A Qualitative Quasi-experimental Evaluation of Using 3D Computer Visualization to Support User Participation in Architectural Design Process

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Abstract

This article evaluates the use of three-dimensional (3D) computer visualization (CV) media against two-dimensional (2D) traditional visualization (TV) media, to support the participation of users at the early stage of the architectural design process, based on a qualitative quasi-experimental approach. As a strategic qualitative approach, a conversational dialogue between an architect and twelve clients was used to assess the participation behavior of the clients in designing their houses by using two different versions of media in experimental design conditions. Results have revealed that the qualitative quasi-experiment was convenient to distinguish the various kinds of media influencing the interaction and information exchange between architects and clients. 3D CV was more helpful in stimulating more information and ideas through the conversation process.

1. Introduction

Many researchers have studied the architectural design process from a social constructivist perspective (Alexiou & Zamenopoulos, 2008; Bucciarelli, 1988; Lloyd, 2000; Luck, 2003; Oak, 2011; Shareef & Farivarsadri, 2020) in which sociality means the tendency to associate with others. Luck (2007) stated that the most obvious sense in which a design is considered to be social is where the design is often carried out as a collaborative activity, wherein the design can be realized in conversations and actions. The architect–client design conversation provides a detailed description of what is going on during the design process (Ungureanu & Hartmann, 2020). Correspondingly, design is seen as an outcome of a series of negotiations between designers and clients or between designers themselves (Parsaei et al., 2016; Tomes et al., 1998).

Focusing on the role of negotiation between architects and clients generate much of the discussion regarding user participation in the architectural design process (Tomes et al., 1998). Sanoff (2000) stated that one of the core values of user participation is that the users should have a say in the actions that affect their environment, therefore the conversation between the user and architect is crucial to meeting their needs. Similarly, Luck (2003), Davidsen and others (2020) explained that the social process of the design dialogue facilitates the transfer of the user's information to the designer who uses it to enhance the design.

The purpose of this paper is to use the qualitative quasi-experimental evaluation as a methodology to reveal the impact of using three-dimensional (3D) computer visualization (CV) media versus two-dimensional (2D) traditional visualization (TV) media, on user participation at an early stage of architectural design process. An analysis of the architect–user conversation is an approach that can be employed to reveal the level of user participation in any stage of the design process (Luck, 2003). The initial conversations between an architect and a user-client were reported in this paper to elucidate the effect of the conversation media on the interaction and information exchange between them.

2. Method

As this study is intended to explore the interactional behaviour of the client with the media of the design in terms of participation, for which the qualitative approach is the most appropriate method. This is because it is well known that the qualitative method is a proper way to explore how people arrange, structure, and make meaning of their daily lives in the real world (Hesse-Biber, 2010; Hillebrand & Berg, 2000). This study was also considered a comparative framework in which the participants were exposed to two different stimuli, and thus the experimental research design is the appropriate entryway. Maxwell and Loomis (2015) and Robinson and Mendelson (2012) stated that, generally, researchers see experiments as being part of the quantitative approach. Therefore, the challenge lies in how to combine an experimental research design and the qualitative approach.

The mixed methodology used has bridged the gap between the traditional quantitative and qualitative approaches (Haverkamp et al., 2005). Therefore this study sought to ascertain how to adopt an experimental design to collect textual qualitative data. According to Robinson and Mendelson (2012) a qualitative experiment is the appropriate means to achieve this. The following section demonstrates how a qualitative experiment can be adopted as a part of a mixed method design to generate conversational qualitative data that can be analysed by using Conversation Analysis (CA).

2.1 Qualitative Experiment

There is a need in this study to use qualitative strategies to explore the clients' experiences and perceptions of participation in the design of their house when using 3D CV media as opposed to 2D TV media. It was necessary to compare the effect of using the two different media by analysing the responses of two different groups of individuals. Here, the interest lies in the effect of the intervention, namely of 3D CV media, on some object, which is client participation, and this is the definition of the experiment. For instance, Moerbeek and others (2000) defined an experiment as a process that is implemented to ascertain the impact of two different treatments, an intervention and a control, on the outcome variables of individuals.

In light of the foregoing, the qualitative experiment approach was adopted in this research to combine the concept of the experimental design with the needed qualitative strategies. Robinson and Mendelson (2012, p. 332) defined qualitative experiment as "a hybrid methodological technique that fuses elements of experimental design with qualitative strategies". They stated that this strategy uses qualitative approaches such as the in-depth interview to assess the differences in the reactions between individuals in groups subjected to different conditions, a technique that is typically associated with experimental research. They further explained that a qualitative experimental design could expose the different experiences of people after they had viewed media content in different formats.

The qualitative experiment has been touched on in some previous studies. For instance, Patton who is one of the experts in qualitative evaluation research in the USA (Kardorff, 2004) referred to this approach as one of the forms of the mixed approach of evaluation research. He proposed six alternative design scenarios, as shown in Fig. 1, one of which is: "Experimental design, Qualitative data, and Content

analysis” (Patton, 2001, p. 250). He regarded this strategy neither as a pure experimental quantitative strategy nor as a pure naturalistic qualitative strategy; rather a mixed strategy.

Cresswell and Clark (2011) identified four major techniques of mixed method design, one of which is embedded design and this has been chosen by the researcher as a suitable approach for this part of the present study. They stated that the embedded experimental model “is defined by having qualitative data embedded within an experimental design such as a true experiment or a quasi-experiment” (Cresswell & Plano Clark, 2011, p. 69). Moreover, Creswell (1994) proposed the “dominant–less dominant design”, whereby techniques from both traditional methodologies are combined, but in just one paradigm, either qualitative or quantitative. Creswell later described this approach as the “Concurrent Embedded Strategy” where “one method could be used within a framework of the other method” (Creswell, 2009, p. 215) as in Fig. 2. Moreover, (Maxwell, J. and Loomis, 2015) in their “An Alternative Approach” research have refer to the use of the quasi-experiment within a mixed methods approach.

Based on the findings in abovementioned literature, the present research adopted the qualitative experimental approach. A conversational dialogue between the architect and client was used as a strategy in the qualitative approach to assess the participation behaviour of the clients in designing their houses in the early stages using two different versions of media in an experimental design condition. The 3D CV conversational group represented the intervention group and the 2D CV conversational group represented the control group.

2.2 Quasi-experimental Design

Campbell, Stanley, and Gage, (1963) stated that when the researcher lacked the full control over the scheduling of experimental stimuli, then this situation is regarded as a quasi-experimental design. In addition, they stated that quasi-experiments lack random assignment. Likewise, Creswell (2009, p. 155) stated that, “when individuals are not randomly assigned, the procedure is called a quasi-experiment”. In the present study, the assignment of participants was carried out within two stages. A non-random assignment was carried out in the first stage, while a random assignment in the second stage. The non-random assignment enabled the researchers to assign the participants into groups following the matching approach to control the variables that might influence the outcomes. In order to achieve that, Creswell (2009, p. 155) stated that “one approach is matching participants in terms of a certain trait or characteristic and then assigning one individual from each matched set to each group”. The criteria for matching that might affect the outcomes were sex, age, number of the family members, and level of education. Therefore, the participants were not randomly assigned into groups in terms of these four criteria. For instance, the 12 participants were not randomly assigned into eight males and four females. The male group was also not randomly assigned into three PhDs and five Masters, and the female group was not randomly assigned into two PhDs and two Masters. However, the number of the family members and level of education were found to be almost in the same range. In the second stage, these groups, namely: the male PhDs group; the male masters group; the female PhDs group; and the female masters

group were randomly assigned to the two groups of the experiment, namely 3D CV and 2D TV. The random assignment in the second stage enable the researcher to control the variables that were not matched because it was difficult to be measured such as clients' awareness in design or their enthusiasm to participate in the design process. The present study is considered as a quasi-experimental design as the assignment process is not fully carried out randomly. However, the researcher still have considerable control over the selection process and over how non-random assignment is execute (Shadish et al., 2002). The final result for the assignment process is as shown in Table 1.

Table 1
Participants' information

	2D TV Conversations	3D CV Conversations
Sex	Four males & two females	Four males & two females
Age	Range between 35 and 39	Range between 34 and 38
Education	Three PhDs & three Masters	Two PhDs & four Masters
No. of the family members	Range between 4 and 6	Range between 3 and 6

2.3 Conversation analysis

Conversation analysis (CA) has been used as a mean to explore this interactional behaviour between the building user and the architect that naturally occurs in early design conversations. CA is a sociolinguistic approach that aims to collect and analyse naturally occurring verbal interaction data, and this data is not arranged by the researcher (Chatwin, 2004; Have, 2008; Ungureanu & Hartmann, 2020). Research on CA has developed an enlightenments into the organization of conversation that can be implemented in several social sciences studies, in which talking together plays an essential role (Hammersley, 2003; Have, 2008; Matthews & Heinemann, 2012). CA approach has been used in a number of previous studies in order to gain insights into design activities (Fleming, 1996; Glock, 2009; Hammersley, 2003; Luck, 2007a; McDonnell, 2009; Ungureanu & Hartmann, 2020; Wendler & Rogers, 1995) The normative approach has been adopted as a method of CA to study the interaction order between the architect and client as stated explicitly in its own right (Heritage, 2001).

A set of conversations between an architect and client in the early stage of designing a house, as it takes place in everyday architectural practice, was adopted as the source of data in a quasi-experimental design. This approach generated considerable information data about the impact of the media used in the architect–client conversation with regards to user participation in the early stage of the design process. The data was collected from 12 separate conversations between the same architect and 12 volunteer participants. All the interviews were audio recorded and then transcribed into a text document using an abridged version of the transcription notation system developed by Gail Jefferson (Whalen et al., 1987, pp. ix–xvi), as shown in the Appendix. Using Jefferson's system, the vocal activities of a conversation can be represented in adequate detail to capture the flavour of the original speech, and more importantly the talk sequence and structure (Luck, 2007a). All the transcripts were broken down into

small units or segments according to the topic under discussion (McDonnell, 2009; Suwa et al., 1998). Each segment treats one issue of the design in a particular way. The output of each issue was either an exchange of information about the design or a decision to do or modify something in the design; hence the researcher called the segments 'design contributions'. A change in the topic or the design issue introduces the start of a new segment.

2.4 Data analysis

One of the good ways to manage qualitative data and interpret its meaning is to develop analytical categories and then index the data accordingly (Bryman & Robert G. Burgess, 1994; Glaser & Strauss, 1967; Locke et al., 2020; Miles, M.B & Huberman, 1994). Developing categories can be done either by deductive approach or by inductive approach, or a combination of both (Chenail, 2008; Green, 2008; Julien, 2008). Chenail (2008) and Green (2008) stated that when the researchers generate the categories deductively, they normally refer to literature, previous studies, and their own experience or a prior questions posed by them. They further explained that when they generated the categories inductively, they do not refer to a preset list, but rather the categories emerged from the data set. Similarly, for this present study the researcher has deductively and inductively developed the analytical categories.

After developing the analytical categories, all the collected qualitative data were analyzed by using content analysis procedures (Baxter, 2009; Erlingsson & Brysiewicz, 2017; Riffe et al., 2014), where they were indexed and coded accordingly (Locke et al., 2020). Nvivo 8 software was used to facilitate the coding process of the textual data (Smith, 2008) as the computer programs provide a variety of techniques for analyzing textual data (Bos & Tarnai, 1999). Frequency counts analysis was carried out based on the number of interviewees referred to the category, or the number of the occurrences of categories in the two groups of the conversational media. In general the frequencies counts are used to identify how often the categories or the themes occurred in a qualitative sample (Witte, Robert S., Witte, 2009) and to convert textual data into quantitative data to be manipulated statistically (Shelley & Krippendorff, 1984; Stebbins, 2008). Therefore, an inferential test for comparing mean value of variables of the analytical categories was conducted in this study. For comparison purpose the study used an independent-samples t-test (also called a two-sample t-test) to test the null hypothesis that there is no difference between the means of the two populations from which the samples were drawn (Pollak & Cohen, 1981).

2.5 The design

The design problem describes a house design on a 20 × 18 m (66 × 59 feet) parcel of land. The design was presented in 2D TV media to six of the 12 participants, and the same design was presented in 3D CV media to the other six. Google SketchUp 8 software was used to create the 3D version. The architect gave the same five-minute brief about the design and the concept to each client regardless of the version of the media. Each client was asked his/her opinion on the design and to feel free to give his/her comments and to ask any questions he/she liked.

Pre-testing of the conversational design format is essential (Malmqvist et al., 2019; Schreiber, 2008) Two pilot conversations were conducted before the twelve conversations were done; one with 2D TV media and one with 3D CV media. As a result of the pilot conversations, some amendments to the initial architectural design were made.

2.6 Selection of Participants

The participants were selected from the lecturers of the XXXX University in Malaysia. An invitation letter to participate in an interview was emailed to 200 lecturers from the university's list. The invitation letters were sent in batches at a rate of 50 invitations every time because the researcher was not able to determine the final number of participants who would be interviewed because the collection of data ceases only at the saturation point (Corbin & Strauss, 2015; Given, 2008; Glaser & Strauss, 1967).

3. Findings And Discussion; Analytical Categories

3.1 Design contributions:

- Number of Design contributions:

The outcomes of the interaction and conversations between an architect and a client in the design process were a collection of design contributions. The bar chart in Fig. 3 shows a comparison between the number of design contributions that were introduced into the conversations that adopted 2D TV media and the conversations that adopted 3D CV media. The number of design contributions ranged from 8 to 22 with an average of 13.66 for the 2D TV conversations. For the 3D CV conversations, the number of design contributions ranged from 17 to 32, with an average of 21.83. The independent-samples t-test showed a statistically reliable difference between the mean number of design contributions that the 2D TV conversation has (Mean = 13.66, Std. Deviation = 5.317) and that the 3D CV conversation has (Mean = 21.83, Std. Deviation = 5.269), $t(10) = 2.672$, $p = .023$, $\alpha = .05$. As the p value was less than .05, the null hypothesis was rejected and concluded that there was an effect of 3D CV vs. 2D TV on the number of design contributions. Therefore, 3D CV media sparked more information and idea through the conversation between the architect and the client at the early stage of the design process.

- Person initiating design contribution

There are two main parties in any design process; the architect and the user-client. An analysis of the role of the two parties in a design conversation reveals the impact of the media used in the conversation on the level of user participation. Figure 4 showed that the average number of segments initiated by the architect in the 2D TV conversations was 4.66, whereas for the 3D CV conversations the average was 4.33. The independent-samples t-test failed to reveal a statistically reliable difference between the mean number of segments initiated by the architect in the 2D TV conversation (Mean = 4.66, Std. Deviation = 3.882) and that the segments initiated by the architect in 3D CV conversation (Mean = 4.33, Std.

Deviation = 1.506), $t(6.471) = .196$, $p = .851$, $\alpha = .05$. As the p value was greater than .05, the null hypothesis was failed to be rejected and concluded that there was no effect of 3D CV vs. 2D TV on the number of segments initiated by the architect. This means that, for an architect, the 3D CV media is not more supportive than the 2D CV media as proposed to initiate a new piece of discussion with a client. However, the average number of segments initiated by the client in the 2D TV conversations was nine, while for the 3D CV conversations it was 17.33. The independent-samples t -test showed a statistically reliable difference between the mean number of segments initiated by the client in the 2D TV conversation (Mean = 9.00, Std. Deviation = 3.286) and that the segments initiated by the client in 3D CV conversation (Mean = 17.33, Std. Deviation = 6.186), $t(10) = 2.914$, $p = .015$, $\alpha = .05$. As the p value was less than .05, the null hypothesis was rejected and concluded that there was an effect of 3D CV vs. 2D TV on the number of segments initiated by the client. This means that for the client, 3D CV was more helpful than 2D TV in initiating a discussion about a new aspect of the design. The increase in the average number of design contribution in the 3D CV conversations against the 2D TV conversations, were due to the increase in the number of design contributions initiated by the clients and not by the architect.

- Type of design contributions

Discussions and conversations between an architect and a client regarding any issue related to a design included either an exchange of information about the design or a decision to do something to or modify something in the design. McDonnell (2009) stated that the outcomes of conversations between architects and clients regarding design issues were twofold:

- Design refinements
- Information exchanges

Figure 5 showed a comparison of the average number of design refinements and information exchanges for the 2D TV conversations with the average number of design refinements and information exchanges for the 3D CV conversations. The average number of design refinements for the 2D TV conversations was 9.66, but it was 13.33 for the 3D CV conversations. The independent-samples t -test failed to reveal a statistically reliable difference between the mean number of design refinements for the 2D TV conversation (Mean = 9.66, Std. Deviation = 5.193) and that for the 3D CV conversation (Mean = 13.33, Std. Deviation = 3.502), $t(10) = 1.369$, $p = .201$, $\alpha = .05$. This difference, although interesting, was not significant because the p value was greater than .05. However, the average number of information exchanges for the 2D TV conversations was four, whereas it was 8.5 for the 3D CV conversations. The independent-samples t -test showed a statistically reliable difference between the mean number of information exchanges for the 2D TV conversation (Mean = 4.00, Std. Deviation = 2.191) and that for the 3D CV conversation (Mean = 8.50, Std. Deviation = 4.416), $t(10) = 2.236$, $p = .049$, $\alpha = .05$. As the p value is less than .05, the null hypothesis is rejected and it is concluded that there is was an effect of 3D CV vs. 2D TV on the information exchanges. This means that the use of 3D CV as a media of conversation between the architect and the client at the early stage of the design process enhanced the information exchanged from the architect to the client and vice versa.

3.2 Conversational turns

The number of conversational turns between the architect and the client can provide a more detailed impression of the interaction process between them. Each time the number of the conversational turns increases, the opportunity for more interaction between the architect and the client increases, which, in turn, enhances the level of user participation. Figure 6 compared the number of conversational turns when 2D TV and 3D CV media were used. When 2D TV media was adopted, the number of conversational turns ranged from 56 to 249 with an average of 139, while for conversations that adopted 3D CV media, the number ranged from 155 to 385 with an average of 238.16. Although the independent-samples t-test failed to reveal a statistically reliable difference between the mean number of turns for the 2D TV conversation (Mean = 139.00, Std. Deviation = 82.244) and that the design refinements for 3D CV conversation (Mean = 238.16, Std. Deviation = 95.414), $t(10) = 1.928$, $p = .083$, $\alpha = .05$, this difference is interesting. This means that the clients had a greater opportunity to express their points of view when 3D CV media was used than when 2D TV media was used, which implied that 3D CV may facilitate an increase in the level of user participation in the early stage of the design process.

3.3 Conversational time length

The time length of the conversations between an architect and client is another indicator of the interaction process between them. Each time, the duration of conversations increases, the opportunity for more interaction between the architect and the client will also increase, which as a result, enhances the level of user participation. Figure 7 showed a comparison of the conversation time lengths when 2D TV and 3D CV media were used. It was evident that the length of 3D CV conversations much longer than that of the 2D TV conversations. When 2D TV media was adopted, the time length ranged from 12 minutes to 33 minutes with an average of 26.16 minutes, whereas it ranged from 30 minutes to 137 minutes with an average of 64.5 minutes when 3D CV was adopted. The independent-samples t-test showed a statistically reliable difference between the mean number of time length for the 2D TV conversation (Mean = 26.16, Std. Deviation = 7.627) and that the time length for the 3D CV conversation (Mean = 64.50, Std. Deviation = 38.350), $t(10) = 2.401$, $p = .037$, $\alpha = .05$. As the p value was less than .05, the null hypothesis was rejected and concluded that there was an effect of 3D CV vs. 2D TV on the time length. Therefore, it could be argued that 3D CV media improved the interaction between the architect and the client in the early meetings of the design process. In other words, this means that the time allowed for clients to understand the design and to express opinions was longer. Perhaps an architect might see this time as wasted time, but the clients might not agree with that view because they have, in a sense, already paid for this time by paying the architect for the overall project.

4. Conclusion

This paper explored the impact of using 3D CV vs. 2D TV media on the interaction and information exchange between the architect and client in the early design meetings. The researcher employed a

qualitative quasi-experimental approach to analyse the conversations and activities of a design process as it took place between an architect and a client in a real practice. A combination of the concept of the experimental design with the needed qualitative strategies helped the researchers to gain insight into the clients' participation experience and perception in designing their houses by using 3D CV media or 2D TV media. The results revealed that 3D CV was more helpful than 2D TV in stimulating more information and ideas through the conversation between the architect and the client in the early stage of the design process. Hence, using 3D CV increases the proposed idea used for design refinements and enhances the information exchanges from architect to client and vice versa. The used of 3D CV also resulted in more conversational turns and a greater length of overall conversation between the two parties involved in the design process. Furthermore, the results also showed that 3D CV media supported the ability of the client to initiate a new piece of discussion, whereas the ability of the architect to initiate a new subject was mostly not affected by the type of media used in the discussion.

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Declaration of conflicting interests

The Author declare that there is no conflict of interest

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Appendix

In the extracts from conversations presented here the following transcription notations have been used for vocal sounds that were part of the data, using an abridged version of Gail Jefferson's notation (Atkinson and Heritage, 1984, pp. ixexvi).

[Indicates over-lapping talk that does not start simultaneously.

- Indicates a short untimed interval between talk.

() Indicates an interval between talk timed in seconds.

= Indicates talk that is latched but does not over-lap.

((Actions that were part of the data.

“ ” explain meaning

Figures

Figure 1

Six alternative design scenarios proposed by Patton, adapted from (Patton 2001:p.252)

Figure 2

Concurrent Embedded Design, (Creswell, 2009, p. 210)

Figure 3

Number of design contributions

Figure 4

Average number of segments initiated by architect and clients

Figure 5

Impact of media type on average number of design refinements and information exchanges.

Figure 6

Number of turns in each conversation.

Figure 7

Length of each conversation in minutes.