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The tacit design process in architectural design education

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Abstract

The purpose of the architectural design studio is that students learn to think and act like designers. However, communication between teachers and students seems to be problematic. Teachers barely seem to explain how designers work, which may be confusing for students. To learn professional reasoning processes and strategies, different teaching activities are involved, such as modelling, coaching, scaffolding, reflection, exploration and articulation. In the design studio it seems tradition that teachers only ask questions, while not articulating the design process.

This paper focuses on the research question of whether teachers in architectural design education articulate the main 'designerly' actions and skills, performed by expert designers, and if so, to what extent and in which manner? To answer these questions video-recordings of 13 tutorial sessions are analysed with the help of an educational framework of five generic elements. The framework consists of the basic design process actions and skills, and is specifically developed as a vocabulary for making the design process explicit and to train students in the design process elements. The main conclusion is that teachers refer to the design product in an implicit way. They leave it to the students to discover the structure and components of the design process more or less by themselves.

Keywords

design process, generic elements, design education, design skills.

Introduction

"One of the things that really bugs me about architectural education is that a lot of things are really implicit, remain under the surface and are not talked about." This statement, made by a student, is quoted by Donald Schön (1987, p. 98) in his case-study of education in the design studio. Schön observes what happens in the studio and concludes, among

other things, that communication in the tutorial dialogue between teachers and students is problematic. For example, when Quist, the teacher in his case-study, tells the student she must 'draw and draw', he means that she must draw in the sense of experimenting, to discover consequences of different options. For students this might be unclear as for them drawing may refer to making a visual presentation only. Oxman (2001) refers to these phenomena in the design studio as "a neglect of attention to thinking in design as legitimate pedagogical content".

However, the purpose of the architectural design studio is that students learn to think and act like a designer. They must acquire habits and patterns which are mostly used by experts implicitly. They have to learn 'reasoning processes of professionals' (Van Merriënboer and Kirschner, 2018). Collins, Brown, and Holum (1991) coined the term cognitive apprenticeship in education to emphasise the (mostly underexposed) reasoning and strategies experts employ. To learn these processes of thinking adequately, different activities are involved. They distinguish modelling, coaching, scaffolding, articulation, reflection, and exploration as teaching activities.

In this case study, the focus is particularly on articulation. Making the process of thinking explicit in the form of explaining and instructing, can help students in understanding ways to approach the design process and achieve adequate conceptualisations of the design process. For example, instead of the notion that designing is coming up with one single solution, students are confronted with the idea that designing is experimenting with different possible solutions and reflecting on them.

Our hypothesis is that teachers talk about the design process itself to only a limited extent, being traditionally not used to articulate the design process and not having an adequate vocabulary to do so. Therefore, a framework is developed based on a valuable body of design process knowledge (Van Dooren, Asselbergs. Boshuizen, Van Merriënboer & Van Dorst 2014). The outcome of this research is 'summarised' into five generic elements that design processes have in common. The framework has already been tested by interviewing designers with different design approaches (Van Dooren Boshuizen, Van Merriënboer, Asselbergs, & Van Dorst, 2018) and turned out to be a generic framework of the main common basic actions and skills. This framework is now used to investigate whether and to what extent teachers articulate the design process during design tutorials.

In the remainder of this introductory section, some thoughts behind the way students learn to design in the studio will be described. Then, briefly, the framework is introduced. The section ends with the main research question and sub-questions. The second section gives information about the research method. In a case-study, the current situation in a first-year design studio is video-recorded and analysed with the help of the framework. Then, the third section presents the results for each of the five elements, whether and to which extent they are addressed in the tutoring session. In the final and fourth section conclusions are drawn and the ways teachers may make the design process more explicit are discussed.

Design process and design education

Sense and myths

Why is the thinking process barely articulated in the architectural design studio? We see three at least possible explanations: (a) complex skills and actions cannot be made (completely) explicit, (b) teachers have (mis)conceptions about (design) education, and (c) it is just common use in the design studio tradition.

Firstly, regarding the possibility of making a professional set of actions and skills explicit, there is a discussion with notions such as tacit (Polanyi, 2009), implicit (Reber, 1989), knowing-in-action and reflection-in-action (Schön, 1985, 1987) at the core of it. On the one hand there is (tacit) knowledge, which people seem to be principally unable to make explicit. On the other hand, there is the conviction in at least the 'positivist' part of the world of science that all phenomena can be made explicit in an objective manner. In our work, we take the position that knowledge can be made explicit at least to a certain extent. It may vary in time and culture, but the aim should always be to derive a vocabulary as adequate as possible for describing the phenomena we experience. As Dewey argues: knowing makes us understand the relation between our actions and their consequences. A better understanding of these relations helps to focus better and act more thoughtfully, more intelligently (Logister, 2005).

Secondly, regarding the misconceptions about design education, listening to colleague teachers over the years, the first author has heard different explanatory thoughts, which seem to underlie the way teachers act in the design studio. Teachers seem to have formed a cognitive model of inconsistent pieces of information (Vosniadou & Brewer, 1992, Vosniadou,1994). Summarised in a statement of a teacher: 'teachers ask questions; they do not give answers'. Teachers know that academics and designers must be independent and critical. They must act scientifically and creatively, not taking for granted what others say, not 'following the rules'. As to learning a complex skill, teachers seem to be convinced that learning is (only) adequate if students make discoveries for themselves. On their own these thoughts are honourable theorems. However, taken into the extreme and in combination with each other, they even may be called a design education myth: you do not instruct, tell, explain or guide students. Nevertheless, making the reasoning processes explicit helps students in performing 'designerly'[1] actions and skills and in achieving and discovering desired professional qualities such as independency, critical thinking, and creativity. There seems to be no body of educational research supporting the idea of using minimal guidance. On the contrary, research points out strong instructional guidance in the case of novice and intermediate learners, for advanced students it may be equally effective. There is even research that suggests that minimal guidance may lead to misconceptions (Kirschner,

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

Sweller, and Clark, 2006). It seems that teachers have forgotten what it is like to be a novice designer, that they have forgotten the confusion caused by not knowing 'what and how to do'.

Thirdly, teachers may simply not know how to talk about the design process. Being experienced, expert designers, most of the time they act implicitly. Not having a professional background in education, they seem to act as they remember from their own teachers in design education and they appear to talk with students as if they would with colleagues in their offices, discussing all kinds of product-related aspects. Therefore, we assume that a vocabulary for having a rich tutorial dialogue about the design process is needed.

A vocabulary for design education

Design problems are by nature ill-defined. Confronted with an open, unique and vague situation at hand, designers approach this in their personal way. However, they also have basic actions and skills in common. For the last decades, researchers coined adequate terms and notions to describe aspects of the design process, such as: reflection-in-action, conducting experiments, a web of moves, imposition of an order, and naming and framing (Schön, 1983, 1985, 1987), primary generator (Darke, 1979), a co-evolution of solution and problem spaces (Dorst and Cross, 2001, Lawson, 1994, 2006, Lawson and Dorst, 2009), and ideation and evaluation (Goldschmidt, 2014). Nevertheless, how valuable this body of knowledge may be, it is not easy to use in design tutorials, especially in the case of novices. Therefore, to make this personal, creative, open-ended and complex process of (architectural) designing more explicit, a framework, consisting of five interwoven elements has been developed (Van Dooren et al., 2014):

Designing is a process of experimenting, of trial and reflection, of exploring and decision-making. Designers play around and find their way in a series of experiments. They come up with ideas and means to express these ideas and test them in a process of reflection. In Figure 1 this is expressed with an erratic line with circles to symbolise the experiments.

This process of experimenting is given direction by a guiding theme or qualities. It acts as a hold during the process and helps in creating in the end a coherent and significant result. In Figure 1 the guiding theme is symbolised by two lines coming together; experimenting with(in) theme or qualities, whilst becoming more and more defined.

The process of experimenting takes place in different domains. For architecture: (a) form and space, (b) material, structure and climate, (c) physical context, site, (d) function, and (e) a broader socio-cultural, economical, historical and philosophical context. Designers have to consider all kinds of criteria and make statements concerning all these domains. Therefore, in Figure 1 the erratic line crosses all domains and relates these domains to each other through the act of experimenting: often a decision in one domain can be taken only in relation to the outcomes of experiments in other domains and has new implications for other domains.

The design process is inseparably embedded within a broader context: a personal and culturally defined frame of reference. Designers use and test patterns and images in a design project at hand, and they transform them into new patterns. In Figure 1 the frame of reference is symbolised literally with a frame, the blocks representing projects, patterns and other knowledge designers are aware of.

The process of experimenting is not possible without the help of a physical language of images and words: a laboratory or a (visual) language. In this laboratory the testing takes place, expected and unexpected implications of experiments can be discovered, all domains can be considered. Being directly related to the process of experimenting, in Figure 1 the laboratory of sketching and modelling is also symbolised by the circles of the erratic curve.

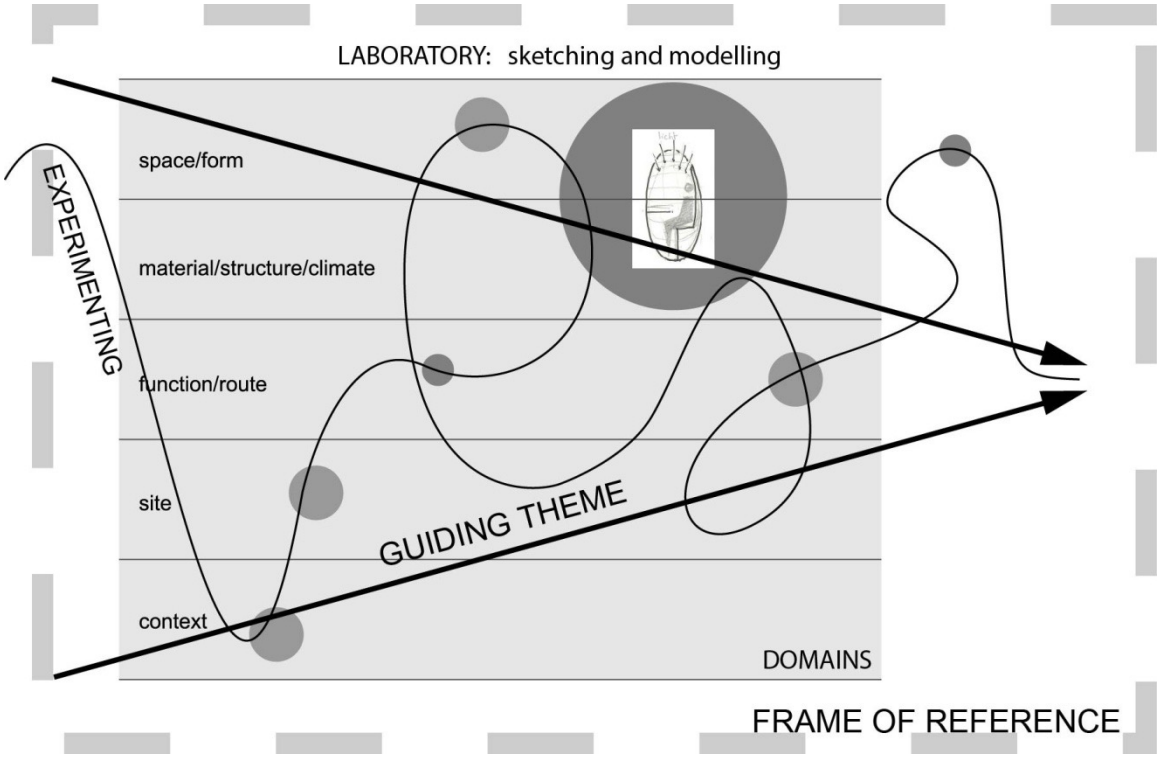

Figure 1. The five generic elements in the design process: (1) experimenting, (2) guiding theme, (3) domains, (4) frame of reference, and (5) laboratory (van Dooren et al., 2014).

The five elements are certainly not meant as a unidirectional design method. They do not form a prescription or recipe to design; they are merely meant to give insight into the 'designerly' reasoning processes and behaviours. The framework can be used in design education in different ways. The two key aims are (a) explanation of the design process in tutoring sessions in all kinds of concrete design situations at hand, and (b) organisation of design education: it may help in deriving practices to train essential design skills and actions. These main aims include all kinds of sub goals, such as working as an individual designer or in a team, and studying differences and similarities in the personal design approaches and methods of all kinds of different designers.

Because the framework is a vocabulary to articulate the 'designerly' actions and skills' performed by expert designers, in the case study presented here, it is used to analyse whether teachers in architectural design education articulate these actions and skills, and if so, to what extent and in which manner. Separately formulated in three sub-questions: (1) Do teachers articulate the generic elements when they discuss design products with their students? (2) If so: to what extent do they articulate the elements of the design process? (3) What kind of expressions do they use?

A remark before giving more information about the research method, the research in this paper focuses on architectural design, including urban and landscape design, but for reasons of readability, regularly the shorter notions 'designing' and 'design process' are used. At the same time, being basic and elementary elements, the framework may also be useful in other design disciplines as well (Van Dooren et al., 2014).

Research method

Participants

All thirteen participants (nine male and four female) are teachers in the first bachelor design project at the Faculty of Architecture TU Delft, the Netherlands. They are practising expert designers and differ in educational experience, ranging from only a few design projects to more than a decade. The teachers are observed and video-recorded at work in the studio, each time tutoring one student.

Setting

Each year twenty or more groups of nine novice students conduct the first design project of their studies. In the studio, students work individually on a given design project. They regularly have tutoring sessions in which the project at hand is discussed with their teacher in a tutorial dialogue. The BSc design assignment consists of designing a small house in a landscape (forest, dunes, ...). varying from a studio and house for an artist with the focus on the environment, a small neighbourhood with a public sculpture route, to a holiday home for two family members with the focus on different users (e.g. two brothers) and an-

choring in a particular landscape. Out of a larger set of recordings, thirteen tutorial dialogues of different teachers and students were chosen at random; only the sound quality of the recordings affected the choice.

Procedure and analysis

The (Dutch) tutorial dialogues were recorded in the studio during three academic years in the period 2012-2015. The transcriptions were analysed and coded with the help of the program ATLAS TI. Two categories of coding were used. The first category consists of notions referring to the different actions and skills of the design process: the generic elements including synonyms and aspects of the elements (see Table 1). The second category refers to the extent in which teachers are implicit or explicit about the design process (see Table 2). This category was defined beforehand and refined during the first round of coding.

The coding of each transcript was completed in two equal rounds of analysing: first, by the main researcher (first author) and a student-assistant, in the second round by a colleague teacher and another student-assistant. Only five cases (presented in the result section) were topic of discussion: the decision was taken by the main researcher (first author).

Also, extra information was collected, such as the duration and structure of a tutorial dialogue. To get insight into the structure (start, middle and end), text fragments were distinguished based on content. Each fragment consists of one or more items, being the smallest part of the text, textually belonging together, often about one aspect of the design product at hand. Fragments and items helped in deciding which notions belonged to one code. When a notion, such as 'you have to vary' was mentioned two times in connection with one item, it was coded as one.

Table 1. Notions referring to actions and skills of the design process.

generic element	notions referring to (parts of) the element
experiment	search / explore / alternatives / investigate / variants / analysing / association / decision taking / testing / reflection / looking for implications / ...
guiding theme	concept / idea / quality / focus / primary generator / design question / essence / starting points / …
domains	aspects fitting together / strengthening each other /...
frame of reference	references / examples / patterns / principles / rules of thumb / abstraction / …
laboratory	sketching / modelling / drawing / physical thinking / external memory / 'way of testing' / drawings, such as perspectives, sections, plans / ...

Table 2. Categories referring to the extent actions and skills of the design process are named.

Category	description
instruction	Giving explicit instructions in terms of 'designerly' actions and skills. For example: come up with at least three different alternative concepts or ideas / come up with at least three different ways to solve this particular problem and study the (dis)advantages.
explained	Explaining the design processes, a design skill or set of activities. Clarifying how designers may approach, such as how to decide, coming up with different alternatives, and testing them. Relating the design products at hand to 'designerly' thinking. Could be about one element or the relations between elements.
mentioned	The design process is named or referred to with one or a few terms or notions (see Table 1). Could be a synonym of an element or referring to an action 'part of the element'. Often in the sense of "you should ...", "you may ..."
not mentioned	The design process is implicitly present, in talking about the product at hand, mostly in the form of product-related examples or instances. No mentioning nor referring to notions and terms of the design process.

Results

The results will be described in three sub-sections. Firstly, some common features of a tutoring session will be given, relevant to understanding the research results in their context. Secondly, the data from the observations will be described per element, based on the sub questions: (1) Do teachers articulate the generic elements when they discuss design products with their students? (2) If so: to what extent do they articulate the elements of the design process? In the third sub section, the results regarding the third sub question are given: (3) What kind of expressions do they use?

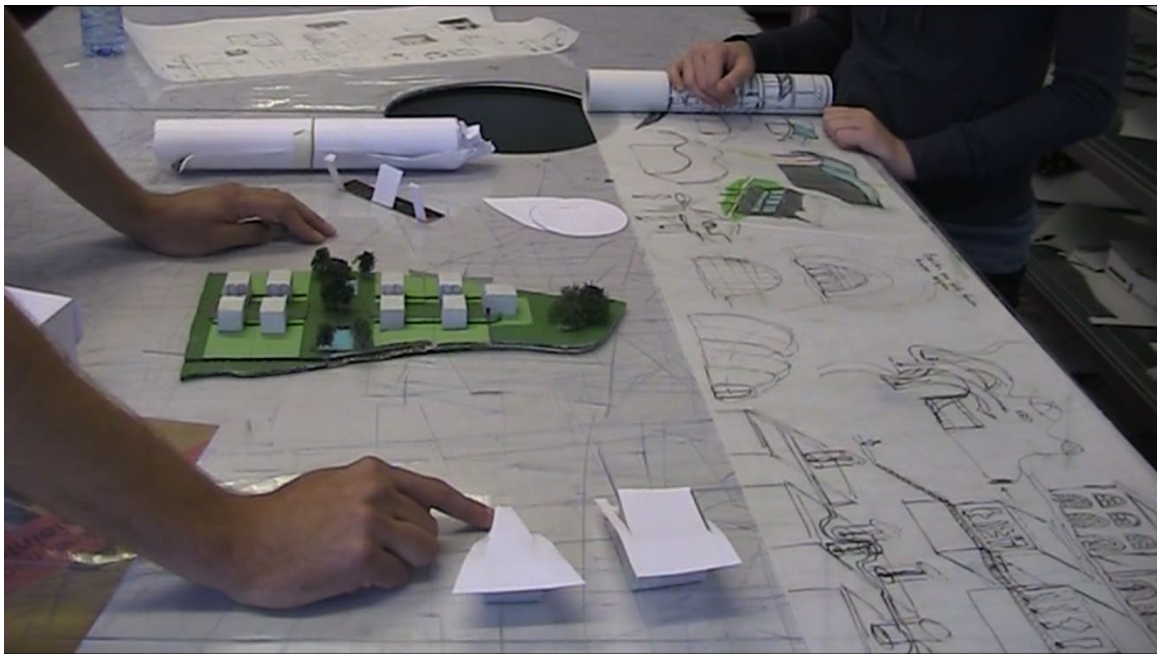

Figure 2. Dialogue between teacher and student in first year design project with models and sketches on the table.

Features tutorial dialogues

The observed dialogues mostly take twenty to twenty-five minutes, with some exceptions of three and forty minutes (see Figure 4). There seem to be no qualitative differences: discussions seem to be simply longer, consisting of more items or more time per item. On the table is the work of the student: sketches, drawings and models (see Figure 2). The amount differs between tutoring sessions; some students show a lot; some students show only few drawings and models. Two types of tutorial dialogues can be distinguished: (a) dialogues with a recognisable start in which the student talks about the project, ending approximately a third of the way through the tutorial in a 'turning point' from which the teacher takes over, and (b) dialogues without a recognisable start; the teacher reacts directly per item to what the student is telling. In all cases, the end of the tutoring is abrupt: it simply ends or a teacher just briefly repeats one of the discussed items.

In general, the discussion is on an 'aspect' level. Students describe the results of what they have done; they describe the product at hand. They talk about the living space, the entrance, and so on. For example, in the tutoring by teacher 3, the student starts by talking about the results of the work done in the past days. The story is descriptive, more or less about 'what is where' (see Table 3 - A1). Besides asking questions to understand what a student has done (see Table 3 - A2), teachers react on the project at hand and what the student has done with monologues and (rhetorical) questions. Parallel to the talking, some teachers sketch, showing what they mean at a visual level.

Table 3. Parts of the tutorial dialogue of teacher 03, with underlined sentences referring to the design process (translated from the original dialogue in Dutch).

	The design task at hand is a house plus studio for an artist. The discussion takes 22 minutes.	label
A	START TUTORING / EXAMPLES TEXT STUDENT	
The student starts telling about changes made in the design in the past days. The story is descriptive, about 'what is where'.		
1	S: *I have also thought about changing these rooms: the dining room and the living space. But that didn't work out with the kitchen. I want to have a separate kitchen. An open kitchen is good, but not functional.* S: *To make it quieter, I have made the living space over there. And I have made a longer wall here...* S: *In the living room is an opening in the wall; you can look into the studio.*	
The teacher is mainly trying to understand the drawings.		
2	T: *I'm lost; where are we?* T: *It is a beautiful drawing, but I don't know… where are we, in what direction do we look?* T: *I try to analyse what you do. In fact, you make a house consisting of two parts. ... In the largest part you make a staircase.*	
B	MIDDLE TUTORING / EXAMPLES TEXT TEACHER	
The tutoring continues and is about the walls around the staircase and hallway downstairs and upstairs: they are not placed over each other. The teacher assumes there is a reason for it and the student explains:		

3a	S: *Here, I wanted to make a kind of mini-sculpture walk, with some tables over here, with sculptures on it.* T: *Look, now we are talking. What next? I should think; okay, I want to know …. This means that this staircase…. what is the size now?* S: *0,8 metre* T: *can it be wider?* S: *it may be also 1,0 metre* T: *if you want to make in fact room for exposition here.* S: *yes* T: *what does that mean? It means that the inhabitants and guests will see the art. Then there is the chance that the artist takes his visitors upstairs: 'Come, I want to show you some things'. So, it is not a hallway anymore, but it is more. Then, for me, it may have more space. What would that mean? What if you would say .. I am going to find this out. What does it mean, for your design?".* S: *my design?* T: *maybe the library would become a little bit smaller?* S: *Yes, but the sculptures will not be on the staircase ..* T: *No, but you can make the stair wider, making it more conspicuous."* S: *yes*.	experiment, mentioning
3b	T: *Making it more important. I understand that the sculptures are not on the stairs, but you may take more space […] What happens then?... Do things shift?...* [...] T: *What I try to say to you … that when you start designing, these small things may change your whole design. But in the end, it will be important… this is tough, because it is a lot of work to make this kind of beautiful drawings and then change them again. But… that's what being an architect is about... changing everything continuously. Until you think: this is how I want it to be*.	experiment, mentioning
The tutoring dialogue continues about symmetry in relation to the rooms and the way you walk through the house. Later on, the teacher also refers to making a load bearing wall and a column.		

4	T: … *that means that you have to make something like a column here. You may put it inside. So, you can make the facade the way you want it to be … but you have to do something. <u>You should look at the house of Lina Bo Bardi again.</u>* S: *Yes, but what should be the proportion of the column?* T: *The column may be 30 centimetres… like the walls … square or round, doesn't matter…* […]	frame of reference, not mentioning
The tutoring dialogue continues, mainly on a product level. The teacher jumps from one aspect to another, barely referring to the process, only:		
5	T: *<u>then the exploration is what you need..</u>*.	experiment, mentioned
Later on, the student asks how to explore:		
6	S: *yes… in fact I don't know how to explore further…* *<u>T: By drawing, drawing, drawing, … by asking yourself what you are doing?</u>*	experiment, not mentioned + laboratory, mentioned
C	END TUTORING / EXAMPLES TEXT TEACHER	
The tutoring ends with some sentences such as:		
7	T: *<u>it is all about making choices</u> […] <u>so: sections</u>. And make also a drawing of the house on the site. That is a first sketch of the garden, that is important.* *Okay? Good luck!*	experiment, mentioned

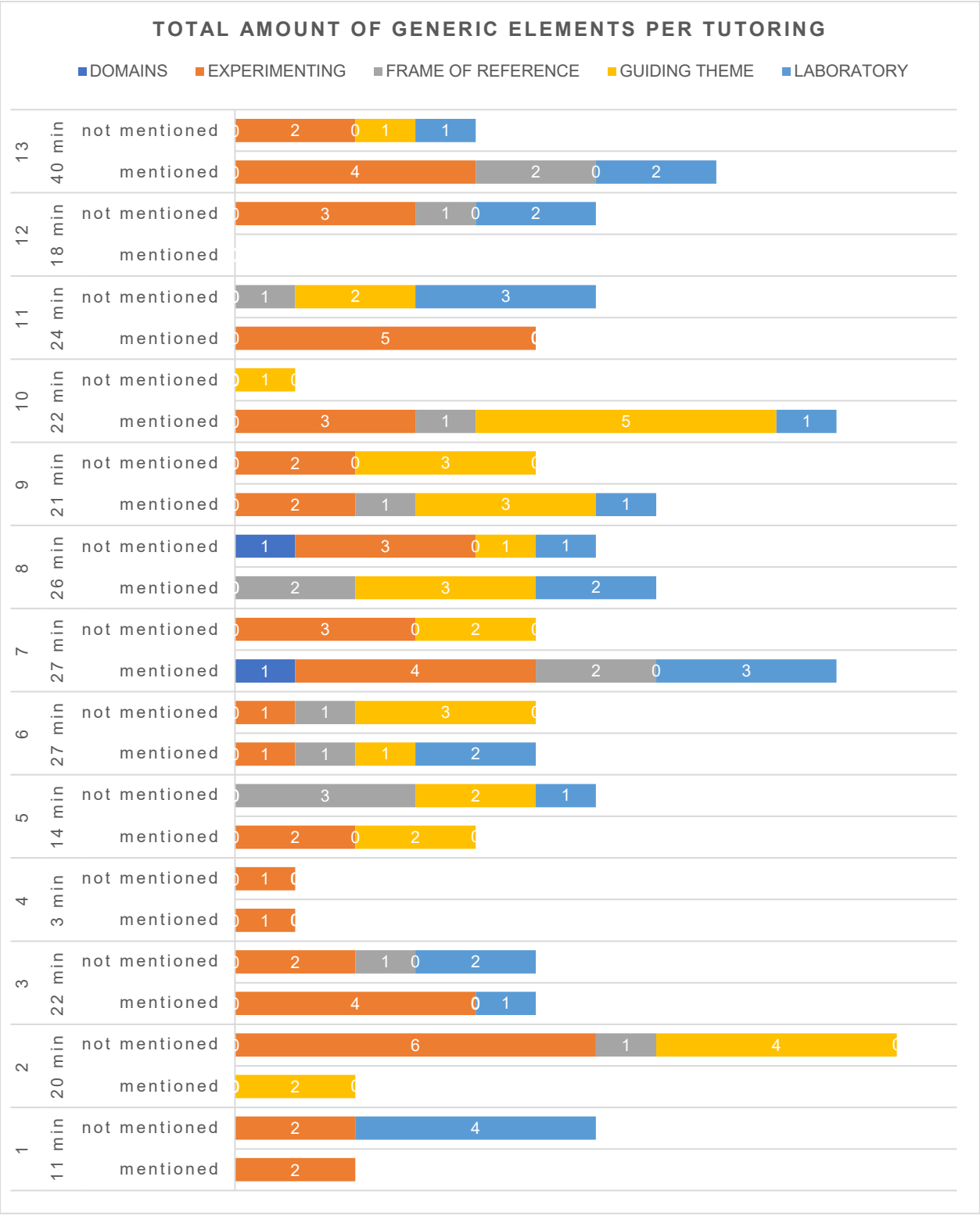

Figure 3. Number of times design-process elements are referred to during tutorial dialogues and duration of tutorial dialogue in minutes per teacher.

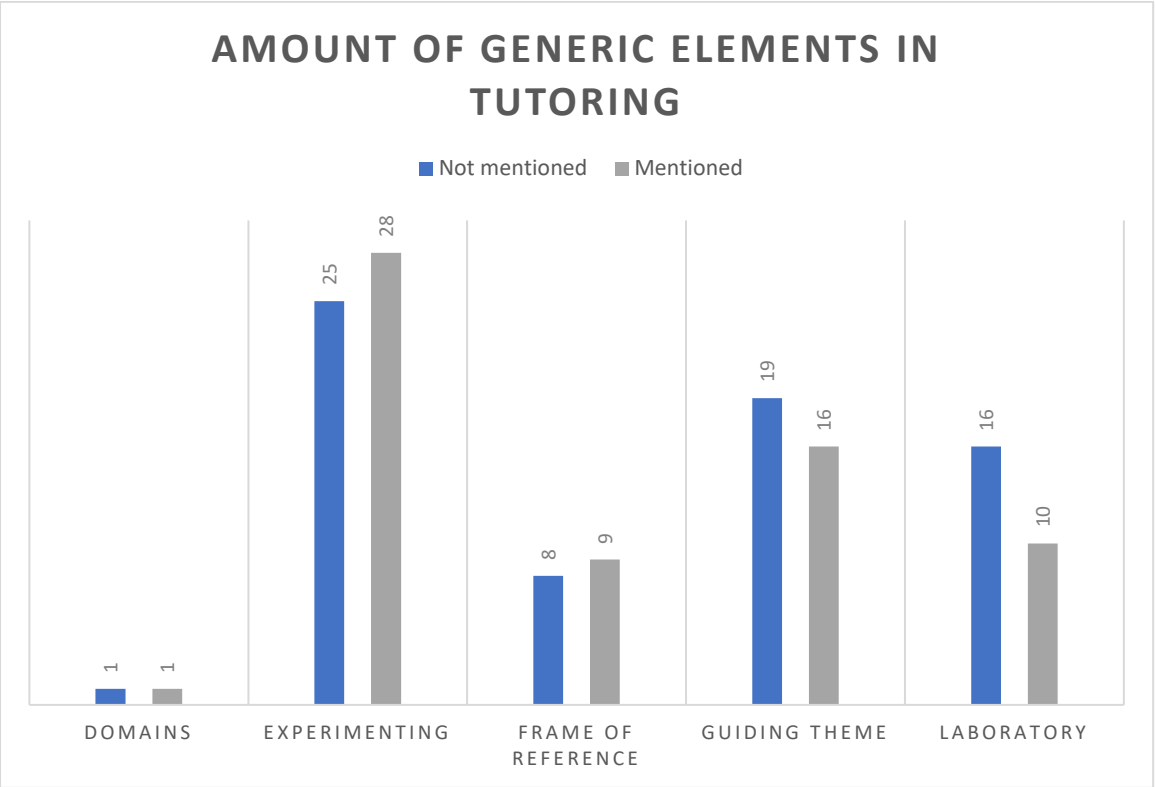

Figure 4. Total number of times design-process elements are referred to during tutorial dialogues: teachers give examples (not mentioning) or refer to (mention) notions in the design process.

Experimenting or exploring and deciding

Of all the elements, teachers referred most to the element of experimenting: n=53/133 in thirteen tutorial dialogues (see Figure 3 and 4). However, teachers did not explain the 'how and why' of experimenting, neither did they give instruction in this respect.

Teachers showed the process of experimenting by suggesting and talking about possible solutions of the particular design problem at hand (n=25 'not mentioned'). For example, a student tells teacher 04 that concerning an issue of the previous tutorial dialogue - transporting large pieces of art to and from the studio on top of the house - he will solve this problem with a lifting platform. The teacher reacts by saying that it is possible to use a platform *"being a large intervention […] you may make a hoisting beam at the façade […] or hire a crane each time you have to transport something […] or use the staircase."* He mentions that the last two options are not so handy. Then he simply goes on with another item without a conclusion or explanation.

Teachers also refer to the element of experimenting by using notions, such as 'different solutions', 'studying', 'alternatives', 'exploring things', 'just doing', 'testing', 'finding out' and 'choices you have to make' (n=28 'mentioned'). They use sentences almost as a kind of side-remark, while talking about the design product. See for an example, table 3, part 3a.

In two quotes teachers give a glimpse of what experimenting actually means (coded as 'mentioned'). For example, see table 3, part 3b. And teacher 07 refers to testing (in combination with the element of laboratory): *"You need to test it. It is inventing or making and then testing if it is like that. (..) Testing is making or drawing. In making you may surprise yourself. …You cannot visualise everything, so your hands can do more than your mind. With a model it is the same, maybe you cut it the wrong way, but then it shows something, you may like".*

Guiding theme or qualities

Teachers also regularly refer to that what gives direction in the design process, a guiding theme or quality: n=35/133 in thirteen tutorial dialogues (see Figure 3 and 4). However, teachers do not explain the role of the guiding theme in relation to the product at hand, neither do they give instructions in this respect.

Teachers seem to refer to the process of giving direction by talking about possible aspects and moves regarding the particular design problem at hand (n=19 'not mentioned'). For example, teacher 11 seems to refer to how a designer may make a jump from a 'local' aspect to a theme for the entire design, without naming it: *"Instead of just using solar panels, you could consider finding out how to make the house as sustainable as possible? How can you make use of that in the architecture?"*

Teachers also refer more literally to the guiding theme, using a palette of names and notions, such as 'motives', 'starting points', 'dream images', the 'essential', that 'what gives surplus or value', 'the importance of doing something that distinguishes your design from another', 'key-point', 'strip down to the core', the 'value' of the design, a 'story', a 'bigger story' and 'setting priorities' (n=16 mentioned). They all seem to have their personal names or notions.

Teacher 08 refers to a 'starting point': *"A contrast between an 'underground' and a 'floating' volume. That may be visible in the materialisation. That it is clear that they are different, … a contrast, being two different functions in two different elements. […] two characters… [..] That may be a starting point as well: that you have two similar things, worked out entirely differently".*

Three times a glimpse of 'the how and why' of a guiding theme is given (coded 'mentioned'). Teacher 05 refers to a bigger story: *"What I hear you saying is, I have looked at the roof, I made a variant for the roof, I know about the entrance, but those are all small solutions. […] What I miss is a bigger story. So you could take all kinds of small actions … it is all possible… but what do you want to achieve in the end? [...] Well, you are the designer. You have to say: this is what I want. It's like having a 'steppingstone', that makes it easier to take decisions".* Teacher 09 refers to the quality in relation to making decisions: *"You may set priorities, for example, requirements that are essential for you, that may help you*

make decisions. If you make it all equal in value, it is hard to decide. If you say for example, it is about the dinner table, […] you may add quality by making a central space [..] Not everything has the same importance". Teacher 10 seems to explain on a product level: *"Now you have to go to the key point, what is it that you want to achieve? So, you have to strip it down to the core, now. What is the most important?" […] I want to know what the core is. What do you want? […] Let's say you will present this to the brothers. They say they don't have the money. So you have to cut. Then it may become a slack extract of what you really wanted. So, from the start, you have to have a clear picture, so that you cannot miss what you want. […] It is not about the budget; we do not have a budget now. But it is about being aware of what you are doing".*

Domains

Throughout most of the tutoring sessions teachers refer to all kinds of aspects. Teachers and students talk a lot about aspects such as light, texture, colour, proportion, mass, composition, form, detail, structure, column, beam, span, experience space, function, and so on. The discussion is 'in' the domains, on a 'product-level'. However, teachers barely address the domains on the level of the design process. Only on rare occasions do teachers talk in a more abstract way about the aspects and scales and the relation between them, about how to work in and across the domains: n=2/133 in thirteen tutorial dialogues (see Figure 3 and 4).

Two quotes refer to the relation between aspects. Teacher 08 does this in the form of an example (n=1 not mentioned*): "Do you want the hallway over there or over there? Do you want to be surprised? That you enter a room with its own view? But that is related to the anchoring. To the location. And a feeling of holiday".*

In the other quote (teacher 07) a first glimpse of explanation can be seen (n=1 'mentioned'): *"You can look at a building from different points of view, so from shape, function, direction of the wind, location. […] The location, the view, the function and the dynamics of eventual facade panels, that those relations… In a good design it appears at a certain moment, that your choices will strengthen each other."*

Frame of reference or library of examples

Teachers refer to the frame of reference, to the professional principles and patterns designers work with: n=17/133 in 13 tutorial dialogues (see Figure 3 and 4). Teachers do not explain the role of references in the design process, nor in relation to the specific design product at hand. Neither do they give instructions on how to work with references.

Teachers refer to a reference project by simply mentioning its specific name (n=8 'not mentioned'). For example, teacher 10 simply refers to being inspired by an architectural type*: "It is good that you let the treehouse inspire you."* Teacher 08 refers to a specific item in a reference project: *"You had the teahouse of…"* (S:) *"Toyo Ito"* (T:) *"There is a large*

void, where downstairs and upstairs come together". Teachers also refer literally to the frame of reference, using one of two notions: 'reference' or 'example'.

Solely in two quotes more is said about the reference projects: teachers 06 and 07 refer to the analysis of a reference. They do not mention what to do with it in the design at hand.

Laboratory or the language of sketching & modelling

Teachers address the process of sketching and modelling: n=26/133 in 13 tutorial dialogues (see Figure 3 and 4). They do not explain the role of sketching and modelling in the design process, nor do they give more instructions. Teachers refer to the laboratory with all kinds of sketches involved, such as drawings, sections, and plans (n=10 'not mentioned'). Teacher 03 says: *"You have to draw sections, you have drawn the facades well, now you have to draw the section".* Teachers also refer to the laboratory with the actions involved, such as sketching, modelling, drawing different times (n=16 'mentioned'). Teacher 01 says: *"Maybe you should think this over ... sketch what happens here"* and *"so, you have to sketch... different times. Roughly, as I do now. It does not have to be orderly*"".

Because sketching and modelling are literally the laboratory for the process of experimenting, a direct relation can also be seen in the dialogues. For example, teacher 13 asks: *"Did you test that in a model?".*

Expressions used by the teachers

Exploring the way in which teachers talk, the open character is quite striking. Besides the obligatory statement: *'you have to ...'*, teachers let students decide what to do with what is said and how to do it. Teachers ask a lot of questions. For example, regarding the width of a staircase in relation to a place to show art (teacher 3): *"what is the size now?, "could it be wider?".* Furthermore they keep statements 'personal': *"What if you would say .. I am going to find this out"* (teacher 3*), "What is missing for me is a bigger story"* (teacher 05) and *"You may set priorities, for example, requirements which are essential to you, that may help you make decisions"* (teacher 09). When a student has made a choice regarding an aspect, it is regularly left open if it is a good choice or not. For example, in the example about the lifting platform mentioned earlier, new options are given when a student has come up with a solution, without discussing how to make the decision.

Conclusion and discussion

Regarding the first sub-question, in general teachers refer to elements in the design process several times in a tutoring session (see Figure 4). However, teachers refer to the design process (second sub-question) mainly in two ways: (1) implicit by using examples, directly related to the project at hand to show the process of designing, without mentioning or explaining the actions they 'model', and (2) literally to the design process by mentioning

all kinds of notions, such as exploring, testing, variants, starting points and sketching. These notions have the character of side-remarks or footnotes, almost hidden in the discussion about the design product at hand. Teachers barely explain the design process. Only in five quotes (5 out of 133 quotes, teachers 03, 05, 07, 09, and 10), a first glimpse of making the design process more explicit can be seen. However, it is more a matter of justification than explanation. Therefore, they are labelled as 'mentioned'. None of the observed teachers gave explicit instructions. Regarding the kind of expressions (third sub-question), teachers mainly use questions and suggestions. They seem to leave the student to decide if and what to do with what the teacher has said: 'you can / may do that', 'for me, it is'. Even in the case of 'you have to', they do not explain the why and how of the mentioned action.

Answering the main question in this paper whether, to what extent and how teachers articulate the design process in architectural design education, we may conclude that it remains for a large part implicit. Overall, the tutoring is about all kinds of aspects involved in the design project at hand. Teachers talk with students about the position of the rooms, the form of the building, the position or measurements of a staircase, a view, the entrance, the composition of the facade, and all other kinds of aspects. Amongst this, teachers regularly mention design actions and skills in terms of 'you have to' or 'you may'. For example: they tell the student to explore, but they do not explain what they mean by that, how to explore in the particular situation at hand, and how it relates to ways designers generally explore.

Experienced designers may understand each other, however, for (novice) students this may be confusing. There may be a significant difference between what teachers mean and students understand, as Schön (1987) already illustrated with the 'drawing' example, mentioned above. Before discussing how teachers can make the design process explicit, first the limitations of the research will be discussed.

Limitations

In this paper, the articulation of the design process is literally the subject of research. However, as already mentioned in the introduction, tutoring in the studio is more than the text of the dialogue. Regularly, teachers and students refer to sketches, such as plans, sections, and models. In several cases teachers sketch parallel to their talking. Also, aspects such as body language and the atmosphere between teacher and student play a role. Together, these aspects could make the dialogue becoming more or less clear than only looking at the language and notions used.

One could justifiably argue that the design process should not be articulated in all tutorial dialogues. However, in thirteen randomly chosen observations in the first design project of the architectural design program, one may expect the design process to be explicitly articulated more often than it actually was. This should also be the case if the process is subject in other courses. Being subject in parallel courses *and* in the design studio, helps bridge the gap between theory and practice.

In principle, the results of the case study presented here are not proof for other design school situations. However, recorded in different contexts and with different research approaches, the results presented here seem to run parallel to the results presented by Schön (1983, 1985, 1987), Dinham (1987b), Uluoğlu, 2000, and Goldschmidt, Hochman and Dafni (2010), which supports the generalisation of our findings.

Other limitations to the study presented here, are natural implications of the chosen research method: the process of recording and coding. Teachers may be affected by the presence of a camera. Furthermore, the number of labels per element may still be a point of discussion. However, these decisions do not interfere with the main conclusion. Only five quotes were topic of serious discussion, being on the border of being explicit. In fact, these quotes are an extensive way of mentioning, a kind of description what may happen in the design process. They do not explain the design process.

Making the design process explicit

In the process of analysing and labelling the framework helped in comparing what actually is said and what can be said seen from the perspective of the design process.

For example, in the dialogue about the staircase with some sculptures (see Table 3), teacher 03 starts to ask if the stair may be wider. The student ('yes, 20 cm') seems to interpret it as a matter of measurement, being a first-year student without a large frame of reference. The teacher seems to 'pull' the student to the idea of a 'function exceeding staircase' and concludes about small things which may change the whole design, "that's what being an architect is about changing everything continuously. Until you think: this is how I want it to be." To avoid misinterpretations, to give an overview and to explain design process actions, it could be discussed more directly, such as: the staircase as (1) a functional staircase, (2) a staircase with room for having some pieces of art, (3) making the staircase as an art gallery, as the core of the house, or (4) making the house 'living in a loft-like art gallery'. Each with its (dis)advantages and its own specific proper means to achieve it. This way the student gains an overview and logic of architectural ideas, such as qualities or themes (e.g. house as art gallery) and architectural means, such as principles and patterns (e.g. enclosed staircase and hallway with rooms or a staircase in an open 'loft' space, each with corresponding constructional principles). The student still has to choose, but the teacher now articulates the kinds of choices and how these choices are related. This example seems to run parallel to the way teachers mainly seem to tutor their students: reacting 'afterwards', discussing all kind of aspects of the design product at hand.

However, studio and tutorial dialogues may also be structured according to the 'designerly' actions and skills, to train students 'automatically' in the way designers think and act. First year students may be given small tasks as part of the whole design task, such as coming up with three themes or qualities next time, or coming up with alternative solutions and means to develop the preferred theme. For example; regarding the lifting platform the

teacher might have given in the previous tutoring the instruction to study different methods of transporting objects vertically in reference projects, presenting them in diagrams or icons and reflecting on them in the situation at hand.

To conclude: teachers barely articulate the how and why of the design process in general, and in connection with the development of the design product at hand. They do not relate the situation at hand to the larger context of the design process. As educational practice proves, students may learn how to design simply as a result of doing design tasks and discussing the products at hand with their teachers – even when the design process stays implicit. However, making the design process explicit can significantly enrich and speed up their learning process (Kirschner, Sweller & Clark, 2006; Van Merriënboer & Kirschner, 2018). Students may experience learning-how-to-design as less confusing, they may in the long term become better designers, they may spend their time in education more effectively, and their self-confidence may increase. With the help of a design vocabulary teachers should be able to talk about the design process and train students in a more explicit way.

Next research steps will be testing the framework in design education. Does it help teachers in being more explicit and in organising design education? And even more important, does it help students in mastering the confusion and become more successful designers?

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