Point and Sketch: Collaboration in the Hybrid Ideation Space

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RESUME
Cet article documente une étude sur le travail d'idéation collaborative dans l'Espace hybride d'idéation. Nos observations se concentrent sur la nature collaborative du design conceptuel, comme processus social fait à travers des gestes et des représentations graphiques et verbales qui permettent la négociation et la prise de décisions. Deux groupes différents d'usagers ont participé à cette étude : une courte expérience (20 minutes) avec des étudiants de design travaillant en paires et une expérience longue (6 heures) avec une équipe de designers praticiens. Nous avons observé que les membres de l'équipe participaient de manière égale dans la conversation réflexive quand ils étaient à l'intérieur de l'esquisse immersive, l'un(e) manipulant le crayon numérique, l'autre le pointeur laser.

MOTS CLES : Outils de design conceptuel collaboratif, Espace hybride d'idéation, Design comme processus social, conversation de design.

ABSTRACT
This paper documents a study on collaborative ideation in the Hybrid Ideation Space. Our observations focused on the collaborative nature of conceptual design, as a social process through gestures, graphical and verbal representations, allowing negotiation and decision-making. Two different groups of users participated in this study: a short-term experiment (20 minutes) involving design students working in pairs and a long-term experiment (6 hours) with a team of design practitioners. We have observed that team members participated equally in the reflective conversation while inside immersive sketches, one using the digital pen, the other, the laser pointer.

CATEGORIES AND SUBJECT DESCRIPTORS: H.5.2 [User Interfaces]: Theory and methods | Input devices and strategies; I.3.7 [Computer Graphics]: Three-dimensional Graphics and Realism |Virtual Reality; I.3.6 [Methodology and Techniques]: Interaction techniques.

GENERAL TERMS: Design, Human Factors, Mesurement.

KEYWORDS: Collaborative conceptual design tools, Hybrid ideation space, Design as a social process, Design conversation.

INTRODUCTION

"Put this there and make this longer" are typical verbal communications between designers during collaborative ideation. In order to accomplish these actions within a 3D modeling software, even with intuitive interfaces, the designer needs to deal with the logic of computers before s/he can engage the logic of design. This fact keeps designers from enjoying the advantages of digital tools during conceptual design, limiting the use of these tools to represent already conceived ideas.

The trigger for this study came while assessing and comparing an innovative hybrid tool intended for ideation—Hybrid Ideation Space (HIS)—to 3D modeling tools [5] [7]. In those two previous studies, pairs of students and a pair of practitioners did the ideation phase of a project with different tools: 3D modeling, traditional sketches and physical models, and the HIS. Typically with 3D modeling tools, the conversation between participants centered on the software, modeling strategies and how to get them to achieve certain things. On the other hand, within five to ten minutes of learning to sketch and work with physical models in the HIS, users were heavily involved in discussing design issues: naming, evaluating, negotiating and making design decisions [2] [8] [14]. The HIS allows the designer to intuitively use traditional manual techniques augmented by the advantages of a non-intrusive immersive environment. After years of working with and teaching students to use digital tools in design, we instantly noticed a difference in the users' conversation when working in the HIS. These initial ad-hoc observations lead us to do the present study.

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We decided to view with a new focus three experiments we had conducted and recorded in 2007. The original studies focused on ideation and creative flow. This time, relying on the video recordings of those sessions, we paid attention to the collaboration within each team as they worked in the HIS. Since, according to Bucciarelli [2], design is a social process, design tools should appropriately support its social aspects. This paper is not a comparative study. It documents what we have observed about collaboration during the conceptual design phase when it is conducted inside an intuitive, immersive cognitive artifact designed for ideation [6], as is the HIS. Our goal is to learn more about the relationship between collaborative ideation and the cognitive tools that support it, in order to further the research for more appropriate conceptual design tools.

At first, we looked at two experiments involving 47 pairs of interior and industrial design students [7] doing ideation in the HIS for 20 minutes each. Then, in order to have a deeper understanding of what we had witnessed with the students teams, we looked at a third experiment that followed a team of two professional interior designers [5] over three days of a 6-hour conceptual design phase in the HIS. Throughout, the teams were co-located (in the same space) and worked synchronically (together at the same time). All the participants were novices to the HIS. This paper is based on participant-observation from video recordings, on which we applied two data-mining methods: firstly, a conversation analysis on all the experiments covered by this study, followed by a word count of the verbatim of the 6-hour professional experiment. The conversation analysis consisted in observing the collaboration dynamics by identifying certain types of conversations, as opposed to a hermeneutical interpretation of the material.

We have found that collaboration was dynamic and productive in this kind of intuitive (freehand sketches and models) and immersive representations. The team was literally and figuratively "in the project" because of the immersive quality of the HIS and because of the directness and intuitiveness of the manual actions. Life-size scale and real-time interaction, all within a 360° panoramic perspective achieve a sense of being present inside the representation which, in turn, facilitates user communication and iterative evaluation. In the HIS, both team members actively participate in the reflective conversation, which is in sharp contrast of the common dynamics of a team in front of a PC. Immersion and direct manipulation of the representation keeps the conversation focused on design related issues rather than discussing the tool.

COLLABORATIVE CONCEPTUAL DESIGN TOOLS

A number of researchers have produced digital conceptual design tools seeking improved interactions. Digital tabletops seem an ideal interface for sketching out a rough version of an idea. Haller and colleagues [9] proposed the Shared Design Space Interaction (interactive table) where designers use digital pens to sketch. This system allows sharing of sketches, images and notes. Another type of new conceptual tools is Verlinden and Horvath's augmented prototyping system [17] that combines analog and digital tools, like the HIS, bringing physical form and digital information together, facilitating direct manipulation of information and improving decision-making. Ishii [10] developed an experimental system, the "Illuminating Clay", with applications in the domain of landscape architecture. By using a landscape model that is augmented by computer projections the user makes use of different objects (paper, cardboard) as an input/output device. The systems mentioned above seek to improve collaboration and communication providing a common platform centered on a table workspace. Although these benefit from digital augmentation, they remain in a scale best suited for individual use, providing only the environment of a piece of paper or scale models.

The HIS addresses scale needs associated to architecture or object design (large scale) projects as well as project calling for large quantity of visual information needing to be taken in simultaneously, by offering life-size representation that can be experience from within. This larger scale supports collaboration by allowing ready access to the representation to all members of the team.

HYBRID IDEATION SPACE

Technology is an invaluable partner to the designer, mostly in the task of representing already identified concepts. There is a discrepancy between current computer systems and the designers' needs for uninterrupted reflective conversation with the representation in order to exteriorize mental images [14]. In the early phase of design, when ideas have yet to be clearly formed, traditional pen-and-paper sketches and physical models remain the tools of choice to do ideation because they are intuitive, direct, and they allow ambiguous, abstract and imprecise representations. To address this void between the current technology and the designer's needs, we have developed the Hybrid Ideation Space (HIS). The HIS is an immersive environment where designers sketch and make models all around them in real-time and life-size scale using a digital tablet (sketches), image capture (physical models) and a spherical projection device for immersion. It dwells on traditional analog manual tools and augments them with digital capabilities. Two techniques are used in the HIS: Immersive Sketching and Immersive Model Making (Figure 1). As stated in our previous work [5] [7], our assessment of the HIS points to the fact that it supports ambiguity in the service of conceptual design better than traditional digital design tools.

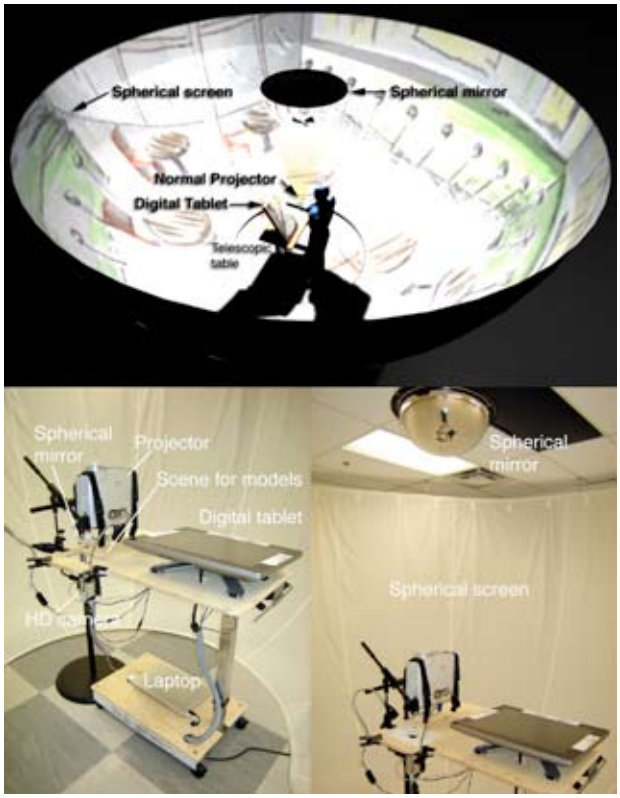

Figure 1: The Hybrid Ideation Space, setting and components.

Immersive Sketching

This technique is based on an anamorphic spherical panoramic perspective. In order to help the designer get use to this kind of the representation, a spherical graphical template is constructed using a ray-trace render of a reflective sphere in a basic 3D model containing elemental shapes or primitives. This sets proportions, which become graphical guides for sketching. This template can be used with any painter or image editing software (Corel Painter™ or Adobe Photoshop™) via a digital tablet (Wacom Interactive Pen Display™) as an input device connected to any powerful laptop. The computer has two displays, one for the digital table and another for a conventional projector. These two display devices are mounted on different supports in order to avoid shaking the projected image by manual actions. The digital tablet is supported by a telescopic table permitting work seated or standing, the latter being better for immersion because the user's eye level is well aligned to the projected perspective. The projector, placed at table level so as not to disturb the user's gaze and supported by an individual tripod, points upwards (Figure 1).

The full-screen image is inverted and projected over a semi spherical mirror mounted on the ceiling and centered on the projector. As a result, the spherical image is reflected over a semi spherical screen of synthetic fabric mounted on the ceiling, centered on the spherical mirror. The minimum diameter of the HIS is 16' for 8' of height, allowing up to four users in the space. The projected spherical image is subsequently corrected, and the user can see all around her/him in a normal perspective, in real-time, while drawing with the digital pen. To sketch all the surrounding space, the user can move around the two sides of the rectangular table and sketch both hemispheres (Figures 1 and 2).

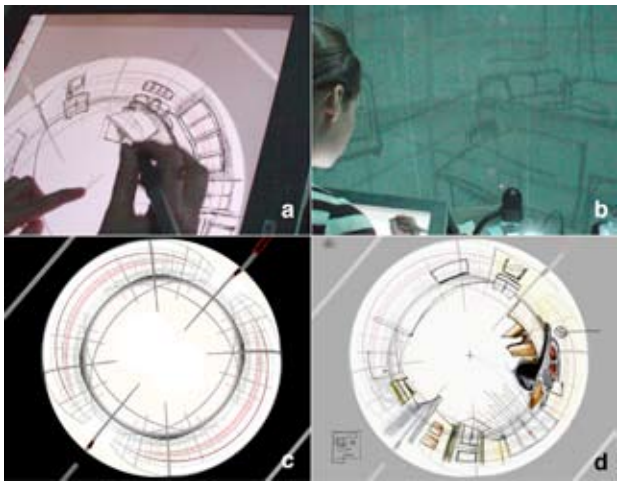

Figure 2: Immersive sketching in action (a and b), Spherical graphical template (c), Spherical sketch (d).

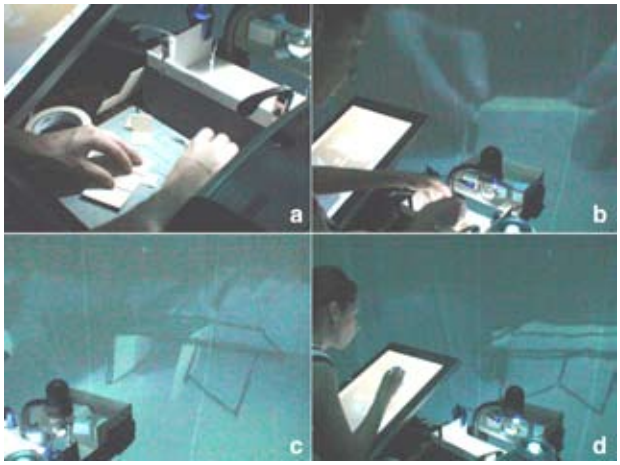

Figure 3: Immersive model making in action. Pieces of paper, cardboard or foam are used as initial information input (a and b), captured image (c and d).

Immersive Model Making

In order to augment rough models combined with sketches during ideation, we use a small high definition camera (1080i) and a small mirror-ball as a spherical panoramic lens. The camera is attached vertically to the table's edge and the mirror-ball is centered in front of its lens. As simple as the immersive projection system discussed earlier, this apparatus is used as input device. The camera captures a deformed spherical panoramic image reflected by the mirror-ball placed at eye level of the small physical model. The real-time HD image is then displayed by the same laptop to the immersive projection system. This way, as users move and modify the

scaled model, they can see a life-size immersive projection of the model all around them. In order to solve contrast problems, the model is sometimes placed in a small scene placed on the table, controlling color background and lighting (Figure 3).

Immersive model can be combined with sketches to explore graphically the physical modifications to be made, or make annotations over the image for self or collaborative ideation. The monitored HD image is capture by the system and used as a background layer in the painter software. The user can thus sketch over a graphical spherical panoramic template easily produced by the scale model and the mirror-ball (Figure 3).

COLLABORATIVE DESIGN

Several CAD research have been made mostly focusing the collaboration within a mediated environment. Achten [1] has developed a general knowledge based on the requirement needed in collaborative design in architecture, without going in depth on how collaboration is made by designers. Our research intends to get a better insight on the collaborative mechanisms using technology.

Design as social process

Bucciarelli [2] presents the design process as a complex synthesis of expertise and agendas, directly or indirectly influential on the process.

These many approaches will bring some amount of ambiguity in the initial conceptual design stages. Concepts need room to be maneuvered, discussed and developed. Design tools need to help the team discuss and negotiate between participants whose representations of the design are not congruent (aligned), and they do so by respecting the inevitable ambiguity while fostering a design conversation between the parties [2].

Design conversation

In a collaborative work setting, the designers must communicate their ideas to others in the best possible way. In order to do that, they use verbal communication, gestures and representations. But the verbal communication remains the main way of explaining ideas. In this process the ability to articulate verbal meanings associated to visual images is very important [16]. Previous studies show that verbalization on its own or in combination with other conceptual design tools drives ideation and is the most common means of externalizing design intentions [11]. Lawson and Loke [12] suggest that the strength of verbalization relies on words, in face-to-face settings or in computer-mediated environments. Words are more than just medium for communication: they are part of the thinking process.

Buxton [3] explains the conversation with sketches as being able to “speak” or “read” sketches for the designer her/himself or to others. In this situation the inability to read (perceive) or to speak (produce) a sketch can compromise ideation. However, the significance of the sketch quality itself is debatable, as the meaning of design intentions is well understood by the designer’s mind, even if there are some problems representing them. Likewise in synchronic collaborative work, the sketch, however ambiguous, will be completed by its accompanying commentary, which allows it to remain approximate and still be fully meaningful, in spite of approaches against sketch ambiguity [15].

This process can happen internally as in Schön’s [14] reflective conversation, between designers and their materials. In a collaborative setting, the reflective conversation is shared by the members of the design team, as they need to discuss their design intentions. Vygotsky [18] calls these two levels of interaction the inner and the external speech. The inner speech tends to omit the subject of a sentence and words connected to it. Think-aloud is closer to the inner speech while the conversation is an example of external speech; together they form a unity of speech. When the speech takes place during the activity of design, we can call it design conversation. This is the medium by which to exchange information and externalize creativity used in the design process [13]. Creativity and information exchange are mediated by the social nature of design. And in turn, the collaborative and social aspects of design are supported by verbalization [4].

Roles in designing

In collaborative design, social interactions, roles and relationships need to be considered [4]. The roles in the design team can be established prior or can be assumed on a voluntary-base during the activity. The main challenge in a collaborative setting is that the roles not interfere with the generation of ideas or concepts. The information has to be communicated and shared without problems in order to function as a team. The design conversations normally involve negotiations between different specialists that not only have different opinions but also different backgrounds.

Since this paper covers strictly conceptual design situations involving designers of similar backgrounds, the variation in the roles they assumed once inside the HIS was due to the cognitive task they choose to take on in the process of exchanging information within the team and with the representation. Those tasks are drawing, looking and analyzing that, in turn, lead to manifesting design intentions. Those tasks were combined in all possible ways between the team members.

METHODOLOGY

Our original impression was that design conversation was well sustained in the HIS over the whole ideation process. Faced with hours of rich video recording, we

devised of an assessment method that could give us an insight into the relationship between the conversation, the ideation activity and the tool while sieving out participants' personal differences. We created a methodological instrument grounded in Bucciarelli's design as social process, complemented by Schön's reflective conversation concept and Goldschmidt's [8] graphical representation of concepts and actions. We feel this combination covers the scope of the collaborative phenomenon and by doing so we have a precise assessment of the process.

Bucciarelli's design as social process gives us an initial framework, taking into account various roles, backgrounds, abilities as well as different phases of the design. He identifies the constraining discourse, the naming discourse, and the decision discourse.

To Bucciarelli's initial framework, we added elements from Valkenburg and Dorst's [19] method for observing designers collaborative work, based on Schön's reflective conversation [14]. In their method, the core elements are actions and the team's design information exchange. They proposed four steps in reflective conversation, of which we adopted three: naming, moving and reflecting.

Goldschmidth's [8] concept of *design moves* came in as a confirmation of the action taking place during ideation. She used a protocol analysis, called "linkography", to identify how the design idea-generation processes occurres. This method uses design moves to represent the design process in a graphical way. The move correspond to the action that makes the design moves forward.

We developed the conversation analysis grid based on five elements that seemed to be common in the analysis of the design conversation and process amongst those three authors. The first element of the grid is the act of "naming" that refers to identifying (by name) a part of design task as being [18]. Naming outlines a common concern and allows the design to move on [2] also corresponds to Schön's reflective identification [14]. The second one is "constraining" in which designers explore the boundaries (time, budget, space constraints) of a given project. This state remains mainly in a conversation [2]. The third one is "moving" which is characterized by a verb, is a step, an act, an operation, which transforms the design situation, as previously stated [19][8]. The fourth one is "negotiating", when the designer's ability and expertise to articulate verbal meanings associated to visual images comes into play. The design will move forward depending on how well they can express their ideas [15]. The fifth one is "decision-making". In this last step, the designers reflect on what they did, they also ask questions about the design, concept or product [2][14]. We used conversation analysis to identify these five elements during design conversations. We were interested to see if these elements appear, and in what configuration. These five elements are the theoretical framework through which we did both the conversation analysis and the word count.

Data analysis

The data for this study was collected by listening to and observing the design conversations that were recorded during the student experiments (47 teams of industrial and interior design students working in the HIS 20 minutes each) and during the 6-hour ideation by a team of professional interior designers.

Analyzing the design conversation of the 47 student teams provided us with a general pattern on how the participants interact with each other and with the representation. The students were encouraged to exteriorize their thoughts through the think-aloud method in order to expose their inner-speech and to fuel the design conversations between the team (external-speech). The professional designers did not need to be probed into talking since they were use to working and communicating together. The professionals' design session was followed by post-experience interviews to confirm some of what we had observed in session. Notes were also taken during the session.

In the conversation analysis of the student experiments, we observed and noted verbalizations, gestures and graphical representations of design intentions as they occurred every 20 seconds. We were attentive to shared information, interaction between the participants via the tool, gestures (be they permanent lines or ephemeral laser stroke) and density of exchange. From this first fine-grained analysis in slices of 20-seconds, we went on to see how the conversation actually develops over a whole conceptual design phase. So we applied the conversation analysis grid to the 6-hour practitioners' sessions, at the longer interval of one minute. The difference in the point of view, (looking at 6 hours), highlighted the relationship between the conversation patterns and the evolution of the ideation process.

To complete the information provided by the conversation analysis of the 6-hour session, a word count was done from the verbatim transcript of the professional team. We tallied the different kinds of conversations that were exchanged between the interior designers over the course of their work: design conversation, tool-related technical exchanges, casual unrelated conversation, training-related conversation, and research-related exchanges usually lead by the researcher.

Sampling

The study was carried out with second year industrial (31 teams) and interior (16 teams) design students and one team of professional interior designers. Each team was composed of two participants.

Our observations were contingent on the limitations associated with student participants and practitioners. Student's projects are hypothetic having few real-life constraints and being driven by novices. This kind of setting allows more freedom for the design conversation. On the other hand, the practitioners have expertise and motivation, and their approach is based on constraints like budget, clients' needs and timeframe. Their design conversation needs to be precise and must lead to an outcome that fulfills the expectations of the client as well as the designers.

Industrial design students were working on the conceptual design of the interior of a car, the interior design students, a cafeteria and the professional interior designers, a hotel bar.

RESULTS AND DISCUSSION

Our main finding is that a conceptual tool with an intuitive hybrid (digital-analog) interface, offering an immersive representation every participant can interact with, as the HIS in this case, fosters design related conversation over tool-related technical exchanges in a proportion of nearly four to one. Word count analysis of the verbatim of the 6-hour session revealed that 50% of all verbal exchanges related directly to the conceptual design process (specifically naming, constraining, moving, negotiating and decision-making), while 14% were technical exchanges pertaining to the digital interface of the HIS. The remaining 36% included setting up on three different days, unrelated casual conversation as well as special instructions related to the research. The subsequent results correlate the main finding.

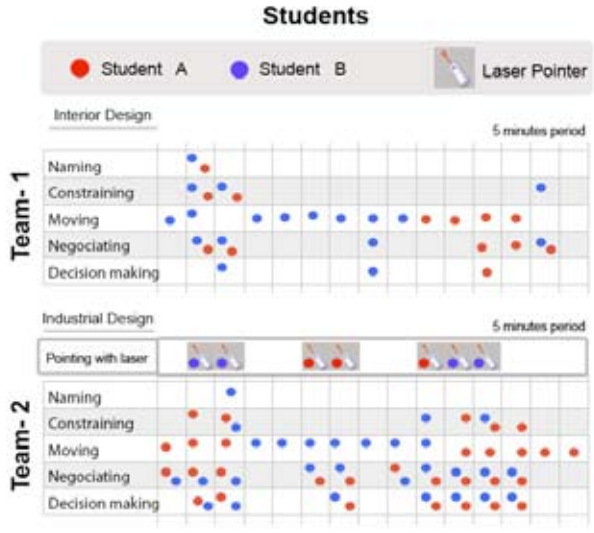

Figure 4: Two examples of the conversation analysis of the students, with (team 2) and without (team 1) using a laser pointer to communicate over the representation.

Design moves

Figure 4 shows the conversation analysis of two teams of students typical of the teams that worked better, team one, representative of teams not using the laser pointer and the team two, of those using it. Each dot represents an event from one of the five categories of the design conversation. The graphic representation of the conversation analysis shows a steady flow of "design moves", which is to say that the teams were continually drawing in uninterrupted ideation mode. In the case of team two, the student involved in the moving was sketching while the other was using the laser to point to different aspects of the design.

Roles in ideation

Inside the HIS, one of the designers was using the digital pen and tablet to draw while the other was looking at, verbally reacting to the immersive representation and using the laser pointer to facilitate graphical communication on the projected immersive image. In the student experiments, the use of the laser pointer coincides with moments of greater exchange within the team, as seen by the higher density of dots below the laser, in figure 5. When the designer manipulating the laser pointer took it out and kept it at the ready, s/he usually used it to intervene in the design process. There seems to be a difference between a strictly verbal intervention and a pointer (gestural-visual) intervention: The pointer-gesture draws an ephemeral representation that requires the team member with the pen to look away from the tablet and onto the immersive representation. This ephemeral representation of the pointer-gesture is equivalent to the gesture of the pen, both being intuitive and free, both participating in the representation. The two partners thus share equally, both acting as hands and eyes, and not polarized in being the hand (acting, moving) or the eye (analyzing). Due to this equal sharing in the cognitive roles, the leadership pole in most teams has moved fluidly within the team in both student and professional studies. Interestingly, in dysfunctional student teams (where one member was not participating, or where the two members were not communicating) the designer with the digital pen assumed both hand and eye roles to him/herself.

Once the conversation of the professional designers is laid into the grid (figure 5), we can observe how the ideation developed: at the beginning, the conversation involved many episodes of naming, moving and negotiating which corresponds to the early stage of the design where a new and solid concept as yet to emerge. In the middle section, there is less naming, more decision making, as the team agrees on a concept. In both the beginning and middle, both team members are equally involved (if you compare the numbers of entry for each color).

Figure 5: Three 27-minute extract taken from the beginning, middle and end of the practitioners' session in the HIS. These are representative of the evolution of the conversation as the design concept develops.

In the last segment, there is no naming, less argument over design as seen by the quick agreement (decision making) following each negotiation. This corresponds (as we have witnessed in the session) to the later phase of the design where the team wrapped up the concept and focused more on producing a clear representation. In this last segment, the laser pointer was used to guide the hand of the designer with the digital pen.

We have observed that there are different needs at different times (early on, the tool needs to be able to support a fair amount of abstract naming and negotiating that may occur at a lively pace, it needs to be able to record the tangible traces of the decisions that have been made with some flexibility at first, and later, with enough details to carry the results of the ideation to a different setting and audience). Conceptual design tools must respond to the different needs of ideation in collaborative setting. To our knowledge, the HIS seems to respond to those needs because of its immersive quality and intuitive interface.

Immersion and collocated collaborative ideation

In co-located, synchronic collaboration, the immersive quality of the HIS seems to help the team find a common language because the representation is right there all around them. Immersion makes the visual information more real in comparison to 2D images that require a cognitive translation from 2D to 3D. By simplifying the cognitive process there are less opportunities for miscommunication and stepping out of the design conversation, thus interrupting the ideation process. The life-size scale also allows for quicker identification of errors, better understanding of the space and therefore better communication during negotiations.

CONCLUSIONS

Even if this is not a comparative study with other digital tools, we find it significant that in the HIS, the proportion of design conversation (50%) dominates the proportion of technical tool-related exchanges (14%) nearly four to one. This result shows a high degree of concentration on design issues. By making the representation physically accessible to all, the immersive quality of the HIS seems to allow every member of the team not only to reflect and part-take in the conversation on the representation, but also to act on the representation with both the digital pen or the laser pointer. That laser pointer's vanishing stroke suggests that the quality of a drawing is of little impact to its significance in a synchronic design conversation. The ability of a sketch to sustain in time long enough to have an exchange of ideas may be its biggest asset (Figure 6). Its quality as an asynchronic trace is only secondary to having supported a synchronic exchange.

Figure 6: Laser pointer's vanishing stroke in the HIS.

The HIS appears to support this high degree of concentration and active involvement without requiring any great technical training (5-10 minutes to be able to sketch), or cognitive detours into the logic of the tool itself.

FUTURE WORKS

We are planning structured comparative studies on collaborative conceptual design with digital and analog tools, and the HIS (co-located and remote, synchronic and asynchronic) involving designers, clients and others actors.

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