A COMPARATIVE STUDY OF DIGITAL AND TRADITIONAL TOOLS FOR PARTICIPATIVE DESIGN

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Abstract. Computer tools have been used by experts for a wide range of activities including design and planning, historical conservation, urban management, education, and marketing and promotion. However, the difficulty of using these tools has meant that they have only been used by experts and their benefits have not been available to the public when engaged in participative design exercises. This paper reviews the extent of computer tool usage within urban design and goes on to propose a new way of utilizing digital tools in order to involve non-experts. The work that is presented here takes the form of an experiment which compares the traditional participative design approach with one that employs a three-dimensional digital approach. The setting for the experiment is based on the design of student housing on the University of Bath campus in the United Kingdom. Findings from the experiment demonstrate that the digital toolkit that is proposed has considerable potential to aid the process of participatory design.

1. Introduction

Although there are many ways of using computers for design, there are very few examples where three-dimensional computer models have been used for direct interaction with the public during participative design. This paper proposes just such an approach and impetus for the research came from the fact that public participation is an obligatory part of the planning and development control process in the United Kingdom (ODPM 2004; Owens 2005). The UK government is also promoting electronic governance. And digitally-based public engagement as part of the design process therefore embraces that spirit.

2. Computer Tool Usage Within The Built Environment

Within the realm of urban design, the techniques and technologies associated with the representation of urban spaces have undergone many changes (Ratti and Baker 2003; Mitchell 2002). Technological advancement has enabled the creation of several computerized urban models, including the Glasgow model (Ennis et al 1992), the Edinburgh Old Town model (Grant 2005), the Bath model (Day 2005), the Los Angeles model (Liggett and Jepson 1995), the Cairo model (AlSayyad et al 1996) and the Sheffield SUCoD model (Peng et al 2002; Peng and Jones 2004). The Bath model, for example, has shown that a digital urban model need not only function as a form of three-dimensional database but can also be of direct use in the planning, building and conservation of the city. The model has been used as part of the development control process in the City of Bath, which has a strict planning policy because of its World Heritage status. Digital urban models have also raised the possibility of the user-client being brought directly into the process of design along with the architects and planners. This paves the way to facilitating active client and public participation in the future planning of the city.

2.1. UTILISING COMPUTER TECHNOLOGY FOR PUBLIC PARTICIPATION

Within urban design circles, the exploration of computer technology for public participation has been rather limited, and even the professionals still tend to be stuck at the clerical phase of IT utilisation (Littlefield 2004). One of the most successful approaches to participative design and planning is *Planning for Real* (Pearce 2000; Wilcox 1994), a method for actively engaging the public in design (Kernohan et al 1996; Sanoff 2000). The way it operates is that members of the public work with a facilitator on a project by making use of drawings, sketches, maps, simple physical models and even post-it notes. The models tend to very basic so that they can be constructed quickly and this has the advantage that participants are not inhibited when it comes to making changes. However, there is a huge divide between this and the sophistication of photo-realistic images and animations employed by designers and developers when communicating directly with their corporate clients. It is generally accepted that laymen have difficulty in comprehending architectural drawings such as plans, sections and elevations (Robbins, 1994) and the use of interactive 3D computer models provides a way of allowing non-experts to understand the form of a proposed building without having to use the relatively abstract two-dimensional representations.

2.2. EXAMPLES OF DIGITAL-BASED PUBLIC INCLUSION

There are a number of examples of digital tools being used as part of the participatory design process. These range from examples which engage with very small groups of participants to those which involve the population of an entire city.

2.2.1. Small Scale Public-User Inclusion Utilising Desktop Technology

Hall (1996) and Pietsch (2001) have discussed the issue of designing directly on the computer during design negotiation. The immediate relationship among participants in these cases was limited to the designer, the client and the planning officer as they tried to resolve planning issues relating to visual appearance, building overlooking and shadow casting. The participants sat around a computer screen and went through the process of making design changes together. In these examples the design had already been prepared by the architect using a CAD system and the participative design exercise involved altering that model in order to explore alternatives. The need to get planning permission required the client to sit with the designer and a representative of the local authority at the end, rather than the beginning, of the design process. In an ideal situation participative design would occur from the very start of the design and would be employed on larger projects which are more likely to have a significant impact on the urban environment.

2.2.2. Small to Medium Scale Public-user Inclusion Utilising a Hybrid of Desktop/Laptop Technology with Non-Immersive Virtual Reality

An investigation involving the public has been carried out using the non-immersive setting in a VR suite at Teesside University (Reeves and Littlejohn 1999). It involved a dozen or so laymen in the design of a community centre. Although the participatory session was deemed successful, the public's comment about not feeling comfortable in such a formal set-up is a point which should be considered when planning a participative design exercise. Accessibility is not just about the number of people taking part, or whether the venue is easy to get to, but also whether the event can be replicated elsewhere without too much difficulty. In practice most public participation sessions take place in school halls and community centres rather than in specialised VR facilities.

2.2.3. Large Scale Public-User Inclusion Utilising Web-based Technology

There have also been studies into using the computer to involve a wider range of the public. Notable among these is a project carried out on the West Cambridge development to build a new Computer Laboratory (Richens & Trinders 1999). Computer tools were used as a means of being accountable to the main client, Microsoft, who commissioned the project in a joint venture with the University of Cambridge. In this case, Microsoft specifically required that all aspects of communication between their representatives, the consultants and other related parties should be carried out via e-mails and the Internet. Furthermore, the design and visualization of the new building was to be carried out through computer modelling. The whole process of development, from the sketch-design stage to construction, was documented, presented and shared with the users through an official web-page. Communication channels were expanded through an Internet design-forum and web-based questionnaires. Traditional tools were also utilised where plan drawings were displayed on notice-boards for people to draw or write their comments. Feedback was routed directly to the designers and constant design revisions were displayed. The design evolution of the new computer laboratory was progressively visualised using gaming software, Quake II where visitors could walk around the spatial simulation using avatars, which could be customised if desired.

The key to this large public inclusion is the use of the Internet, which was appropriate to the well-networked university community. In the normal world, however, this level of Internet access is seldom available, which hampers the noble intention of digitally involving all the public in participative design. This is illustrated in another project utilizing on-line planning in North London (Hudson-Smith 2003). A web-site was supposed to run in parallel with the start of the public consultation for the regeneration of the Woodberry Down area in Hackney. However, free Internet access and computers had first to be provided to a selected group of residents. This involved the installation of telephone lines so that Internet access could be provided and there was often insufficient room within the dwelling to provide a dedicated space for the equipment. If web-based public involvement is to reach disadvantaged groups, hardware and Internet access often has to be provided along with the necessary training and support.

2.3. THE DIGITAL TOOLKIT AND PARTICIPATIVE DESIGN

Whilst the approaches discussed above have served their purposes, there have been limitations in their implementation. In order to be effective, any participatory session has to first of all be accessible. The logistical requirements for immersive virtual reality and for web-based methods are very costly to set up and to maintain. The approach outlined in this paper is framed within the lower end of computer technology. It attempts to build on the success of the approach used by *Planning for Real* with the intention of complementing, and hopefully enhancing, current well established practice. If digital participative design is to be more widely accepted, the approach has to be simple and cost effective enough to be put into practice. Simple CAD software, a standard laptop computer and an inexpensive data projector can be afforded by even the smallest design practice and this equipment should be all that is needed in order to run the digital toolkit. Table 1 summarises the proposed approach and locates the digital toolkit in relation to other participatory methods.

TABLE 1. Spectrum of Traditional and Computer-Based Participative Design.

Approach	**Traditional** **Planning for Real-type events**	**Digital** **Proposed Digital Toolkit**	**Digital** **Immersive Virtual Reality**	**Digital** **Web-based or On-line Planning**
Roles of Players	Equal roles for experts and lay public.	Equal roles for experts and lay public.	Extensive roles for experts. More limited participation to lay public due to logistics.	More roles for the experts. Limited roles for lay public as end consumers giving feedback and viewpoints.
Mode of Social Interaction between expert and non expert during design	Direct visual and verbal communication. Face to face.	Direct visual and verbal communication. Face to face.	Visual communication via specialised medium such as 3D glasses, head-mounted displays.	Detached and indirect textual communication.
Participatory design level	Deciding together	Deciding together	Possible to decide together	Informative and reactive consultation
Design Involvement Level	Total design involvement. Manual hands-on.	Total design involvement. Digital hands-on.	Partial involvement, more design consultation.	Partial involvement, more design consultation.
Time-lapse implication	On the spot resolution and real-time decision.	On the spot resolution and real-time decision.	Some real-time decision	Long time lapse or sporadic time-interval of feedback.
Technique	Traditional	Desktop Digital	Immersive VR	Digital Web-based
Tools and Equipment	Cardboard and post-it notes.	Simple 3D digital model and spreadsheet.	Immersive VR such as CAVE system with sophisticated animated 3D environment.	Sophisticated web-page and interface
Technical Sophistication upon users	Low.	Medium.	High.	Medium.
Skill level required	Basic model making skills.	Some computer skills useful although a facilitator is available.	Limited to navigating in a VR environment.	Basic computer skills – web navigation and e-mail.
Documentation	Need to store models or to rely on photography.	Digitally-based and easy file transfer.	Digitally-based and easy file transfer.	Feedback/data to be compiled and interpreted.
Usage Cycle	One time cycle, models being disposed of after event.	One time cycle with re-use, layering of models possible – can be repeated easily.	One time cycle with re-use of models possible – can be repeated easily.	Continuous or until stipulated period ends.
Visualisation performance	Good but inaccurate dimensions.	Good with accurate dimensions.	Very good if high quality model is built.	Good with realistic end-product views possible
Ease of understanding what is proposed	Good but lacking in detail.	Very good with accurate dimensions and ability to change model.	Very good although model cannot be amended in real- time.	Good but limited to views of the model with no direct interaction.
Logistics	Large work space	Highly portable – a	Fixed location and	Costly to set up

	needed and can be messy.	laptop and LCD projector.	very costly to set up and to keep running.	and to keep running.
Criticism	Limited by model sizes and scales and amount of details to be incorporated.	Cost of proprietary software licensing.	Limited by logistics and costs	Limited public access to Internet.

3. The Experiment: Traditional Versus the Digital Toolkit

The setting for the experiment is based on the design of student housing on the University of Bath campus. The basic parts of the scheme for both the physical and digital settings comprised eight choices of student rooms with a variety of showers/washbasins etc, three sizes of kitchens, four types of staircases and a lift. Other facilities such as a TV-lounge/common room and study room/computer room were built or improvised during the experimental process. Supporting services such as housekeeper's office, laundry area, and re-cycling and refuse collection, mechanical and electrical facilities were not included in the brief although the approximate cost for them was incorporated in the cost calculation. The reason for this was to reduce the design complexity in order to suit the time limitation of the experimental session. Each participant decided on the choice of room types and facilities that he/she preferred for the student housing scheme. The experiment was done within one hour as a one-to-one session and comprised four parts: the project briefing, the interactive design stage, the cost calculation and questionnaire administration.

3.1. THE TRADITIONAL AND DIGITAL SETTINGS

The experiment compared two settings. In the traditional setting full use was made of freehand drawing and pre-built physical models whereas in the digital setting a three dimensional digital toolkit was employed using SketchUp, an inexpensive and easy to use CAD package. This digital toolkit can be thought of as electronic version of LEGO that can be interactively manipulated. This may involve simple copying, moving, stacking, rotating, flipping or mirror-imaging or grouping, as well as enlarging and reducing the various forms created. More detailed versions of the different spaces showing furniture layouts were also prepared to allow participants to fully visualize the different types of study bedrooms that were available. A digital model of the University of Bath campus was used as the context for the project (Figure 1).

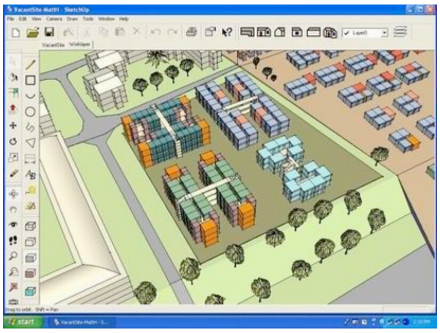


Figure 1. A participant's exploration using the digital toolkit

In the physical setting the individual student rooms, kitchens, staircases, etc were pre-built at 1:50 as hollow models (Figure 2). This size enabled the participants to see the interior of each study bedroom, including the furniture and equipment. The 1:50 scale makes the smallest building part, the single shower cubicle, big enough to hold and these 1:50 models were used to allow the participants to create the layout of the study bedroom clusters. However, because of space a resource restrictions a smaller site model at 1:200 was utilised for the site planning part of the exercise.

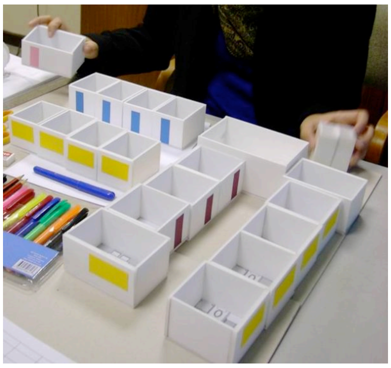


Figure 2. Pre-built hollow models at 1:50

Another aspect of the experiment was the provision of a spreadsheet to calculate the cost of each scheme. Both groups had access to this spreadsheet which provided a way of converting the capital cost of their proposal into a weekly rental for each of the room types. At the beginning of the interactive design stage, each participant was asked how much rent per week he/she would be willing to pay for each of the room types they had selected. This provided a comparison between what the user was willing to pay and what it would actually cost the University to cover building and maintenance costs. A participant who was not willing to pay more than his/her budget usually resorted to making changes to their earlier space decisions. The experiment not only offered an opportunity for the users to voice their opinions on their preferred design for student housing, but also became a way of helping them to understand the cost implications behind every decision they made.

The setting for the experiment was a large office which had a table in the middle with the participant and facilitator seated opposite each other. A projection screen was placed about 1.8 meters from the end of table with the LCD projector placed at the other end. The table held the site model and pre-built block models during the physical setting. A laptop to show slides for the project briefing and the spreadsheet was placed on a smaller table near the facilitator. Other extra units of pre-built models were placed on top of file cabinets behind the participant. During the digital session all the physical models were hidden away and the laptop was placed on the table but slightly skewed towards the facilitator. The projection screen was the main viewing panel by both the participant and the facilitator.

3.2. SAMPLING TECHNIQUE

The experiment was carried out with eighty participants. Forty participants used traditional participative design tools to form the Control Group while another forty participants used the digital toolkit in the Digital Group. Each group consisted of nineteen males and twenty one females. None of the participants had any architectural or design background. The total number of participant was determined based on previous studies of a similar nature as well as using the 'Sample Size Calculator' by *Creative Research System* (http://www.surveysystem.com). Using the worst case percentage of 50% with confidence level of 95% based on the total UK population of 60 million, a sample size of 80 persons gave a confidence interval of 10.96 which is deemed acceptable for this kind of research.

The participants were enlisted through open advertising of the experiment in the University of Bath electronic and paper-based notice boards. It was open to postgraduate and undergraduate students from throughout the university. The project was described as an architectural experiment for a PhD without indicating what was involved in order to avoid the participants coming into the experimental sessions with pre-conceived ideas about student housing or of the tools being tested. The participants took part based upon a first come first served basis until the quota of 80 persons was reached. The researcher usually asked for an indication of gender and program of study to achieve a balanced ratio in the allocation of the control and digital groups.

3.3. QUESTIONNAIRE DESIGN

The questionnaire was divided into three sections. The first section was the Introduction which outlined the three purposes of the experiment. The first was to gain the participants' feedback on the student housing experimental session. The second purpose was to seek the students' input on the type of student housing they would welcome. The third indicated that the experiment would look at the implications of having the students participate in the design process. These purposes were directly related to the design exercise undertaken and simultaneously camouflaged the primary examination of the tools being used for designing. This was in order to secure the participants' responses via an indirect and non-pressured or neutral approach. The final section of the questionnaire elicited demographic data from each participant which included information about age; gender; nationality; program of study; types of accommodation; and their willingness to be contacted for another version of the experiment.

The main body of the questionnaire elicited responses from each participant about his/her experiences while using the traditional or digital tools. This segment contained 24 items that were a mixture of closed and open-ended questions. The closed questions required rating a semantic differential scale of 1 to 10 with responses such as; Very Unsatisfactory/Very Satisfactory; Very Poor/Very Good; Not Very Well/Very Well; Very Little/Very High; Very Little/Very Highly; Very Difficult/Very Easy; Not At All Useful/Very Useful. Another type of closed question required a 'Yes', 'Uncertain' or 'No' answer. The questions were devised to secure feedback in three main areas namely the suitability of tools and equipment for design; design satisfaction and enjoyment; and ideas exchange and design communication.

The questions to evaluate the suitability of tools and equipment for design were as the following:

- "How well did you feel the equipment and tools for designing helped to materialise your ideas during this project?"
- "Please rate the ease of handling tools/equipment/materials for designing."
- "Would you have wanted other equipment during this exercise? If Yes, what? Why?"
- "Please rate the ease or difficulty of creating a number of alternative designs."
- "How did you find the duration of the session?"
- "Please rate the ease or difficulty of manipulating each design."

The questions to gauge design satisfaction and enjoyment were as the following:

- "How would you rate the final design that was produced?"

- "How would you rate your design input for the final creation?"
- "How would you rate your knowledge of student housing before doing this exercise?"
- "How would you rate your knowledge of student housing after doing this exercise?"
- "Please rate the introduction (Project briefing)."
- "Please rate the usefulness of the costing element."
- "How much did the costing element influence the final design?"
- "How well did you enjoy participating in this exercise?"
- "Do you think that the University should undertake this kind of exercise for future student housing development?"
- "Do you feel that this kind of exercise may also work with other types of buildings?"
- "Which aspect(s) of the session did you like most?"
- "Which aspect(s) of the session did you like least?"
- "Overall, how would you describe your experience of the session?"
- "Do you have any additional comments?"

The questions to appraise ideas exchange and design communication were as the following:

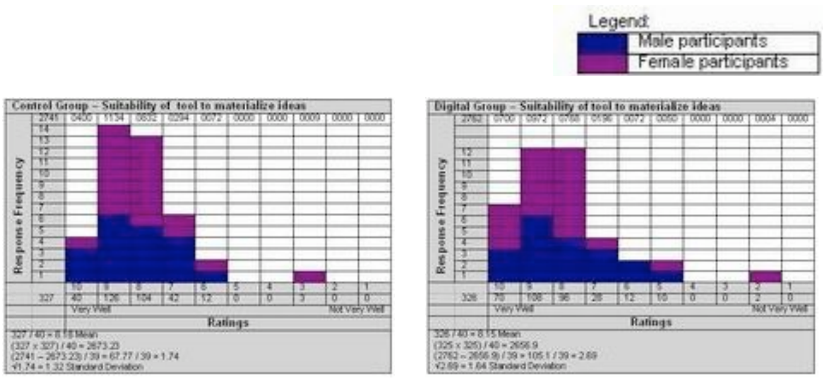
- "How would you rate the room setting during this session?"
- "How much interaction was visible during the session?"
- "How well did you think the researcher-facilitator understood your ideas?"
- "How well did you feel you were able to express your own ideas verbally during this project?"
- "How well did you feel you were able to express your own ideas physically or graphically during this project?"
- "How much design cooperation was visible during the session?"
- "How much did you have to rely on the researcher-facilitator throughout this session? Please comment."
- "Please rate the ease or difficulty of visualising the design form."

4. Preliminary Findings

The first part of the findings looks at the experience of the participants in using the two participatory tools. This is descriptively analysed from their feedback in the questionnaire as well as through recorded observation during the experimental sessions. No statistical analysis has been carried out at this stage beyond the calculation of group means with standard deviations (sd) and percentage indicators.

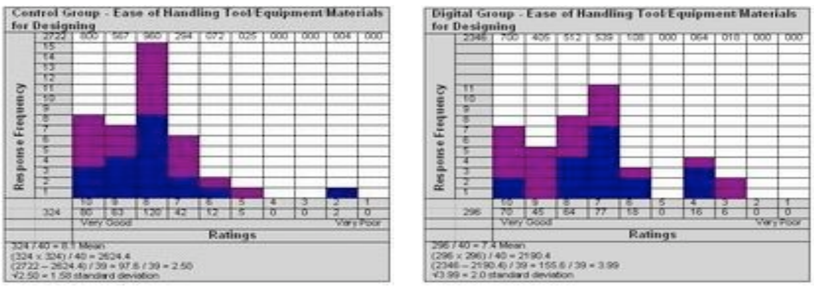
4.1. THE SUITABILITY OF TOOLS AND EQUIPMENT FOR DESIGN

Both groups shared virtually the same mean for their assessment of the tools' suitability to realize their ideas at 8.18 (sd1.32) for the Control Group and 8.15 (sd1.64) for the Digital Group. This implies that either tool suited the design task rather well (Figure 3).



Control *Figure 3.* Tools suitability to materialise ideas Digital

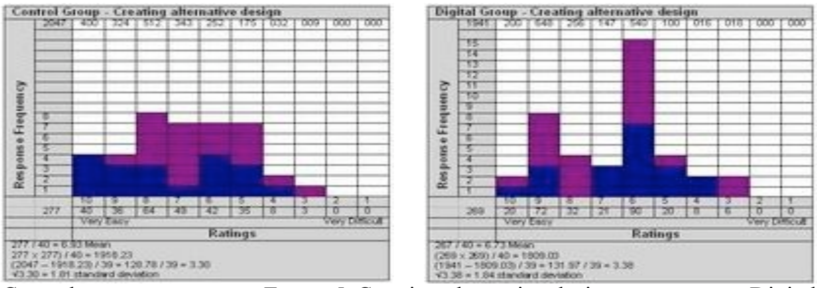
However the Control Group felt that it was easier to use the traditional tool (mean 8.1, sd1.58) compared to the Digital Group (mean 7.4, sd2.0) (Figure 4).



Control *Figure 4.* Tools handling Digital

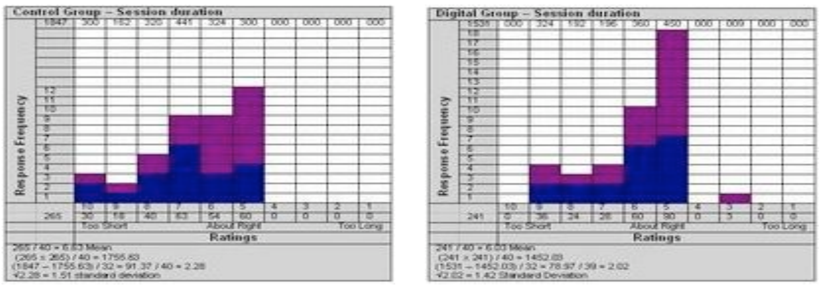
On both occasions several participants wanted other equipment during the exercise (17.5% among the Control Group and 15% among the Digital Group). The requests from the Control Group included some form of computer software as well as different shapes and types of building blocks. This indicates a need for a sense of design accuracy and variability or modifiability in the models they used. The requests from the Digital Group included physical models or LEGO blocks which they felt would be quicker to build. The other requests were for touch-screen or e-board interfaces and a faster computer.

When evaluating the ease of creating a number of alternative designs, the Control Group had a mean of 6.93 (sd1.81) whilst the Digital Group fared slightly lower with a mean of 6.73 (sd1.84) (Figure 5).



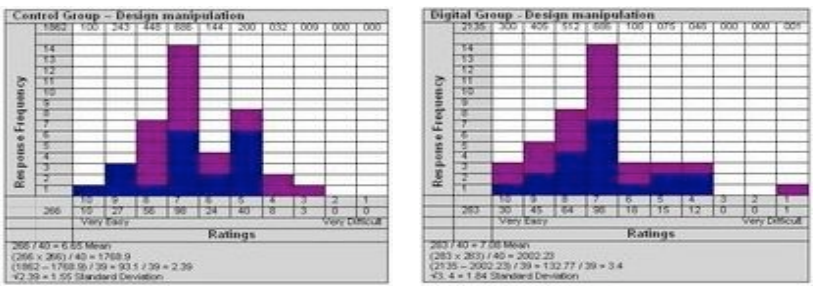
Control *Figure 5.* Creating alternative designs Digital

Surprisingly, the Digital Group (mean 6.03, sd1.42) evaluated that the session's duration for design was about right. The Control Group meanwhile (mean 6.63, sd1.51) implied that longer design time was required (Figure 6).



Control Figure 6. Session duration Digital

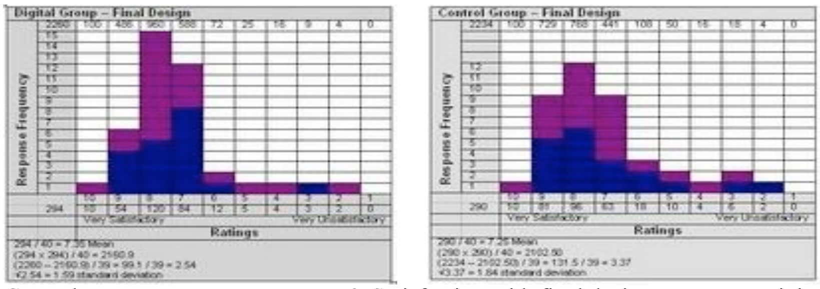
These results are congruent with their assessment of the ease or difficulty of manipulating each design. The Digital Group was more positive with a mean of 7.08 (sd1.84) compared to the Control Group (mean 6.65; sd1.55) (Figure 7).



Control Figure 7. Design manipulation Digital

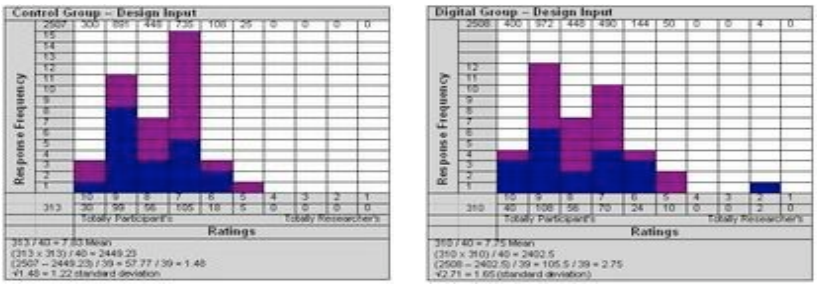
4.2. DESIGN SATISFACTION AND ENJOYMENT

The mean for satisfaction with the final design from the Control Group (CG) is 7.25 (sd1.84). It is slightly higher in the Digital Group (DG) at 7.35 (sd1.59) and both fell within the satisfactory range.



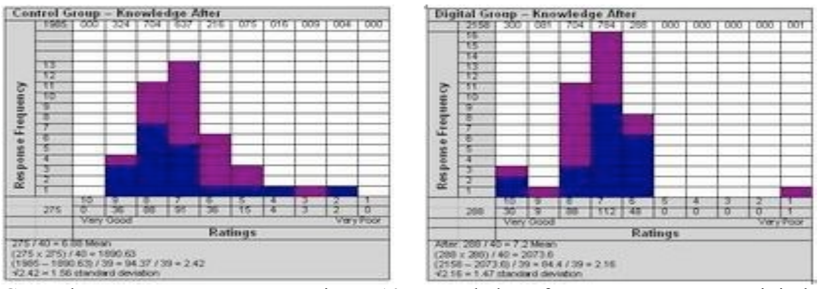
Control *Figure 8*. Satisfaction with final design Digital

However the Control Group felt that they contributed slightly more design input compared to the Digital Group with a comparative mean of 7.83 (sd1.22) to 7.75(1.65) (Figure 9).



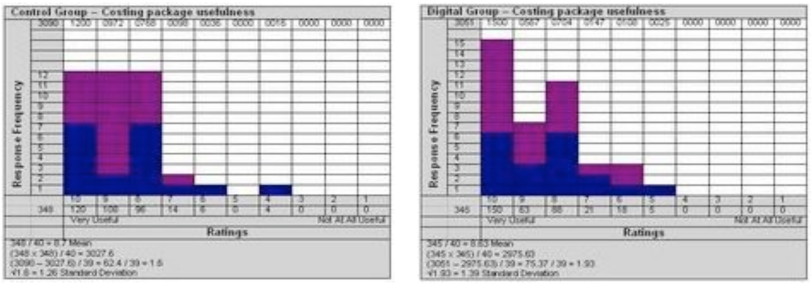
Control *Figure 9*. Design input Digital

The Digital Group on the other hand recorded a higher mean for their knowledge about student housing after doing the exercise at 7.2 (sd1.47) compared to 6.88 (sd1.56) for the Control Group (Figure 10) even though both groups started with fairly the same mean of 5.38 and 5.35 (sd1.94 for CG; sd1.54 for DG) or moderate knowledge of student housing before doing the experiment.



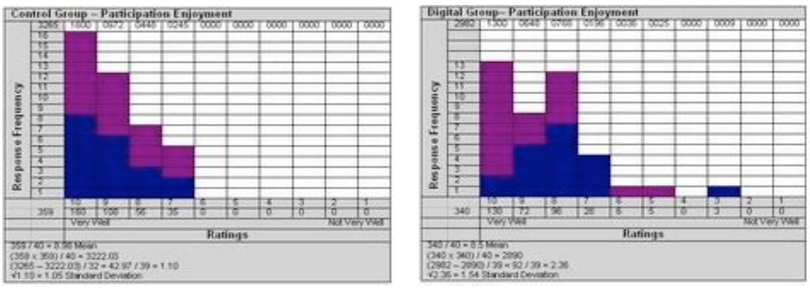
Control Figure 10. Knowledge after Digital

There was a slight discrepancy in the groups' evaluation of the project briefing. The Control Group gave a much higher rating at mean 8.73 (sd1.01) whilst the Digital Group gave a rating of mean 8.15 (sd2.39). The introduction shared exactly the same contents (two slides of the same illustrations/photos of the project site and surrounding) and the facilitator spoke from a prepared script. Both groups also used the same costing package and here again the Control Group gave it a slightly higher rating at a mean of 8.7 (sd1.26) whereas the Digital Group gave a rating of mean 8.63 (sd1.39) (Figure 11).



Control *Figure 11*. Usefulness of costing package Digital

In terms of their enjoyment of participating in the exercise, both groups gave a high rating. The Control Group gave a mean of 8.98 (sd1.05) while the Digital Group recorded a mean of 8.5 (sd1.54) (Figure 12).



Control *Figure 12*. Participation enjoyment Digital

These results were echoed in both groups' agreement that the University should undertake similar participatory processes in future student housing developments. 95% of the Control Group agreed completely with this proposition while 90% of the Digital Group shared their view.

When asked about the most liked aspect of each setting, 12.5% of the Control Group refrained from giving any comments. This can be construed as an indicator about their reservations towards this approach. The rest (87.5%) gave positive comments about liking all aspects of the process.

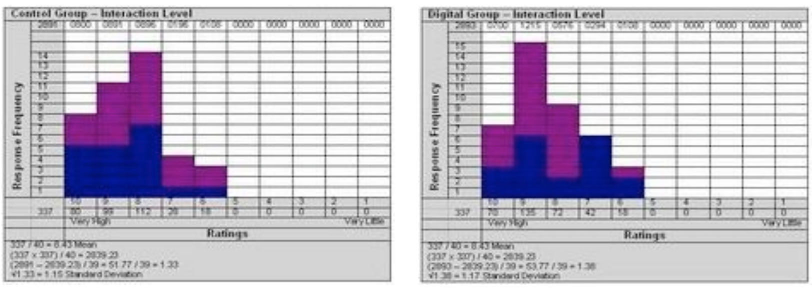
With the Digital Group, only 2.5% refrained from giving any comment, which is a substantial contrast and implies the public's openness towards the digitally-based approach. 97.5% of the Digital Group gave positive comments about enjoying seeing their design materialise on the screen. Other positive comments included their freedom to choose and express opinions, being consulted or included in the design process, and also seeing the cost implications.

On the least liked aspect of the sessions, 50% of the Control Group gave negative comments. These included disliking cutting fiddly bits of paper, difficulty with integrating various spatial functions, trying to adapt to practical requirements such as all rooms needing windows, having to draw and time pressure. With the Digital Group 58% gave negative comments which included difficulty in using the computer, practical planning consideration such as fire escape or design functionality, landscaping and time pressure.

Overall, the participants' response towards either setting was positive. In both groups the adjectives and phrases which were most common when describing their experiences of the session included: enjoyable/very enjoyable; educational/informing; insightful/new insight; eye-opening; expanded learning; excellent understanding of design difficulties; interesting/very interesting; fun/great fun; very interactive; excellent/good/very good/great; useful; entertaining; thought-provoking. There were also suggestions that all students should do the exercise and that the exercise should be implemented for the design of lecture rooms and staff offices. Several participants also commented that they should do the costing aspect first before embarking on the design.

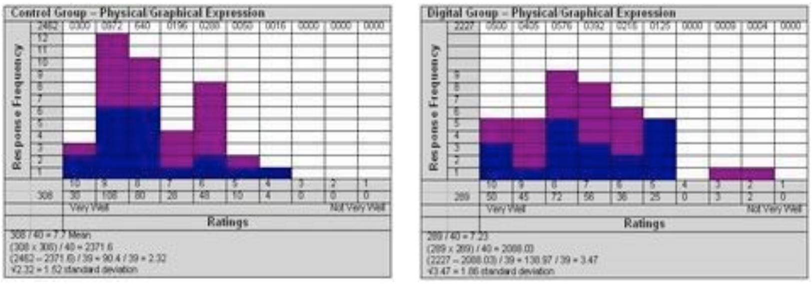
4.3. IDEAS EXCHANGE AND DESIGN COMMUNICATION

The experiment also gauged the potential for ideas exchange through communication and interaction between participant and facilitator within each setting. Both groups were satisfied with the room setting for the experiment (CG mean 8.35, sd1.2), and for the Digital Group (mean 8.33, sd1.37). Both groups express fairly similar ratings for the level of interaction visible during the session at a mean of 8.43 (sd1.15 CG; sd1.17 DG) (Figure 13).



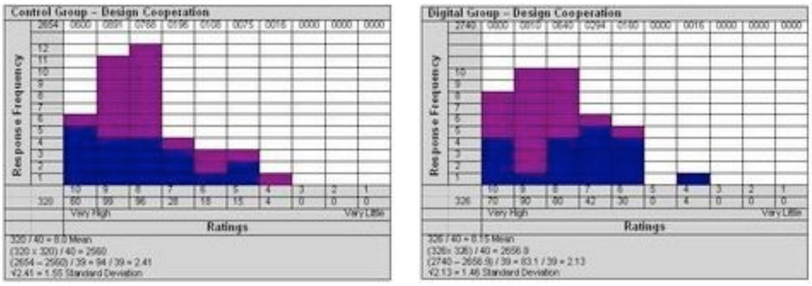
Control Figure 13. Interaction level Digital

However the Control Group consistently gave higher ratings for other aspects of communication. The mean for their evaluation of the facilitator's understanding the participants' ideas was 8.75 compared to 8.38 (sd0.93 CG; sd1.3 DG). The mean for ideas expression whether physically or graphically was 7.7 compared to 7.23 (sd1.52 CG; sd1.88 DG) (Figure 14).



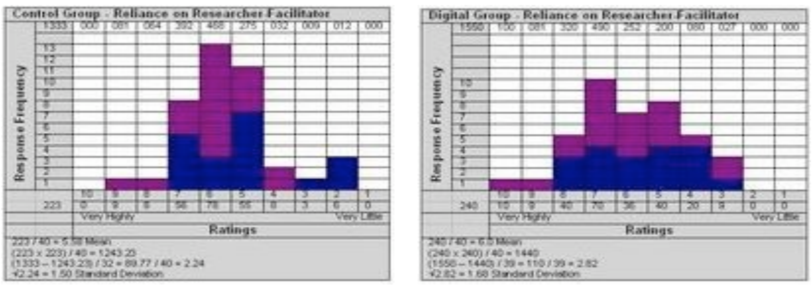
Control *Figure 14*. Physical/graphical ideas expression Digital

One inconsistent evaluation was for the expression of verbal ideas. It was assumed that both groups would share similar means given that verbal expression is a natural and thus neutral condition. However the Control Group gave a more positive rating at 8.28 (sd1.28) compared to the Digital Group at 7.9 (sd1.96). Despite this, the Digital Group recorded a more satisfactory level for design cooperation with a mean of 8.15 (sd1.46) compared to the Control Group mean of 8.0 (sd1.55) (Figure 15).



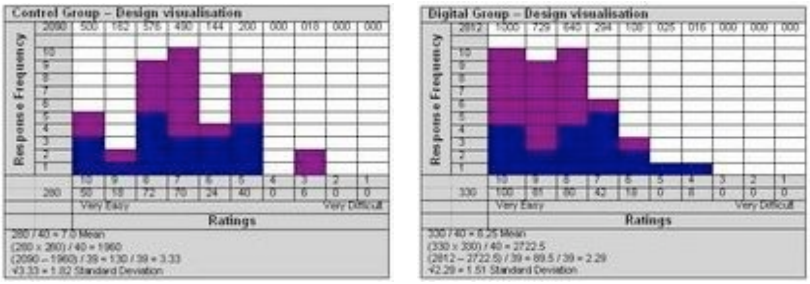
Control *Figure 15*. Design cooperation Digital

This was also true for the amount of reliance each group had on the facilitator. The means were 6.0 for the Digital Group compared to 5.58 for the Control Group (sd1.68 DG; sd1.5 CG) which are rather moderate (Figure 16).



Control *Figure 16*. Reliance on researcher-facilitator Digital

Perhaps the most significant difference between the physical and digital settings related to the issue of design visualisation. The purpose of the participatory process is, after all, about communicating and negotiating with the public about design issues. On their evaluation of the ease or difficulty of visualising the design form, the Control Group had a mean of 7.0 (sd1.82), while the Digital Group gave a much better rating with a mean of 8.25 (sd1.51) (Figure 17).



Control *Figure 17*. Visualisation Digital

This is a significant contrast. As one participant in the Digital Group put it, the most liked aspect of the digital setting was, “Seeing the design build up from scratch into a recognisable building” (Figure 18).

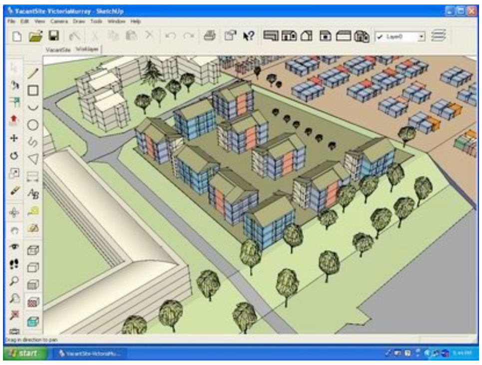


Figure 18. From digital toolkit to recognisable building

The results indicate that both groups were very satisfied with the technology that they were using to engage in participative design. The most important result (Table 2) was that the Digital Group found it easier to visualise the design as it emerged and this represents a significant improvement over existing practice. This improvement also implies that it will be easier for the designer to interpret the proposal into a fully developed scheme.

TABLE 2. Summary of results.

Experimental Aspects	Control Group (Mean)	Digital Group (Mean)
Suitability of tools	8.18	8.15
Ease of use of tools	8.1	7.4
Ease of creating alternative designs	6.93	6.73
Time available for design	6.63	6.03
Ease of manipulating the design	6.65	7.06
Satisfaction with the final design	7.25	7.35
Own contribution to the design	7.83	7.75
Knowledge on student housing before exercise	5.38	5.35
Knowledge gained on student housing	6.88	7.2
Evaluation of project briefing	8.73	8.15
Evaluation of the costing package	8.7	8.63
Enjoyment with participation	8.98	8.5
Satisfaction with the room setting	8.35	8.33
Level of interaction	8.43	8.43
Facilitator’s understanding of participant’s ideas	8.75	8.38
Visual and physical expression of ideas	7.7	7.23
Verbal expression of ideas	8.28	7.9
Level of design cooperation	8.0	8.15
Level of reliance on facilitator	5.58	6.0
Ease of visualising design form	7.0	8.25

There is one final stage to the experiment to be undertaken. This will involve independent professionals comparing the design proposals created during the two sessions. In this appraisal, each final design will be evaluated in terms of its spatial planning, its cost and its appropriateness to its context in order to provide a way of establishing whether the Digital Group or the Control Group produced the best schemes from the functional and aesthetic points of view.

5. Conclusion

The results that have emerged to date show that each of the two approaches has its advantages and also limitations. The strengths of the traditional approach lie in these following areas:

- Suitability to realize ideas and ease of using the tools (despite complains about disliking paper cutting and the inaccuracy issue).
- Ease of generating alternative designs.
- High level of participatory enjoyment.
- Better verbal and physical expression of ideas.
- Less reliance on the facilitator-designer during the session.

The strengths of the digital toolkit approach meanwhile lie in the following areas:

- Good visualization in three dimensions with immediate realization of the design decisions at every move.
- Ease of manipulating the design form.
- Shorter duration for design production.
- Improved knowledge attainment.
- High level of design cooperation.
- Better satisfaction with the design product.

Both groups of participants agreed on the usefulness of the costing element in helping them understand the implications of their design decision. Whilst the conventional approach of participative design is clearly successful, there are nonetheless several limitations to its usability, namely the problem of scale and amount of design details that can be incorporated in a typical study model. The digital method enhances this process by utilizing the properties that digital-based tool can offer, especially rapid copying and true to scale depiction at any level of detail. This research draws upon the capacity of computer hardware and software that is readily available and uses it to involve the public in design. The interim results of the experiment have illustrated that digital tools can perform at least as well as their traditional counterparts when used for participative design. The CAD package that was used in the experiment, SketchUp, has an in-built programming language that allows it to be customized to suit particular applications. This means that it could be developed to suit the particular requirements of participative design thus overcoming some of the difficulties that have been identified in this experiment.

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