Analyzing the display of professional knowledge through interpersonal interactions in design reviews

Neeraj Sonalkar

Center for Design Research, Stanford, USA
sonalkar@stanford.edu

Ade Mabogunje

Center for Design Research, Stanford, USA
ade@stanford.edu

Larry Leifer

Center for Design Research, Stanford, USA
leifer@cdr.stanford.edu

Abstract: Design review in an educational setting is an activity that helps educators in assessing students' progress, and provides opportunities for students to learn how professionals in the field perceive and judge design-in-process, aka professional vision. In this study we analyzed design reviews to understand how interpersonal interactions between participants provides a context for the expression of professional knowledge. We identified episodes of professional vision interaction, and examined the interpersonal responses that constitute a design review meeting. The results of the analysis demonstrated how the context for the display of professional vision was co-created through interactions between the reviewer and the students.

Key words: Interpersonal interactions, professional vision

1. Introduction

Design review is an important social technical activity both in product design industry, and in product design education. In industry, reviews provide an opportunity for multiple stakeholders to evaluate a design artifact, verify its conformation to standards, and approve its further progress. In design education, reviews serve to critique student designs, suggest improvements and provide learning opportunities for students to understand effective design.

Design review as an activity has been studied in the past from a number of different perspectives. Some researchers have directly addressed design reviews in industry from an information handling and knowledge management perspective (Huet, Culley, McMahon & Fortin 2007, Verlinden, Horváth & Nam 2009), while others have used design reviews as a means to understand human behavior in design activity. For example Schon and Wiggins (1992) highlight the different ways of 'seeing' inherent in design through a design review conversation between an expert and a student designer.

Schon and Wiggins allude to the interactional nature of design reviews. However, a number of design reviews in practice are still constructed as one-way presentations followed by reviewer feedback. The interactional dynamics of design reviews have not been previously analyzed to examine the role of interpersonal interaction in design review situations. How do the interpersonal interactions between participants create a context for the expression of professional knowledge? In this paper, we investigate how interpersonal interaction between an expert and novice becomes a design review.

2. Research questions and significance

The basic premise behind our research is that design is an interaction driven activity. If we observe a group of designers over a period of time, we would see team members moving around, interacting with each other and with a number of different objects and tools. Through these interactions, information and ideas circulate among the people on the team, concepts are generated, prototypes are created and tested, and products are specified.

The phenomenon we call a design review, is one such particular set of interactions. We ask the following questions of this phenomenon.

1. What interaction elements characterize a design review?

2. How does interpersonal interaction create the context for the expression of professional knowledge?

Investigating these questions would enable us to understand the building blocks of a design review. This has implications for training design educators as well as practitioners in understanding and subsequently improving a design activity that they routinely participate it and which has significant influence on design outcomes.

3. Theoretical frameworks

Since our research deals with interpersonal interaction and the expression of professional knowledge through such interaction, there are two frameworks underlying our investigation.

The first is a visual framework of representing interpersonal responses as a series of symbols indicating the movement of ideas and information through the on-going conversation. This visual framework is embodied in the Interaction Dynamics Notation used for representing design interactions (Sonalkar 2012, Sonalkar, Mabogunje & Leifer 2013). The Interaction Dynamics Notation is briefly described below. This framework is chosen to analyze interpersonal interactions in this study because of two reasons – it was designed specifically to represent interpersonal responses in conversations, and has been used successfully to analyze concept generation interactions in design teams (Sonalkar, 2012).

In Interaction Dynamics Notation, observable speaker expressions (verbal and nonverbal) are interpreted and assigned symbols to create a descriptive visual model of the interaction. The assignment of symbols is conducted based not on what the expression is from the point of view of the person making it, but on what the expression is taken to be and responded to by others in the team. So what we are modeling is not a series of speaker expressions but rather a series of speaker responses. Thus, the Interaction Dynamics Notation is a visual model of an unfolding interaction. The unfolding interaction can be compared in its narrative structure to a dramatic plot. Just as narrative forces shape the unfolding plot, the forces of individual feelings and intentions shape the unfolding conversation. Hence, the Interaction Dynamics Notation is constructed as a visual synthesis of the Force Dynamics Notation from the field of cognitive semiotics (Talmy 1988, Brandt 2004) and the Free Body Diagrams prevalent in engineering mechanics. Figure 1 shows the Interaction Dynamics Notation of a brief design conversation.
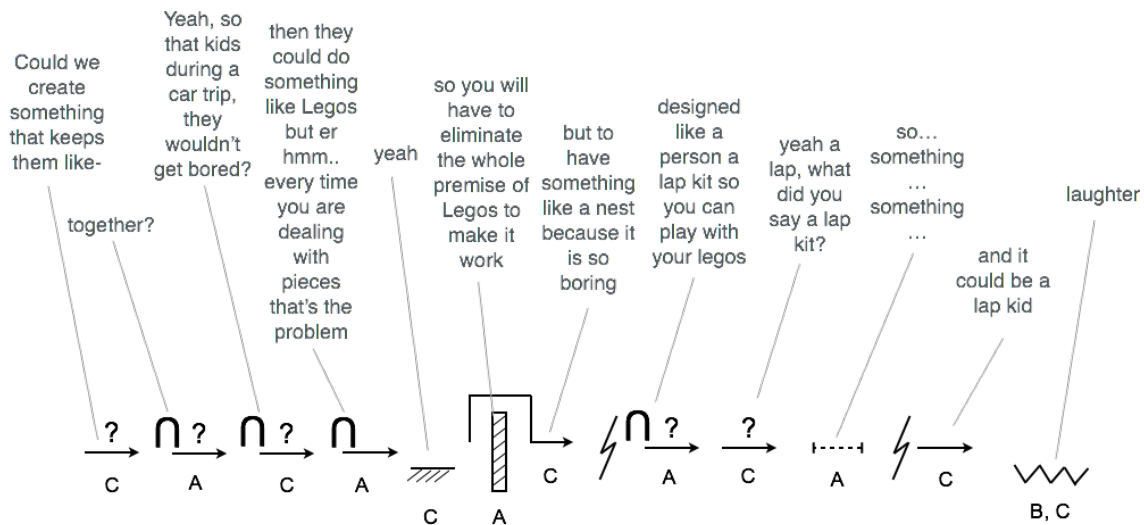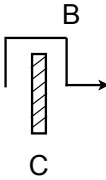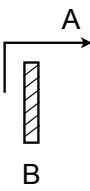

Figure 1. A conversations between three designers A,B and C is visualized using the Interaction Dynamics Notation.

Table 1 gives a detailed explanation of each symbol used in the visual notation.

Symbols	Name	Description	Example
→ A	Move	A 'move' indicates that a speaker has made an expression that moves the interaction forward in a given direction.	A: I need to buy Legos (at) home. Think about how therapeutic it would be.
? → A	Question	A question indicates an expression that elicits a move. A question projects onto the next response and constrains the content of that response because the next response needs to answer the question.	A: Where should we start?
⊢----⊣	Silence	Silence is a state in the conversation when none of the participants speak as they are engaged in other individual	

Symbols	Name	Description	Example
		level activities. Silence has been included in the notation as a number of design conversations are an interplay of both group conversation and individual activity.	
C	Block	Block indicates an obstruction to the content of the previous move. For a block to be felt, the coder needs to feel that the response in some ways obstructed the flow that was established by prior moves.	B: Maybe have something which looks like a computer but you can just type your name or do a simple math, a calculator in the shape of a computer kind of. C: Er, but I don't know, I mean, considering the age segment we are targeting 3 to 7 years.
B	Support for move	Support-for-move indicates that the speaker understands and/or agrees with the previous move.	C: Safe and entertaining (bending forward to write). B: Safe and entertaining, yes.
C	Support for block	Support indicates an acceptance of a block by another person.	A: But that's also, I think that's already done. C: Yeah, its already there. B: Ok.
B C	Overcoming	Overcoming a block indicates that though a block was placed in front of a move, a speaker was able to overcome the block and persist on course of the original move.	C: Er, but I don't know, I mean, considering the age segment we are targeting 3 to 7 years. B: So 7 years they go to school, they would learn A, B, C right?
A B	Deflection	When a speaker blocks a previous speaker's move, that speaker or another can deflect the block with a move that presents an alternative direction for the interaction.	B: So when you say we need to divide the age-group, but you cannot have like 3, 4, 5. A: No, no of course not, but I mean you might have a few different (concepts).
X	Interruption	An interruption is indicative of a speaker being interrupted by another speaker or at times by himself.	B: Should we start generating some concepts now? A: Yeah (interrupted by X) X: 10 min are gone.
C	Yes and	A move is considered to be a 'Yes and' to the previous move if it accepts the content of the previous move and adds on to it.	A: What about... if we made a toy that incorporates girls and boys. Its like a house that has a car with it kind of like enables the guys to play with the girls? C: I think that's a good point to have some sort of a educational point in it.

Symbols	Name	Description	Example
C	Deviation	Deviation indicates a move that changes the direction of the conversation from the one implied by the previous moves.	C: But we need to remember it. C: This is not the buildable room (deviating from previous topic)
A,B	Humor	Humor indicates instances of shared laughter in teams.	A: I don't know I probably would have swallowed but (All of them laugh)

The second theoretical framework underlying our work is the framework of professional vision proposed by Goodwin. Goodwin (1994) describes professional vision as "socially organized ways of seeing and understanding events that are answerable to the distinctive interests of a particular social group." The notion of professional vision thus refers to the salient perceptual elements that professionals of a particular discipline are trained to see and interact with to fulfill the objectives demanded of them. In a design review, an expert designer is faced with a complex perceptual field of the design artifact and social interaction with the student designer or design teams. Based on his expertise, the expert 'sees' information relevant to his expertise that collectively comprises his professional vision. Goodwin's framework of professional vision has been used to examine activity in various professions such as teaching (Sherin 2007), medicine (Koschmann et al. 2011), and architecture (Lymer 2009).

In design research, this perspective has been used in the past by Schon and Wiggins (1992) to study design review conversation. They identified ways of 'seeing' such as "literal visual apprehension of marks on a page; appreciative judgments of quality and apprehension of spatial gestalts. In this paper, we identify responses in the interpersonal interactions during the design review that contain expressions of professional vision. It is through these responses, that the professional knowledge of the design expert becomes explicit. Building on Schon and Wiggins, and Godwin, professional vision responses are identified as responses that contain appreciation, critique or suggestions regarding the artifact or the design concept being expressed through the artifact. The professional vision framework thus helps to highlight expression of professional knowledge in a design review.

It is important to note that professional vision is not the same of framing, which is considered a core element of design activity in design research. Dorst (2011) defines framing as the creation of a novel standpoint from which a problematic situation can be tackled. A frame is a perceptual configuration of an emergent situation that is created to arrive at specific solutions. A designer can adopt a frame and then discard it as the situation changes to adopt a new frame. This framing and reframing (Schon 1983) is a critical aspect of design thinking. Professional vision, on the other hand defines for a designer what perceptual aspects to pay attention to when formulating a frame. If frame is a perceptual configuration of an emerging situation, professional vision for a designer is the identification of what elements to attend to that can be formulated in to specific frames. Professional vision is acquired through disciplinary training and remains consistent throughout a professional community, while frames can change from moment-

to-moment and person-to-person. In a design review setting, students are socialized into the professional vision of a design community through their interactions with the expert designer. In this case, they are not just exposed to an individual expert's framing of a situation, but rather to the professional vision of the discipline they are trying to acquire through their training.

4. Methods

We perused through the different datasets available through the DTRS 10 symposium and selected the Industrial Design, Graduate "ID-G" dataset for further analysis. The "ID-G" consists of video and transcripts of 6 graduate student design reviews with instructors and clients, and pdf copies of design concept boards that were part of these reviews. It provides enough data to analyze the interpersonal interactions in each review. One drawback of the dataset is that from the sequence of review meetings, each student has data missing one or the other reviews. Only 3 of the 6 graduate students – Eva, Mylie and Sydney, who had data available for the initial dsearch review, the concept review and subsequent client review were analyzed for this study.

Analysis involved the following steps.
1. Coding the transcripts for professional vision responses,
2. Coding the video data of each review using the Interaction Dynamics Notation to create a visual representation with an overlay of the professional vision responses in color, and
3. Identification of specific episodes of interaction that correspond to display of professional vision.

Each of these steps is discussed in detail below.

1. Coding transcripts for professional vision responses.

The transcripts of the reviews selected for analysis were analyzed for professional vision responses. Those responses from an expert or peer reviewer that commented on the artifact or the design concept being reviewed in terms of appreciation, critique or suggestions for change were highlighted. Responses that contain clarifying questions regarding the artifact or the concept were not included as professional vision responses. Figure 2 below shows an excerpt from the coded transcript.

Simon (Instructor):	So couple of things. You said this is too big, too important. This – that needs to become an important one. Yeah, 'cause it's showing floating and the infrared rays. Is the washer and dryer two different things?
[0:05:00]	
Eva (student):	Mm-hmm.
Simon:	Which is the washer and which is the dryer? Okay. So you need to, um, this is dryer you said or washer?
Eva:	Dryer.
Simon:	If, if there are new forms of things you kinda' need to point to them and say that's – it's – when it – when it's a washing machine that looks like a washing machine –
Eva:	Mm-hmm.
Simon:	-- you don't need to point it out, but if it's something new in the form, that's the dryer, that's the washer.

Figure 2. Except from Eva's concept review. The highlighted parts are responses that indicate professional vision.

2. Coding the video data of each review using the Interaction Dynamics Notation to create a visual representation.

The Interaction Dynamics Notation was applied to video data of dsearch, concept and client reviews using a specialized coding tool called the IDN Tool. Figure 3 shows the IDN Tool interface.
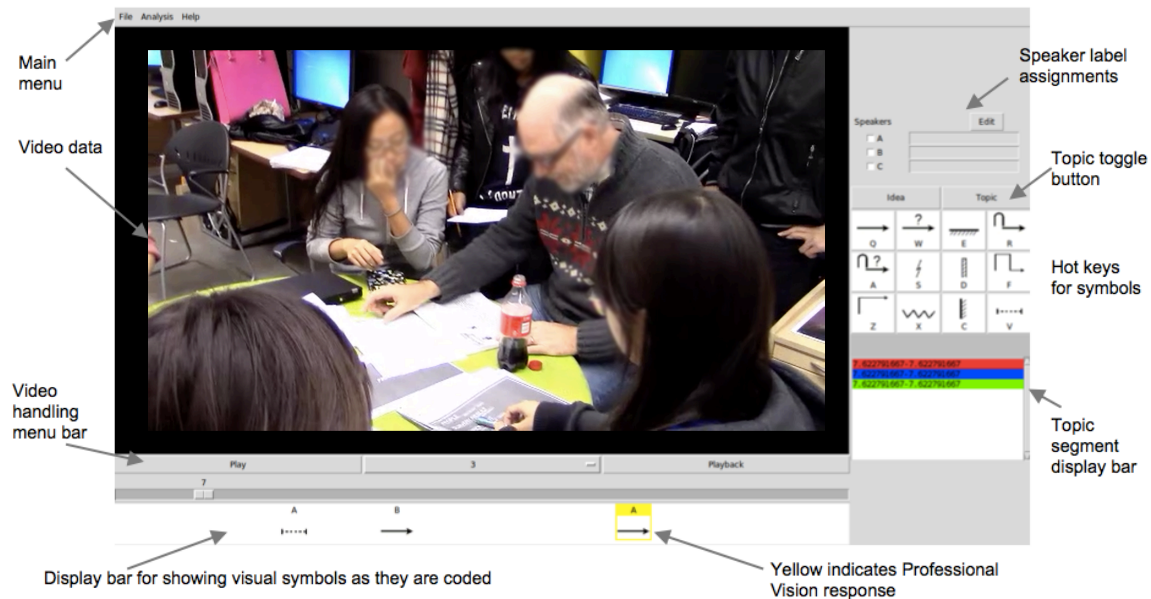

Figure 3. The IDN Tool interface used for creating a visual representation of design review interactions using the Interaction Dynamics Notation.

Each video was coded in two passes. In the first pass, the speaker responses were assigned a visual symbol from the Interaction Dynamics Notation. In the second pass, the responses that were earlier identified to be professional vision responses were not highlighted in color in order to create a visual representation that included both interaction information and professional vision response information. Figure 4 shows an example outcome of the Interaction Dynamics Notation coding with the professional vision responses highlighted. The IDN Tool also facilitated a sequential pattern analysis to identify key interaction response patterns that repeated through the design review.
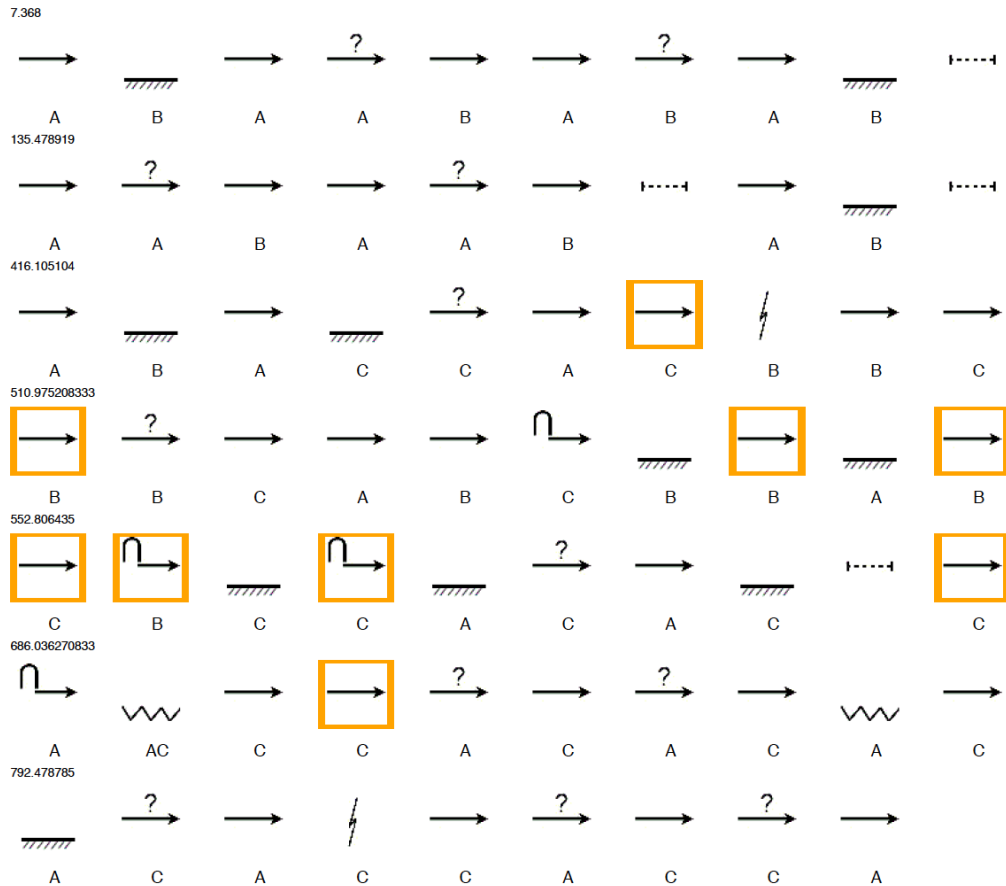
Figure 4. Visual representation of Eva's client review using the Interaction Dynamics Notation with professional vision responses highlighted. The alphabets below the symbols indicate speakers. The number at the start of each row indicates the timestamp in video corresponding to the first symbol in the row.

3. Identification of specific episodes of interaction that correspond to display of professional vision.

Based on the visual representations of design review, further analysis was conducted to identify patterns of interaction relevant to the expression of professional knowledge. Specific episodes of interpersonal interactions that gave rise to professional vision responses were identified based on the topical continuity of the content of the interaction. It is important to note that these episodes are a time-bound set of speaker turns; they are not single speaker expressions. These episodes were characterized in terms of their beginning, middle and end patterns to understand how an episode begins, sustains and ends during the course of the design review. Figure 5 shows the same visual representation as Figure 4, but now with the specific episodes of professional vision interaction highlighted.
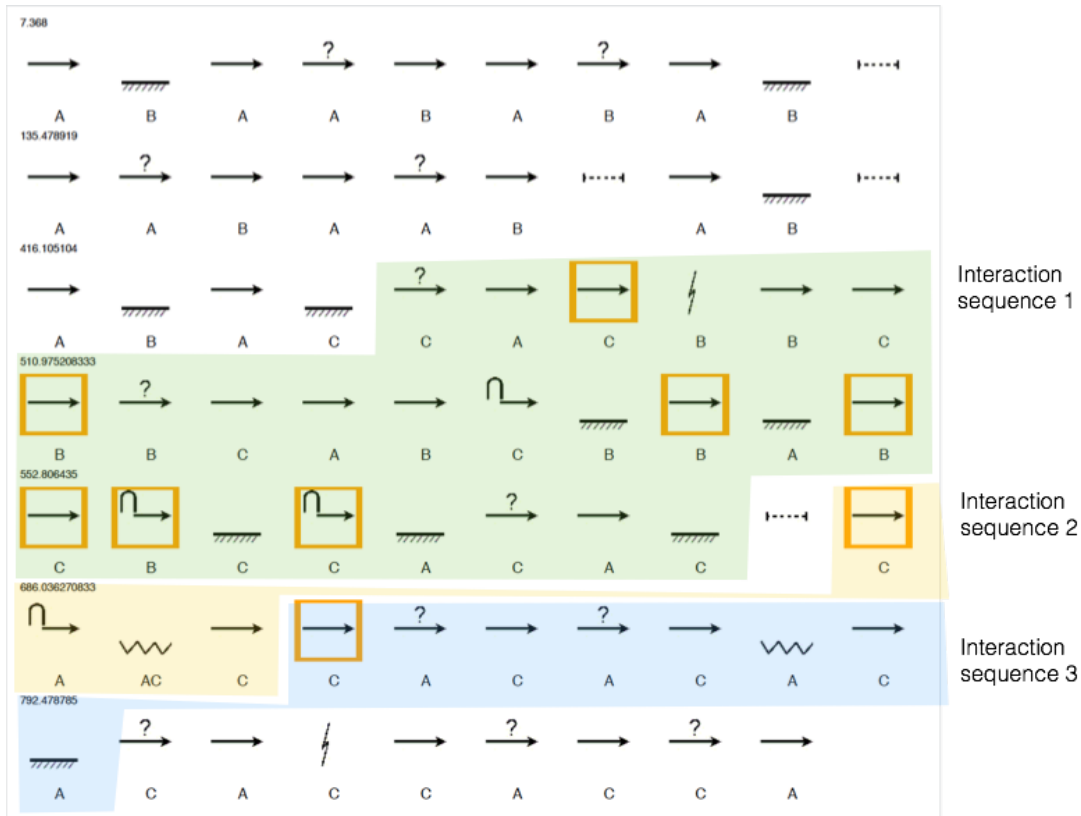
Figure 5. Three professional vision interaction sequences are highlighted in the visual representation of Eva's client review

5. Results

1. Interaction elements in a design review

A sequential analysis of the visual representation of the eight design reviews Interaction Dynamics Notation yielded the following results.
1. Moves were the most commonly occurring interaction responses. The other interpersonal response types that were observed were question, support, silence, yes-and move, yes-and question, interruption, humor, and block. See Figure 6.

Figure 6. A graph of the various interpersonal response types found in the different review sessions analyzed.

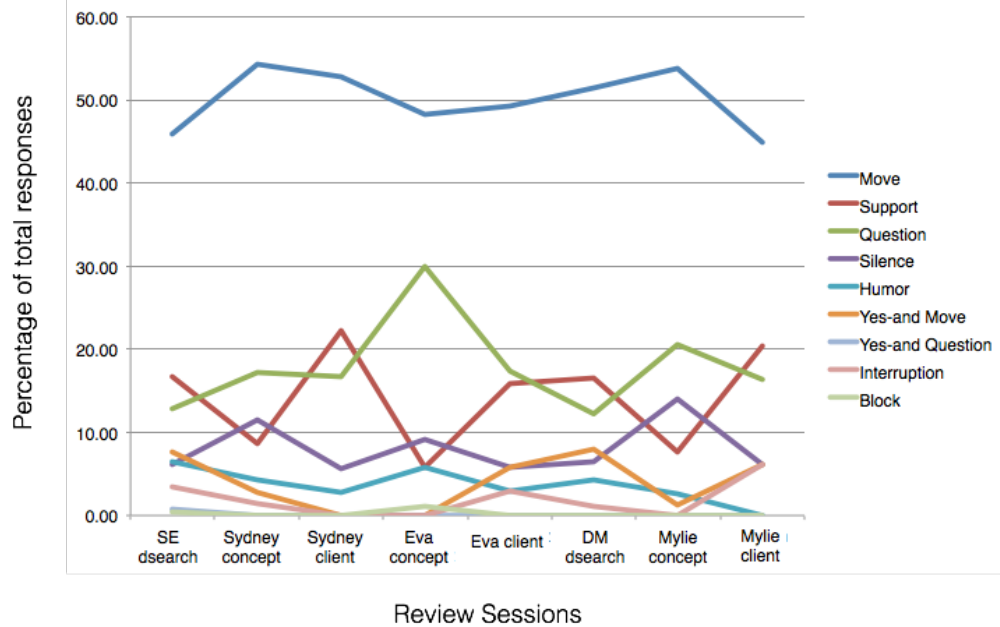From the graph above, moves consisted of 45 to 55 percent of all responses in the session analyzed. In concept review sessions questions and silence occurred more commonly than support, while in client review sessions support responses occurred more commonly than questions and silence. The one exception to this observation was Eva's client review in which questions and support occurred in almost equal amount.

2. A search for interaction sequence patterns more than 3 responses long and occurring at least 3 times, yield patterns that contained move, question, silence and support in multiple combinations. For example the pattern 'move-question-move-question-move' was commonly found in SE dsearch review, Eva concept review and DM dsearch review. It was observed that none of the concept reviews contained sequences with support. Only move, question and silence responses were seen in concept review patterns, while in client review patterns support response was commonly seen.

2. Characterizing episodes of professional vision interactions

Our second research question aimed to investigate how interpersonal interactions create the context for expression of professional knowledge. In order to answer this question, we identified episodes of interaction, which gave rise to a display of professional vision by the design reviewers. Table 2 gives an overview of these episodes of professional vision interaction in terms of their number of occurrence, the kind of professional vision displayed, and the ratio of time spent in professional vision interaction as compared to the total review duration.

Table 2. Overview of episodes of professional vision interaction

	SE dsearch	Sydney concept	Sydney client	Eva concept	Eva client	DM dsearch	Mylie concept	Mylie client
Number of episodes	6	5	2	6	3	10	5	3
Episode 1	highlight significance	Critique communication, appreciate communication critique concept (desireability), suggest alternative	appreciate concept, critique concept (feasibility)	critique communication	appreciate concept, appreciate desirability suggest alternatives	critique communication suggest alternative	critique communication	appreciate concept critique concept suggest alternatives
Episode 2	appreciate technique	critique communication	appreciate concept, critique concept (desireability), suggest alternatives	critique concept (feasibility), suggest alternatives	critique concept, appreciate process	appreciate communication critique communication	critique communication	appreciate concept, critique concept
Episode 3	appreciate technique	critique communication		critique communication	appreciate concept, suggest combination	highlight surprise, insight	critique communication	appreciate concept
Episode 4	highlight significance	critique/suggest communication		critique communication		appreciate technique	critique communication suggest alternative	
Episode 5	Critique communication	critique communication		critique communication		critique communication	critique communication suggest alternative	
Episode 6	Critique communication			critique communication		highlight significance		
Episdoe 7						critique technique		
Episode 8						highlight significance		
Episode 9						highlight significance		
Episode 10						critique technique appreciate technique encouragement		
%Ratio= episodes durations/total video duration	11.89	59.41	41.97	99.64	35.45	27.56	70.56	29.43
Total video duration in seconds	1278	404	529	559	818	1756	659	880

The following observations can be made.

1. Client reviews contain the least number (2-3) of professional vision episodes. This may be due to shorter duration of these reviews as well as the fact that at least half of the time is spent in a one-way explanation of the concepts to the reviewers. Concept reviews and dsearch reviews on the other hand directly start with a review conversation between the expert and the student in which concept explaining and expert feedback are intertwined. Hence concept reviews and dsearch reviews have a greater number of episodes of professional vision interaction (5-6). The exception being Dan and Mylie's dsearch review (DM dsearch) that contains 10 episodes of professional vision.

2. The amount of time spent in professional vision episodes as a percentage of total duration of the design review is highly variable. Concept reviews have the greatest professional vision episode percentage varying from 59.4% for Sydney's concept review, to 99.6% for Eva's concept review. This is followed by client review varying from 29.4% for Mylie's client review to 41.7% for Sydney's client review. Dsearch reviews though they contain a greater number of episodes are low on percentage time spent in professional vision episodes – varying from 11.9% for Sydney and Eva's dsearch review to 27.5% for Dan and Mylie's dsearch review.

3. The nature of professional vision displayed falls in to one of nine categories. Table 4 below lists these categories along with an example of each, and a mapping to the ways of seeing described by Schon and Wiggins (1992).

Table 4. Categories of professional vision responses.

	Nature of professional vision response		Example	Mapping to Schon & Wiggin's classification
1	appreciate	communication	Simon: But they are beautiful drawings, really nicely done. Love the vignette and the way these two drawings are tied together with that vignette. It does a really nice job of showing that. (Sydney concept review, 02:09 min)	literal visual apprehension
2	appreciate	process/technique	Chuck: Yeah, no, I, I, I definitely appreciate the can. I mean, always push stuff out like that 'cause you never know. You might not have gotten to the last concept if you didn't get to that one so. (Eva client review, 11:33 min)	NA
3	appreciate	concept	Peter: I mean, that's something different that at least I haven't seen. Again, you might wanna look out there. Just Google search or patent search foldable hangers you might see there. I think there's a lot of people that could benefit from something like this and it seems so simple and elegant a solution. (Sydney client review, 6:17 min)	appreciative judgment
4	critique	communication	Simon: Now, I read it as a stylized tree, right, and it's actually a product that looks like a tree. Not a stylized tree. Um, to make it look more product like, what can she do? What can she	literal visual apprehension

		do to make it more product-like? (Mylie concept review, 3:22 min)	
5	critique	process/technique	Simon: Okay, translating them into – is it – I think sometimes more is not better so maybe if you can … (DM dsearch review, 23:00 min)	NA
6	critique	concept	Chuck: So, but, ya' know, with us, it's like you don't want yoru gym clothes to smell like my wife's dress, ya' know, cocktail dress. So is this a thing that you kind of – I, I don't know. I'm just kind of thinking. (Mylie client review, 10:34 min)	appreciative judgment
7	highlight	significance	Simon: And this is sort of gray. It's that – and so a storage system that deals with that sort of transition between maybe every third time I need to wash it. Has it got there yet and how does it progress from one to the other? That's an opportunity. (SE dsearch review, 06:04 min)	appreciative judgment
8	suggest	alternatives	Simon: But you could create anti – you want things to just like freely tumble around? Um, you could use like a – like a rotational molding where it is constantly tumbling randomly and so things are always just tumbling around as a way to clean it. Um. You could also use anti-gravity magic rays. Um, we're allowed to propose that. (Eva concept review, 03:01 min)	appreciative judgment
9	encourage		Simon: So it gives us this great diversity of things we can explore. Um, I think they really want us to scare them with crazy, wild ideas, so don't be afraid to let yourself go wild and crazy in your ideations, okay. (DM dsearch review, 29:00 min)	NA

The 'appreciate process/technique' and 'critique process/technique' categories and the encourage category do not have direct one-to-one mapping with the ways of seeing described by Schon and Wiggins. Their research focused on the artifact and the concept as it was being created through the artifact. In the design reviews, in this dataset the focus on concept and the artifact is predominant. However, at times the experts comment on the process or technique shown by the student in preparing the artifact. On one occasion the expert, Simon encouraged his students to "go wild and crazy" in their ideations. These aspects of professional vision that deal with the design process were not captured in Schon and Wiggin's work.

Taking a cognitive semiotic perspective, each episode of professional vision interaction can be considered as an unfolding narrative with a beginning, middle and end. How do episodes of professional vision begin? How do they end? What interaction patterns sustain such episodes? We analyzed each of the 40 professional vision episodes to answer these questions.

The analysis revealed that most episodes (34 out of 40) begin with a move or a question prompted by the artifact being reviewed. A few episodes (5 out of 40) begin with a question

unrelated to the artifact but relevant to the design review activity. One episode was prompted by the reviewer questioning the explanation being offered by the student.

Most of these episodes of professional vision (32 out of 40) were sustained through moves, questions and support. 8 episodes were expert monologues.

The ending of professional vision episodes was difficult to categorize in terms of patterns of interpersonal response. Episodes end when the reviewer and the student move back to studying the artifact, or when a new topic of interaction starts, or when there is an interruption with a new topic of interaction. There were no specific interpersonal responses that were associated with ending of episodes of professional vision.

Figure 7 below gives an example of the interaction dynamics of a professional vision episode. This episode begins with a question based on the artifact, is sustained by interaction consisting of moves and support, and ends with the expert moving on to searching on his cellphone for a teachable example.
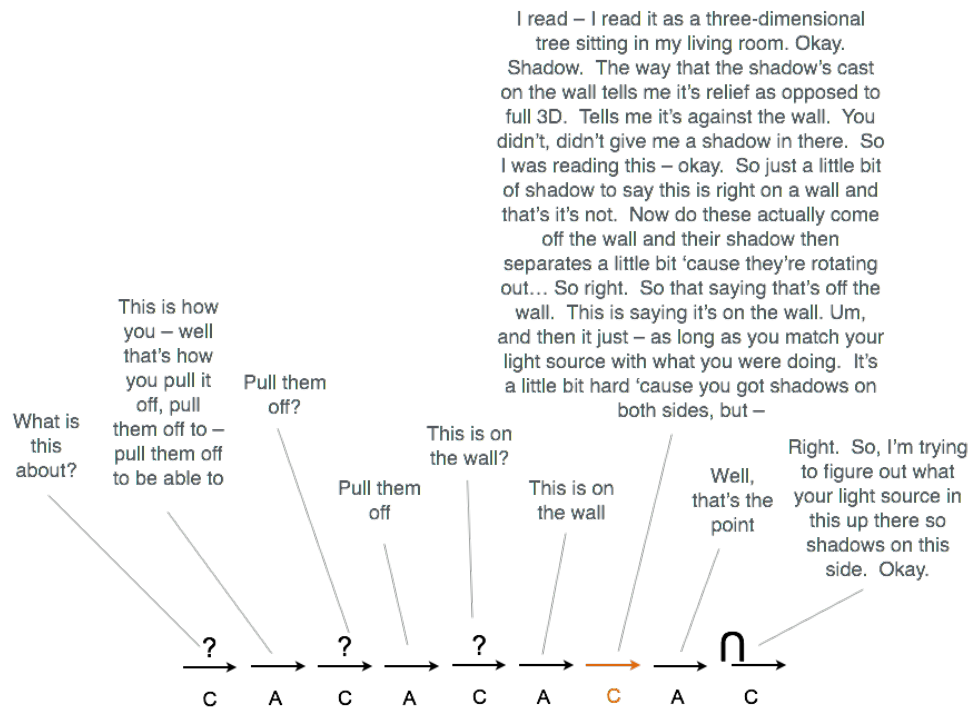

Figure 7. A and C indicate the student and the expert reviewer respectively. The colored symbol indicates a professional vision display response by C.

6. Discussion

We set out to answer two research questions in this study. How do interpersonal interactions create the context for the expression of professional knowledge? And what are the elements that characterize such interpersonal interactions? In this section, we discuss the results in the context of these questions.

A key element of design review meetings that qualifies them to be review meetings is the expression of professional knowledge on part of the reviewer with regards to the design artifact being evaluated. In this study, we used Goodwin's notion of professional vision to identify expressions of professional knowledge. The analysis revealed that such expressions rarely happen in a monologue. Interpersonal interactions create a context for the expressions of professional knowledge in which the students and the artifact play a crucial role.

Analysis showed that unsurprisingly, the design artifact played a key role in the initiation of social interaction that encompasses the expression of professional knowledge. Prior research on design review conversations (Schon and Wiggins 1992) also focuses heavily on the artifact. Schon and Wiggins's analysis of a design review of a sketch drawn by Petra, an architectural student sparked significant interest in sketching and drawing in the field of design research. But the interpersonal dimension of that design review interaction was missing from research discourse. In this paper, we presented the various responses elements that constituted the interaction of a design review.

Question-asking emerged as a key interaction element. Questions prompted by the artifact commonly occurred at the beginning of episodes of professional vision. Reviewers asked clarifying questions such as the one indicated in Figure 7, to understand certain aspects of the design artifact, which opened up opportunities for further comments. In some cases during client reviews and concept reviews, generative design questions (Eris 2002) sustained an interaction between the reviewer and student in which further elaboration of concepts occurred along with a discussion of possible alternatives. Cardosa, Eris and Badke-Schaub (2014) who also analyzed the graduate students' design review dataset, mention that the reviews were lacking in deep-reasoning questions. While this observation is supported by our analysis, we find that question-asking in design reviews, even if it was clarifying questions, served as a prompt for initiating an interaction that led the reviewer to display his professional vision. Hence, question-asking irrespective of question type is a key interaction element in professional vision interactions.

In terms of categories of professional vision responses, question-asking was not limited to a particular category per se.

Support responses indicating verbal or gestural understanding and acceptance played a role in sustaining professional vision interactions. Support was more commonly observed in client review than in concept review for each of the subjects studied (see Figure 6). We hypothesize that this could be an outcome of the client-student relationship dynamics and the short time allocated to the review. In concept reviews, while support responses were present, dialectic interaction episodes indicated by block-overcoming-block-overcoming were absent from interaction. Dialectic episodes in interaction indicate an argumentative two-way elaboration of a particular topic as opposed to an acceptance-based elaboration, which tends to be a one-way from the reviewer to the student.

In addition to the interaction analysis, the content analysis of the different types of professional vision expressions yielded two categories of professional vision that were not identified earlier by Schon and Wiggins (1992). These were 'appreciation of design process', and 'activity encouragement'. 'Appreciation of design process' includes appreciating or criticizing design

process or technique that has resulted in the design artifact being reviewed. For example, Simon mentions to Dan and Mylie in their dsearch review that generating more ideas is not necessarily better, when they show a large quantity of concepts in their ideation. This feedback indicates Simon's own perception of design process, his own professional vision. The category of 'activity encouragement' relates to the professional vision a design educator has in terms of motivating his students towards certain design behaviors. For example, at the end of Dan and Mylie's dsearch review, Simon extols the students to generate wild and crazy ideas. Both these categories of professional vision expression indicate 'ways of seeing' that in the context of design education research were not identified in prior literature. The interpersonal interactions through which these ways of seeing are manifest are driven by questions, moves and support responses as discussed above.

From the perspective of design research, a key contribution of this paper is the demonstration of a method of using a visual representation such as the Interaction Dynamics Notation to identify salient interaction patterns. The data of three students' reviews analyzed by this method though not large enough to draw conclusive assertions, highlights areas of interest for further investigation. These include the role of questions in navigating the concept evaluation interactions, the central role of the design artifact in anchoring the interpersonal interaction between the participants, and the absence or presence of acceptance-based or argumentative elaborations in episodes of professional vision interaction.

From the perspective of design education, this study raises further generative design questions such as the following. How might we structure reviews to encourage question-asking, both from reviewers and students? What would a dialectic driven design review look like, where students defend their design concept and perspective? These questions prompt further studies and explorations that when measured across outcome metrics, have the potential of improving design review processes in education.

7. Conclusion

Design reviews in the context of design education are an important activity both in terms of assessing student work, and in terms of sensitizing students to ways of perceiving, understanding and executing design. In this study, we aimed to understand how interpersonal interactions between participants in design reviews create a context for the display of design expertise that provides a learning opportunity for students. Eight graduate industrial design reviews were analyzed in terms of their constituent interpersonal interactions using the Interaction Dynamics Notation, and the expertise displayed by reviewers in the form of their professional vision. The analysis highlighted the role of questions amongst the interaction responses coded through the notation, in beginning episodes of professional vision interaction and in the unfolding of design reviews where understanding of the artifact and expert feedback occurred simultaneously. The analysis of professional vision also led to the identification of two categories – 'appreciation of process/technique' and 'activity encouragement' that were not identified in prior research.

The study, thus, demonstrated the use of a visual representation to analyze interpersonal interactions in the context of design reviews and identify patterns of interaction in which experts help prepare students to become professional designers.

References

Brandt, P. (2004). *Spaces, domains, and meanings: essays in cognitive semiotics*: Peter Lang.

Cardosa, C., Eris, O. & Badke-Schaub, P. (2014) Question asking in design reviews: how does inquiry facilitate the learning interaction? *Proceedings of DTRS 10 Symposium*, West Lafayette, IN.

Dorst, K. (2011). The core of 'design thinking'and its application. *Design Studies*, *32*(6), 521-532.

Eris, O. (2002) *Perceiving, Comprehending, and Measuring Design Activity through the Questions Asked while Designing*. Dissertation submitted to the Department of Mechanical Engineering, Stanford University.

Eris, O. (2003). Manifestation of divergent-convergent thinking in question asking and decision making processes of design teams: A performance dimension. *In Human Behaviour in Design* (pp. 142-153). Springer Berlin Heidelberg.

Goodwin, C. (1994). Professional vision. *American anthropologist*, 96(3), 606-633.

Huet, G., Culley, S. J., McMahon, C. A., & Fortin, C. (2007). Making sense of engineering design review activities. AI EDAM: *Artificial Intelligence for Engineering Design, Analysis, and Manufacturing*, 21(03), 243-266.

Koschmann, T., LeBaron, C., Goodwin, C., & Feltovich, P. (2011). "Can you see the cystic artery yet?" A simple matter of trust. *Journal of Pragmatics*, 43(2), 521-541.

Lymer, G. (2009). Demonstrating professional vision: The work of critique in architectural education. *Mind, Culture, and Activity*, 16(2), 145-171.

Schon, D. (1983). *The Reflective Practitioner: How Professionals Think in Action*: Basic Books.

Schon, D. A., & Wiggins, G. (1992). Kinds of seeing and their functions in designing. *Design studies*, 13(2), 135-156.

Sherin, M. G. (2007). The development of teachers' professional vision in video clubs. *Video research in the learning sciences*, 383-395.

Sonalkar, N. (2012). *A visual representation to characterize moment-to-moment concept generation through interpersonal interactions in engineering design teams*. Dissertation submitted to the Department of Mechanical Engineering, Stanford University.

Sonalkar, N., Mabogunje, A., & Leifer, L. (2013). Developing a visual representation to characterize moment-to-moment concept generation in design teams. *International Journal of Design Creativity and Innovation*, 1(2), 93-108.

Talmy, L. (1988). Force dynamics in language and cognition. *Cognitive Science*, 12(1), 49-100.

Verlinden, J., Horváth, I., & Nam, T. J. (2009). Recording augmented reality experiences to capture design reviews. *International Journal on Interactive Design and Manufacturing (IJIDeM),* 3(3), 189-200.

Biographies

Neeraj Sonalkar is a Research Associate at the Center for Design Research in the School of Engineering at Stanford University. He holds a PhD, MS and BS in Mechanical Engineering.

Ade Mabogunje is a Senior Research Scientist at the Center for Design Research in the School of Engineering at Stanford University. He holds a PhD, MS and BS in Mechanical Engineering.

Larry Leifer is a Professor in the Department of Mechanical Engineering at Stanford University. He is also the director of the Center for Design Research. Larry holds a PhD in Biomedical Engineering, an MS in Product Design and a BS in Engineering Sciences.