Architect-Client Communication During Co-ideation with 2D Digital and 3D Immersive Sketches

A Case Study

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Effective architect-client communication is crucial for the successful progress of the design process. Traditional 2D sketches may pose challenges due to the high uncertainty experienced by clients regarding the project. This kind of communication is perceived as the intersection of clarity of information, clarity of sketched representations, and suitable communication methods (verbal and non-verbal). Aiming to support it, this case study evaluates the level of uncertainty and clarity experienced by architects and clients when using 2D digital sketches and immersive 3D sketches during co-ideation. This case study followed an architect and two clients co-ideating two similar small projects, using three digital sketching tools: 3D sketches on Gravity Sketch using Oculus Quest 2 VR headsets, Hyve-3D co-design immersive projection system (VR without headsets), and 2D sketches with a digital tablet using its pen. Each project included three twenty-minute sessions per tool, followed by a questionnaire. Preliminary findings suggest that 3D sketches offer better clarity and reduce participants' uncertainty. We found generally high expectations from the tools at the beginning of the collaborative sessions and a subsequent decrease in impressions at the end due to the lack of clarity of the proposed representations. The immersive projection system better supported non-verbal communication, observed through gestures, whereas the VR headset restricted this activity.

Keywords: *Architect-Client Communication, Digital 3D Sketching, Social VR, HMD, Co-ideation.*

INTRODUCTION

"Architecture is primarily about communication" (Gabriel & Maher, 2002). Effective communication between the architect and client (A-C) is essential to the success of any design project. It is important to prioritize information clarity, use appropriate tools, and choose appropriate communication channels (Norouzi et al., 2015).

Using new digital drawing tools, combined with 3D models and immersive 3D sketches, could support this objective by making the solution more comprehensive to clients during the design process, reducing uncertainty, and improving communication between A-C. Therefore, it is essential to study the impact of new digital drawing tools on A-C communication.

Traditional architectural sketches mediate the design process, communicating ideas and information for the architect him/herself and for others. Sketches reveal relationships and stimulate discussion (Baskinger, 2008). Sketches comprise abstraction, ambiguity, and imprecision that are beneficial for creativity and communication (Goel, 1995; Goldschmidt & Smolkov, 2006; Schon & Wiggins, 1992).

A-C communication involves additional forms of communication. Non-verbal communication, in the form of gestures, such as pointing, is mainly used by clients who are laypersons that often lack sketching skills. The representation used as a reference for this type of communication plays an essential role in designing (Beaudry-Marchand, Dorta & Pierini, 2018). This implies that it is necessary to carefully choose the appropriate sketching tool in A-C communication, to support the communication flow.

However, there are several limitations in A-C communication. Traditional sketching on tracing paper is limited by having printed materials prepared in advance, and it is not possible to edit analog sketches, which can take more time and provide less clarity. On-site analog sketching in a sketchbook can be misleading due to the scale of the artifact being sketched. Many architects do not sketch in front of clients at the co-ideation stage because of the difficulty of synchronizing querying-thinking-drawing-controlling tools alternatively because it might look too simple in the eyes of the client (Dzurilla & Achten, 2022).

Communication can be hindered if ideas are not sketched with the client (Siva & London, 2011). Uncertainty in two-dimensional sketches and technical details may hinder A-C design messages, resulting in delays, poor communication, and unsatisfactory designs (Goel, 1995).

The detail of the 3D model for sketching can lead to fixation, which limits problem-solving ability and creativity. This can lead to thought looping and memory blockage, limiting the client's ability to openly invent and explore different uses (Cardoso et al., 2009; Tessema, 2008).

Moreover, VR has a steep learning curve *and* fatigue with prolonged use (Peniche et al., 2011). Life-size 3D sketching and VR/A-C communication clarity have not been studied together. There is a lack of current research into using digital tablets in A-C communication. Norouzi's aspects of effective communication (2015) have not yet been combined anywhere with a practical exploration of A-C communication tools and techniques.

This case study explores how digital sketching tools, including 3D sketching, can support effective A-C communication. What level of uncertainty is experienced by architects and clients during co-ideation when using different digital sketching tools, and under what circumstances is this uncertainty reduced?

Expectations / Hypotheses

- Each co-ideation session should reduce uncertainty and gain clarity for the project.
- A Social VR system (without VR headsets) will support non-verbal communication since people can gesticulate.
- A 3D model with 3D strokes in VR will be the clearest because it provides more detail.
- The tablet will produce the clearest results compared to VR systems because it is easier to use and will only be used to sketch simple static images.

LITERATURE REVIEW

Mutual understanding supports A-C communication (Taleb et al., 2017). Effective communication involves exchanging knowledge through a proper medium and channel (Lunenburg, 2010). Participants think the information and messages have been fully comprehended and processed appropriately to achieve the desired aim with the shortest effort and duration (Norouzi et al., 2015). Summarizing, successful communication is influenced by the following:

- *Clarity:* the information exchanged between A-C is clear and confirmed by both parties;
- *Use of communication tools:* Selection of appropriate tools (instruments) that support verbal and visual clarity for the other party (Kliem, 2007; Lee, 2011);

- *Communication method:* Choosing clear methods (verbal or non-verbal) and channels (face-to-face, remote, virtual) (Schnabel et al., 2007; Tipili, Ojeba & Ilyasu, 2014);
- *Meeting expectations* (Weiss, 1994) *and clarity of message* (Cheung, Yiu & Lam, 2013): How clear were the outcomes produced by the instruments?

Immersive 3D sketching tools

Since VR tools support immersion but also presence, we consider it important to distinguish these concepts. Slater (1997) defines immersion as a technology that creates a vivid, inclusive reality on computer displays. It requires connecting body feedback with display information. Presence is a psychological state in which virtual reality is more engaging than the real world (Slater, 1997).

VR tools use 3D sketches. Hughes et al. (2013) characterize stroke-based 3D sketching as having the ability to draw lines, curves, and objects in varied depths and keep their position while orbiting.

Real-scale drawing in VR headsets is problematic, particularly in the architecture field. Since participants cannot contain the building's height with a natural hand motion, they must sketch at a reduced scale, which inherently distorts understanding for laypersons. The physical design movement imitates the digital scale. Because they represent gestures (pointing with hand or laser pointer, arm, or body movement) are used among words (Dorta, Lesage & Perez 2008).

Head-mounted displays (HMD) or immersive projection systems are potentially effective for A-C. VR tools that provide life-size views for multiple participants overcome the limitations imposed by analog sketches.

In this way, Hyve-3D is a Social VR co-design system that lets people work in an immersive environment projected onto a concave screen, using tablets with 6DOF (3D cursor) to 3D sketch instead of using VR headsets. (Dorta, Kinayoglu & Hoffmann, 2016). Sopher and Dorta (2022) showed that Hyve-3D's 3D sketches enabled collaboration and fresh design concepts to advance ideation. They observed designer and non-design students using this Social VR system in an educational setting.

Markowitz & Bailenson (2019) found that VR can be used to assess social and psychological dynamics, while Porwol & Ojo (2021) found that dialogue using VR to mediate communication has the potential to encourage remote participation.

Dzardanova et al. (2022) found that VR-mediated communication is as sophisticated as face-to-face conversation since all subjects complied. Fact-based, moral knowledge was a factor. This may affect co-ideation and architectural design. The study also noted collaborative VR's undiscovered potential.

Design communication using tablets

To date, there is little research on A-C communication using tablets. Harstad et al. (2015) describe the tool's support in reducing document transfer and tracing design errors in the communication process while pointing to the investment costs and the learning curve for the user. Studying A-C communication, Dzurilla & Achten (2021) found that the tablet has a problem with the size of the display when it is used for interactive sketching with the client, leading to the necessity for exploring the use of immersive systems enabling sketching during communication. When using digital sketching tools (e.g., immersive whiteboards), sketches retain the same scale limits as analog sketches (Riva, 1999).

METHODOLOGY

This case study explores the use of three types of digital sketching tools during A-C co-ideation. All values were obtained through a questionnaire answered pre and post each session (Q letter in Figure 1). Participants rate their activities in a questionnaire on a Likert scale of 1 to 10. For each mentioned parameter. Evaluated the contribution of the sketching tools to effective A-C communication in terms of:

- Reducing the "uncertainty" with the design problems at the beginning of the co-ideation sessions vs. Gaining "clarity" of the solutions at the end.
- "Expectations" from the tool at the beginning of the project vs. "impressions" from the tool after the session
- The "clarity" of the representation outcome after each session is a record of visual communication.
- Allowing for "verbal" and "non-verbal" communication.

A fourth measurement of gestures (pointing) was made based on a video analysis of each participant at each session.

Participants
Three participants took part in this experiment: The architect (A) (first author) and two clients: A layperson (C1) and a designer (C2) who has professional experience in 2D and 3D sketching using HMDs.

The projects
Participants identified together two similarly problematic parts of the clients' property that they wish to renovate. These parts were selected as two projects to discuss with the architect: the kitchen (project 1) on the main floor and the rooftop (project 2).

Sketching tools
The digital sketching tools used were:

a) Mid-air 3D sketches with two controllers + head-mounted displays for each participant. Oculus Meta Quest 2. App: Gravity Sketch (HMD tool).
b) 2D sketches on a digital tablet. Apple iPad Pro (2020) 12,9 inches + Apple Pencil. Apps used: SketchUp Go for 3D model views; Concepts App for 2D sketches (DT tool).
c) 3D sketches made with three tablets (6DOF) for each participant within the immersive projection. The Hyve-3D system was used with its Hyve-3D app, referring here to a Social VR system (SVR tool).

Experiment description
The experiment consisted of co-ideation sessions over two projects. Each project had three sessions of twenty minutes, using a single sketching tool. The tools used in project 2 had a reverse order to avoid bias arising from the stages of the design process and experience (Figure 1).

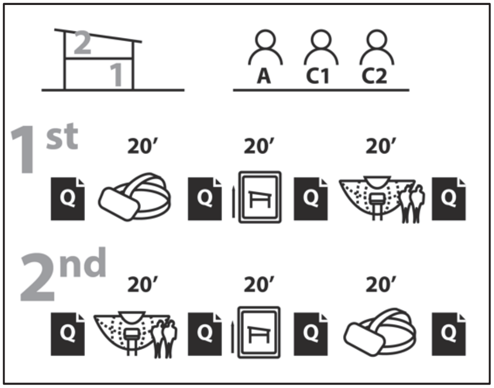

Figure 1. Scheme of the experiment

Representation types
To explore the role of the representational medium in communication, participants had to select the types of representation of the 3D model considered appropriate for communication before the session. The following figures (Figures 2, 3, and 4) present the representations offered to the clients at the beginning of the sessions, allowing them to choose an appropriate type to accompany the communication.

Using a DT tool, we prepared three views of the white 3D model: A perspective, an axonometric, and a plan view (Figure 2-A, B, C).

Using an HMD tool, we prepared three styles of one model: A stroke model, a model with surfaces, and a combined model (Figure 3-A). The plan view is only simulated as a thumbnail on the lefthand controller inside the immersive view (Figure 3-B).

Using the SVR tool, we have prepared three similar styles of one model (Figure 4-A). In the Hyve-3D, any orthogonal views can be perceived on each participant's tablet (3D cursor) (Figure 4-B).

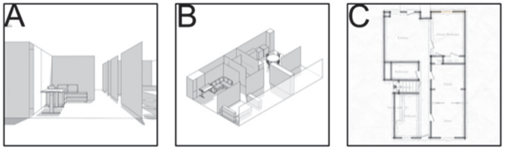

Figure 2. DT tool representations (A) Perspective, (B) Axonometry, (C) Plan view.

Figure 3. HMD tool (A) Three model styles. (B) Plan view within the 3D environment.

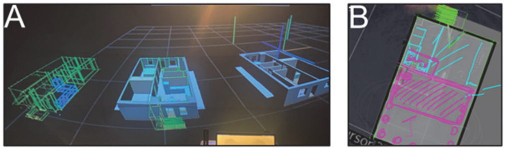

Figure 4. SVR tool (A) Three model styles. (B) Orthogonal views on the tablets (3D cursor).

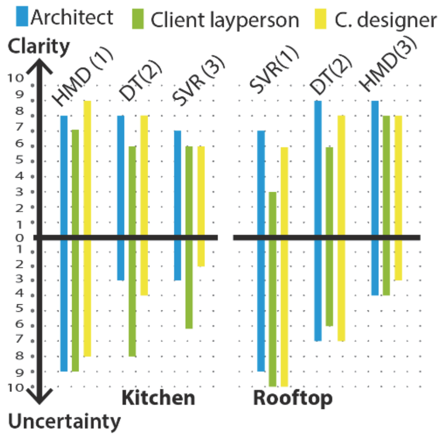

Figure 5. "Uncertainty" vs. "Clarity" for each participant with each tool for each project.

RESULTS

The findings are reported in three categories of effective communication.

Representation types

The chosen representation types for clearer co-ideation were always a combined 3D model with 3D sketches. In the case of the DT tool, the session started with the axonometry (Figure 2-B) shot and then moved to plan view validation. No session used a fixed-perspective screenshot.

Uncertainty vs. Clarity

Figure 5 demonstrates that clients in project 2 were more uncertain than project 1, indicating they had more ideas about project 1 or that it was more complicated. However, there was a decreasing trend of uncertainty for all projects and participants. This is possible because of growing familiar with the tools and the co-ideation process.

In project 1, for the layperson, uncertainty is reduced very little. The co-ideation with the DT tool has opened new questions for clients, and therefore uncertainty persists slightly. The architect's uncertainty after the session with DT tool remained unchanged in the next session with the SVR tool. The clarity of the solution decreased for both the architect and the designer.

Figure 5 also shows that for the rooftop project, participants were already more familiar with the tools, and therefore the reduction of uncertainty and the gaining of clarity is consistent.

The clarity of project 1 was not increased. This may occur because, after the HMD session, new design issues emerged that participants decided to resolve. Clarity increased or stagnated at the same level. In the case of the rooftop, the clarity increased for the layperson. Architect and designer have similar patterns of clarity and uncertainty in both projects.

Expectations vs. Impressions and Clarity

Expectations for using the tools in both projects were high for all participants, with the HMD tool as the highest. When expectations were confronted with post-session impressions, we found a decrease in impressions for all tools except for the HMD tool used in the second round. During this session, the designer sketched intensively everything that was co-ideated, an engagement that may have affected the impression of all participants. However, the impression also increased for other tools in two other sessions. Specifically, the SVR tool (session 2) and DT tool (session 2), presumably to compensate for the impression from session 1 (Figure 6).

When clients evaluated the DT tool, they said the smaller display compared to other tools lowered their expectations. Only the DT and SVR tools exceeded expectations when the architect and both clients had better impressions (Round 2).

In project 1, the SVR tool achieved the lowest clarity of the communicated representation. In round 2 of the SVR tool, expectations and impressions increased, mainly due to the clarity of the representation for project 2. Perhaps to the chosen immersive view inside project 2. For project 1, the view was from above (bird's eye view).

The layperson had maximum expectations of every tool. Also, her impression remained maximal. However, it is interesting to compare the fluctuating clarity of project solutions after a session (Figure 5) compared to the always maximum clarity of outputs from single sessions (Figure 6).

The designer, in contrast, had the lowest expectation of all participants. However, all impressions remained high. As an HMD expert, it can be observed that his rating of both expectations and impressions and the resulting clarity of the sketches were higher levels. Thus, the designer understood visual outputs.

The architect's expectations were high for all three devices. Impressions generally decreased after each session, except for HMD tool. The clarity of the sketches of the other participants also remained at higher levels.

Non-verbal communication

For the third criterion of effective communication, we looked at which tool supported non-verbal communication. The results confirm the hypothesis/expectation, showing the SVR to support the highest non-verbal communication compared to the HMD and DT tools. In the SVR tool, all participants gesticulated a significant amount. They

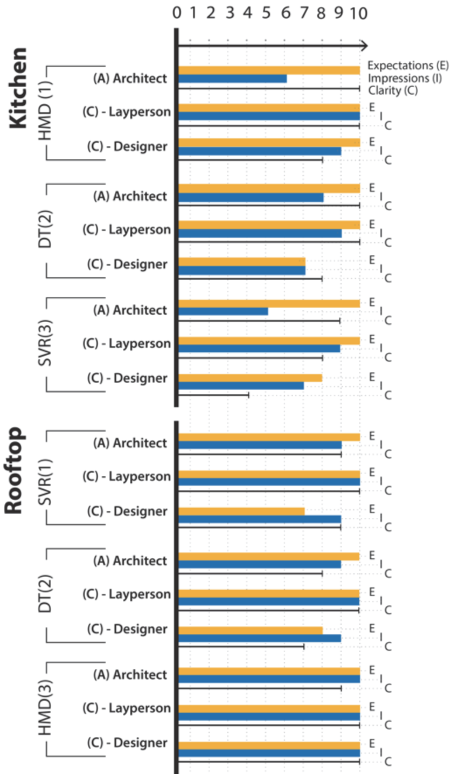

Figure 6. Level of "Expectations" compared to "Impressions" of the tool (colored bars) and clarity of the output from the tool (black lines).

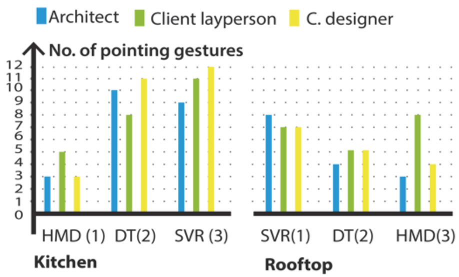

Figure 7. Count of non-verbal gestures pointing during the sessions.

were pointing to the screen while walking and moving.

In the second session, the participants (architect and designer) were much more confident in drawing, so the number of gestures decreased (Figure 7.).

The tools were handled mostly by the architect and the designer (during HMD sessions) since the designer was an expert in the tool, who brought an increase in the flow of co-ideation sessions because he was actively involved in sketching, editing, or grouping strokes to make the model clear all the time. The layperson often stood passively and watched rather than drew. When she spoke, she rarely gestured. The architect asked a lot and mainly accompanied his comments by sketching, so he did not have many pointing gestures in this tool.

When working with the DT tool, all participants gesticulated because only one participant could draw on the device at a time. Therefore, to make their words consistent, they often supplemented them with gestures (both pointing and design gestures). The most active in pointing was the designer.

In the SVR tool, all participants gesticulated a significant amount. They were pointing to the screen while walking and moving. In the second session, the participants (architect and designer) were much more confident in drawing, so the number of gestures decreased.

DISCUSSION

The main findings of this study point to the streamlining of A-C communication using digital sketch tools. They are divided into three categories.

Findings present a continuous reduction in uncertainty and an increase in clarity for all participants in the rooftop project, suggesting that familiarity with the tools and context of the project may play a role in communication effectiveness. Concerning problem and solution co-evolution during co-ideation, the DT tool was associated with slightly higher levels of uncertainty (Dorst & Cross, 2001).

High expectations of the tools were observed in both projects and across all participants. The HMD tool received the highest ratings. After use, all instruments had lower impressions. Two exceptions: The designer sketched everything intensively in the last HMD tool session, which improved everyone's impressions. Second, only the designer's SVR and DT tool impressions exceeded expectations, which suggests effective A-C communication.

The layperson had high expectations for each session and tool, according to participant evaluation. Her impressions were the highest, but the SVR tool sketched representations in round 1 were the hardest to understand. However, in round 2, impressions rose primarily because of the output's clarity and project 2's immersive view (first-person instead of bird's-eye view).

Using a non-immersive view in the first round negatively altered the sessions' impression. In the second round, the immersive view improved the impression, especially for the architect and the designer.

The DT tool in round 2 had the lowest view clarity (for architect and designer) due to the number of strokes above each other. However, the sketched solutions were drawn in separate layers and could be continuously hidden as needed. The small diagonal size compared to the other two tools did not help the clarity.

Surprisingly, for the designer, the clarity of kitchen project 1 on the HMD tool was also lower than expected due to the many strokes. When analyzing the gestures, we noticed that in project 1, a non-immersive view (bird's eye view) was chosen, which may have affected the clarity of the solution.

The architect had high expectations for all instruments in all sessions. Impressions were lowest for HMD and SVR tools due to the bird's-eye view and too many non-sortable co-ideation strokes. After immersive viewing, in round 2, the architect's impression improved.

These findings highlight the importance of meeting expectations (Weiss, 1994) and the clarity of representation at collaborative meetings (Kliem, 2007; Lee, 2011).

In this case study, HMD was good for co-ideation when it was needed to quickly hide or insert new 3D elements, form groups of strokes, and create other variants. The SVR tool was useful for clients and participants without prior experience or who might get dizzy using the HMD tool. DT helped sketch simpler solutions quickly.

Concerning non-verbal communication, the results showed that the HMD tool had the lowest number of non-verbal pointing gestures, while the SVR tool had the most. Interestingly, the client-layperson was passive in the HMD session and did not gesture much due to fear of making mistakes. On the contrary, in the DT tool, where only one participant could draw at a time, all participants gesticulated to make their words coherent. In the SVR tool, all participants gesticulated extensively, pointing at the screen and moving around. In round 2, the participants were more confident in drawing; therefore, the number of gestures decreased (Figure 7).

Results match earlier research. The importance of clarity in A-C communication (Norouzi et al., 2015) and communication tools and strategies. Kliem (2007) and Lee (2011) highlight the necessity of choosing clear communication tools to promote verbal and visual clarity. Previous studies, such as Dorta et al. (2009) and Safin & Dorta (2020), have shown that Social VR supports collaboration and ideation.

Overall, these results suggest that different tools may support non-verbal communication to different degrees and participants' level of familiarity. Familiarity with the tool may also influence the use of non-verbal gestures during the communication process. Non-verbal gestures helped bridge the clients' lack of knowledge of the professional language.

CONCLUSION

With an emphasis on clarity and uncertainty, this study compares three digital sketching tools for client-architect co-ideation. This study's results are non-generalizable due to its small sample size. More participants would mean more real projects and ethical/professional concerns.

However, several important lessons emerged from this case study on what to look for in future experiments with more devices or participants. In particular, projects with a comparable level of complexity and an architect with comparable tools experience. DT and SVR tools provide vital information without requiring training, unlike HMD tools. Importantly, the DT and SVR tools allowed co-ideation gesticulation and seeing each other, which was important for clearer understanding. The clarity of the sketches rapidly affects the overall impressions of the session, both by the clients and the architect. An immersive view from a human level, provided by the SVR and an HMD tool, contributes to higher intelligibility than the limited static view provided by a DT tool.

The study advances knowledge of the critical role that digital sketching tools can play in A-C communication during collaborative sessions, aiding in the faster and more precise clarification of design ideas. Finally, because the process is filled with the interaction between the architect and the client, sessions with these interfaces can improve the sense of connection and elevate the complete architectural design service.

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