a zigzagging, criss-cross, and parallel process, (2) more comprehensive and inclusive terms, such as experimentation, guiding theme (concept, vision), and frame of reference, and (3) naming the design actions and skills more often in relation to each other. The discussion with the client is still there, but students may see designing more as exploring and testing alternatives, working parallel and across in the diverse domains, and working with overall qualities or guiding themes.

Regarding *students' self-efficacy* (third sub-question), on average *an increase is shown* after the design studio. Studying the design process and having more sophisticated conceptions of the design process may be related to the believe in being able to design.

Finally, the teachers involved in the design studios *perceived* working with the framework (fourth sub-question) as a structuring factor, which helps teacher and students to gain an overview and helps in cases of getting stuck. It may help in making the tutoring less dependent on personal preferences of the teacher. The teachers' perception that the framework may be helpful for students seems to run parallel with the changes in students' conceptions and self-efficacy.

General Discussion

The results of the two case studies indicate positive effects of making the design process explicit. At least a part of the students did perceive articulation of the design process as being helpful. For the teachers involved the framework works as a structuring tool. Their perception that it helps students, seems to be confirmed by the change in students' design conceptions and their increase in self-efficacy.

However, the positive results presented here should be taken with caution.
Obviously, there is no guarantee that using the framework terms more often after than before the project will lead to better understanding and improvement of design skills. Secondly, solely based on the second case study, it cannot be concluded that the moves in conceptions are more different than they might have been in a 'normal' product-oriented educational approach. Even though the fact that more or less the same kind of lay person conceptions were seen at the start of both the Academy and the University Project, indicates that there was no difference in conceptions between less and more experienced design students. Thirdly, the increase in self-efficacy may also have other causes, such as a positive encouraging studio environment. And finally, conclusions can be solely tentative because of the limited scale of the case studies.

Only a full experiment with a larger number of students, with control groups and during a longer period of time may provide more robust evidence for the effects of making the design process explicit. In a large-scale experiment, especially during a longer period, it is not only expected that students' self-efficacy increases and student's conceptions of the design process become more sophisticated, but also students' skills may increase and become more adequate and effective.

Yet, the positive results run parallel with the positive informal reactions of participating students and they are in line with other research. Kirschner, Sweller and Clark (2006) conclude that controlled studies support strong instructional guidance for the learning of complex skills. The results of the second case-study show the same kind of lay person conceptions of novice design students, as Newstetter and McCracken (2001) exposed. With only one exception: students do not seem to ignore the constraints and context, they seem to expect that (profound) knowledge of preconditions (site, brief, client) will lead 'automatically' to a design solution.

Framework

Making the design process explicit with the framework did work well in practice. In principle, the choice for the five elements may to a certain extent always remain a matter of discussion. However, the elements seem to be 'resilient'. They fulfil the requirements of being (1) generic, basic skills of the design process, (2) the main skills to be learned by novices, and (3) relatively clear and easy to remember (Van Dooren et al., 2014). They are key items in the design process, distinguishable and providing an overview for teacher and student.

The elements also include a 'world' of notions and mutual relations, related to the nuanced and rich reality of designing, which still has to be discovered, developed and worked out. In

the second case study, we experienced on a small scale that structuring learning tasks accordingly to the elements, may lead to learning to design in a 'natural' way. Especially in the first year(s) of the design study, providing experience in the form of adequate, specified learning tasks may help students to overcome the paradox formulated by Schön (1987): although students do not and cannot understand what designing means, neither can recognise what they see, they have to learn by doing it. Developing the framework more in detail may help in the set-up of the curriculum and the design studios. It should provide learning tasks that are interwoven with the design process. It may also help to 'translate' more general notions such as investigation and creativity in more concrete and specified actions and put all kind of notions such as analysis in a broader perspective.

To conclude: design education, in which the design process is made explicit with the framework may have positive results. A richer understanding of the design process and a better specified training of the students may help students to learn 'the unknown'. Students may experiment more often, taking informed decisions and working with professional patterns. They may articulate, develop and explore qualities more consciously and they their ability to distinguish and compare different design methods and approaches may increase. Students may become more independent when working on a design, also when they get stuck. Their stress level may decrease and their pleasure to design may increase.

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