

Virtual Reality Projection Based Furniture Showroom – A Hypothetical Study of BPR Implementation in a Small Business of Furniture Design & Supplier

Muhammad Faizan Khan, Kamran Ahsan, and Muhammad Azhar Hussain

Abstract – Significant advancement in the field of virtual reality (VR) has enabled researchers and practitioners to use it in different domains e.g. healthcare, education, assistive technology, trainings, simulation and business. In this study, a hypothetical business process reengineering (BPR) study based Furniture Showroom digitalization has been proposed with projected reality system called ImmersisVR. Digitalization of showroom is not a new concept but through projected virtual reality system in furniture industry at showroom level is an innovative concept. In this research, a hypothetical BPR study is conducted to explore the significance/effectiveness of projected virtual reality system in elimination of impact of availability of limited physical space in showrooms. As proof of concept of study, a prototype of the software application 3D-FC (3d furniture customization) has also developed in Unity3d game-engine. The application provides real-time furniture customization facility which based on desktop application and mouse based interaction. It is also compatible with the upcoming ImmersisVR system which will enable the important feature of 3D furniture content projection. The 3D furniture content projections on different walls of the showroom will minimize the impact and problems of limited space availability. Meanwhile, it will also attract customers to visit showroom and customize furniture according to desired colors and texture patterns with 3D projection on walls. Digitalization of the showroom will help in reducing of labor cost that usually required in furniture item managing in showrooms.

Index Terms – BPR, Reengineering, Furniture, Interior, Projected Virtual Reality, ImmersisVR, Showroom Digitalization, Outlets, Showroom Design

I. INTRODUCTION

Furniture designing & supply companies usually maintain display center or showroom for the display of their brands or furniture items. These companies provide different furniture items for houses, shops, schools, hotels, business and offices [1] and different levels of furniture or interior firms are facilitating consumers at different scales.

Rapid progress in virtual reality (VR) & augmented reality (AR) technology e.g., head mounted display (HMDs) and AR supported Smartphone has enabled effective product presentation but still they are not well-suited within the context of physical environment of the conventional showrooms. Presently, physical showrooms are taking advantages of the digitalization in their showrooms [2] [3] [4]. One famous example of digital innovation in

conventional showroom is Audi City. Audi, an automobile company, implemented virtual showroom concept in physical showrooms spreading worldwide in different countries and calls it Audi City [3].

There are different VR [5] [6], AR [7] [8] and projected reality systems like CAVE [9] [10] exist aimed at digitalize physical showroom but these solutions are unable to effectively solve the fundamental issues of physical showrooms. These systems, however, unable to deal with the problem of efficient utilization of physical space of showrooms. Virtual Reality (VR) based systems can entirely transform the conventional product display mechanism at showrooms by providing products' virtual view through VR headset or HMDs. VR based system requires VR headset to view the virtual content, which is not suitable within the context of physical showrooms, where main focus is presenting furniture items on front display of the showroom to attract customers. Augmented Reality applications pose same kind of limitations as it requires additional hardware to view AR contents. AR allows to view virtual object augmentation into real world but, in showroom perspective, end user i.e. customer require a Smartphone or AR-enabled smart glasses, with a camera and application, to view virtual items. There are additional hardware (Goggles, VR headset, Smartphone) require to view AR/VR content which thus hinder showrooms to use this state of the art technology. The projected virtual reality systems, that use large wall mounted display [11] like a system named CAVE [9], has potential to display furniture items within physical showrooms to attract customers and present the products effectively. In these systems, however, customers require pair of goggles to view its projected contents clearly and without goggles, view of projected contents blurry and overlapped [9]. This issue reduced the chances of CAVE deployment in showrooms. Additionally, another worth noting factor is that CAVE installation and operational cost is high [9] as it requires different sets of projectors, hardware, accommodations and huge amount of electric power.

Therefore, showroom digitalization requires a projection based solution that could work without any additional hardware like goggles and dozens of projectors. The solution should also able to effectively utilized the physical space of the showroom and project the furniture contents on showroom walls/front display to attract customers for visiting showroom, thus, consequently increase the revenue and help business to flourish. Keeping in view the limitations of Augmented Reality-, Virtual Reality- or projected virtual reality based systems, this work presented a hypothetical BPR study of a small business of furniture Design/Supplier Company where IT implementation has suggested through a 3D Furniture

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customization (3D-FC) software application with an upcoming projected virtual reality system called ImmersisVR [12]. The 3D-FC software has particularly developed using Unity [13] game engine, a most widely used game engine [14] and compatible with the ImmersisVR system. The software provides 3D interactive interface for furniture display and its real time customization by changing furniture color and textures using mouse input. Its implementation in conventional showrooms has suggested through ImmersisVR [12] which is projected virtual reality system that provide immersive virtual reality experience without cutting the user off from the real world. ImmersisVR is upcoming projected virtual reality system and it has enough potential to be used within the scope of physical showrooms although it is primarily developed for games [15]. ImmersisVR provides built-in anamorphic algorithm which can convert any panoramic video or 3D scene to map into any surface and it is compatible with proposed 3D-FC application. ImmersisVR provides 180 degree projection on the wall of the room and provides 180 degree field of view [16] which is most suitable for conventional showrooms. ImmersisVR will allow viewers to view the projected content without wearing any special headset or goggles like it usually requires in VR /AR or CAVE, which thus an accurate match to display furniture contents on the front display of the showrooms. The significant advantage of the ImmersisVR system its controls are adaptable with tablet or desktop PC with traditional input i.e. keyboard and mouse [17] that make it more useful and widely acceptable.

The 3D-FC software and its projection through ImmersisVR will benefit the company to upgrade its business by overcome the limited physical space availability problem in showroom and get more customer satisfaction. The paper also explores the expected results of this hypothetical study and considers that ImmersisVR is one of the simple, easy to install, most suitable and new way to transform and digitalize conventional showrooms/outlets. Although ImmersisVR has primarily developed for gamers to make them more socialize but characteristics of ImmersisVR can be exploited for furniture showrooms digitalization. This new system will allow exhibition of wide catalog of products without worrying about the space limitations of the outlets.

II. RELATED WORK & CRITICAL ANALYSIS

In a study [18] a 3D application has presented that provides interactive furniture layout adjustment using interior design guideline (see Fig 1). It enables user to design the room and arrange the variety of furniture/interior in their room with furniture customization option. The application's main focus is on furniture layout adjustment, although it also provides furniture material customization through limited color patterns. The application does not precisely provide procedure to use different texture on furniture objects but it is an excellent effort in furniture layout adjustment. Liu [6] provide web based virtual reality solution for interior design. Fig 2 depicted the proof of concept application view, where user can select any specific interior and can customize it



Fig. 1 Interactive furniture layout application view- Right hand side showing suggestions [18]

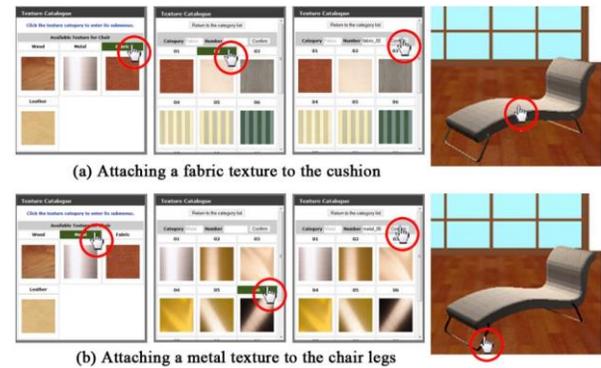


Fig. 2 Interior material customization [6]



Fig. 3 Adjusting color of virtual furniture [8]



Fig. 4 Magic paddle demo [19]

through different textures [6]. In another web-based interior customization application, multi user interior design (MID) [5] had presented. It works in VR fashion and provides facility to interact with furniture objects and also enable user to change the color and texture of the object. Phan and C hoo [8] presented AR based interior design application and demo

of their application is depicted in Fig 3. In another AR based furniture design study, Kawashima (Fig. 4) [19] presented computer vision based AR system called magic paddle. Their suggested system works on tangible AR with an AR interaction system that can manipulate virtual objects.

Different AR/VR and normal 3D based application solutions exist but none of them consider the showroom perspective and their associated problems which mostly faced by showrooms/outlets of the Furniture Supplier/Designers. They are generic applications which are not developed with the showroom context where these application contents projections required in physical space (e.g., walls or front display of outlet). The problems which are associated with VR-based solution are that it cut the user off from the real environment (physical world) and the user unable to see the real environment. As VR completely immerse the user, there are the chances that user stumbles during walk or hit VR controllers to wall or different objects in the physical environment. It is also not feasible in the showroom context where mostly emphasis on displaying the products elegantly in physical space. Meanwhile, to view the furniture items on the showroom, user must require VR headset which, in some conditions, is not feasible. AR applications are also not suitable in the context of physical showroom as it require additional hardware (like AR glasses or Smartphone) to view augmented furniture object. Undoubtedly, AR/VR has own importance, use and scope but they are not well-suited within showroom/outlets context where effective presentation is required. There are also online virtual showroom options available but it has own scope and E-commerce role. It is also necessary to mention here that an online survey concluded that there are no fully-fledged commercial purpose virtual showrooms available [20].

Digitalization of showroom is not a new concept; there are also showroom's digitalization examples available like a multi-touch interactive table design for showroom in Taiwan [4]. Another more related example to our work is Audi city [3] who digitalize their showrooms across different countries. These digitalized showrooms provide new virtual experience to their user by providing different projection screen, power walls and touch sensitive tables. Their high performance computers and servers power the projection surface where user can explore Audi cars. This digitalization brings significant improvement in number of customer, which increases by 60-70% [3]. Same sort of work requires in the context Furniture showrooms, for effective visualization of interior items, to attract customer, effectively present different furniture options and also overcome space limitations problems and customer satisfaction challenges, which are commonly faced in physical showrooms.

Showroom digitalization can also take significant advantages from virtual reality projection technique like CAVE Automated virtual environment (VE). CAVE is projection based virtual reality system [21] and it one of the most successful immersive VR system [10]. It consist of three wall screens (see Fig 5) including front, right and left and also include one more screen for the floor. It looks like a room sized cube and its screen are used to display stereo

images, generated through projectors and workstations [10]. It is a costly setup [10] with significant potential to digitalize showrooms through its screen display at front of the showroom. CAVE has some limitations, such as to clearly view its projected content, the end user requires specific goggles to view the projected contents and an observer without goggles will view the projected contents overlapped and blurry [9], which is not suitable within the context of showroom like VR and AR application solutions. A solution without any intermediate hardware or any head mounted display (HMDs) can highly be successful within the context of showroom.

III. STATE OF ART RESEARCH

There is different AR, VR, desktop/web based solution available (as in section II discussed) but none of them specifically address the requirements and needs of showrooms or outlets. Furthermore, CAVE system, a potential candidate that can digitalize our conventional showrooms pose different limitations as its immersive contents are not clearly visible without additional goggles and it also expensive to deploy. Therefore, it is not an ideal choice in the context of showrooms. It is also necessary to mention here that, there is no considerable amount of study available that comprehensively discussed BPR implementation at showroom level of furniture business or any study that define the digitalization in the context of furniture showrooms. Nevertheless, there are different fragmented interior customizations works available that provide different feature regarding furniture customization but none of them consider the context of showroom. We require such a study that examine some of the main problems of the furniture showrooms and try to solve it through state of the art technology. Therefore, we presented this study to solve some common issues of the furniture showrooms with the approach of hypothetical study of business process reengineering (BPR).

Clearly, most showrooms arrange their products on front display of the showroom in order to get customer attention and increase customer visit at showroom to generate revenue. Typically, Showroom spaces are limited and products catalogs are wide, therefore, products display and arrangement within limited space is a big challenge for showroom management. In this research, we have proposed furniture's virtual 3D contents projection, instead of actual presentation of the furniture items, which is the aim and purpose of this work.

Virtual and immersive display of the furniture items will alleviate the poor impact of space limitations at showroom. For this purpose, a 3D software app based solution that also allows 3d contents projection in immersive fashion is worth to consider. As it can be used with projected virtual reality system along with large LCDs to display furniture items on the front display and can attract customer to visit showroom. This solution is also most applicable for those showrooms where physical space limitation is a main problem and wide range of product catalog is required to arrange/display in showroom. The study specifically considered the case of a

showroom where physical space availability is a big problem along with customer satisfaction challenge. The study considered 3D based software application solution for showroom along with the projected virtual reality system ImmersisVR [12]. Projected virtual reality is the way to project VR contents on the wall of a room (like CAVE). ImmersisVR [12] is one of that upcoming tool to project VR on the wall, it is simple, easy to use and work with projector, TV screen and personal computer (PCs). It brings the virtual world in the living rooms [22] and it has great potential to digitalize showroom with great ease. It allows 180 degree immersion [22] and it is expected to work ideally in the context of showroom where showroom display area can be utilized as the projection screen. Unlike VR, the viewers of immersisVR don't require any additional hardware to watch its content. immersisVR provides shareable immersive environment which is a perfect choice for showrooms.



Fig. 5 A CAVE example installed at Earth Simulator Center [10].

The potential of the new virtual reality system and problems of the conventional showroom has urged us to

produce such a study that digitalize our showrooms and provide great customer experience. Through the combination of state of art projected, shareable virtual reality system and conventional mouse input based 3d applications we can solve common issues of showrooms. Additionally, a comprehensive BPR study in small business within showroom context in furniture industry can bring different results and findings that can help business to grow and provide better results.

IV. BUSINESS PROCESS REENGINEERING BASED HYPOTHETICAL STUDY FOR SHOWROOM DESIGN

Business Process Reengineering (BPR) is a strategy that is refer to fundamental change and redesign of the business processes in order to bring dramatic improvements in the business [23]. BPR is a costly process that requires time for the design and implementation. Its primary objective is to improve performance through quality improvements, cost reduction and speedy/timely delivery of the services [24]. From early 90s [25] it is in the market and frequently used by organizations to improve their organization and compete in market. BPR term was first defined by Hammer who also consider father of the BPR [25]. Hammer and Champy stated about BPR in 1990: "The fundamental rethinking and radical redesign of business processes to achieve dramatic improvements in critical, contemporary measures of performance, such as cost, quality, service, and speed" [26]. The terms which are require attention in above definition are, "fundamental rethinking", "radical redesign", "business process", and "dramatic improvements". Fundamental rethinking and radical redesign states that BPR is not about marginal changes but it is actually about fundamental change in business for gaining dramatic improvements and it particularly concern with "business processes". Business

TABLE I. BPR STEPS

8	Name	Description
1	BPR Planning	<ul style="list-style-type: none"> Operational and strategic goal are specified in this step along with the scope of BPR [36]. Create vision and mission for BPR project
2	Fact Analysis/ Process Identification	<ul style="list-style-type: none"> Gather data from internal and external sources. This data will be analyzed by BPR team in order to identify current problems and improvement area of business and their consequently impact in business [29] Organization's processes are identified that require redesigned on the basis of cost analysis or revenue generation process.
3	BPR Design	<ul style="list-style-type: none"> BPR team will create step by step procedure in order to reach their desired aim which mention in the first step [6].
4	BPR Process Implementation	<ul style="list-style-type: none"> In this step new model of business meets with current model of business. continuous monitoring to notice the impact on organization behavior and structure along with the people who directly or in-directly get affected [29]
5	BPR Assessment	<ul style="list-style-type: none"> new business processes, benchmarks are set and analyzed. Testing strategy checks BPR implementation through two constrains which are time and cost. If the findings are not positive then, the alternative methods applied to attain desired objectives [29].

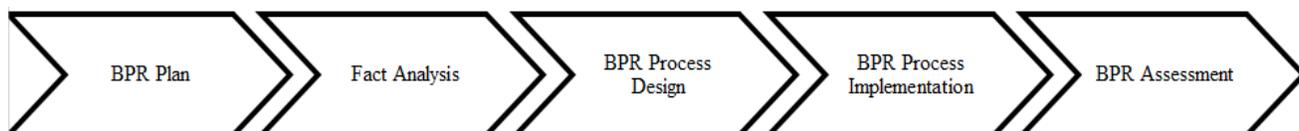


Fig. 6 BPR implementation steps.

process is a set of logical tasks which are performed to attain definite business outcome [27]. Business process is a key concern in BPR where actual changes become happen and directed in BPR. While the Last term “dramatic improvements” of the definition has defined the objective of BPR which clearly states that it is used to get definitive, big outcomes. The definition of BPR mainly states about the change in business process in order to attain performance measures like cost, speed and quality service.

There are three level of BPR defined by Sage, which are product, process & system [28]. BPR implementation model is almost similar with conventional software development life cycle (SDLC) [29]. The steps of BPR are given in Fig 6 that includes BPR planning, BPR Facts analysis, BPR process design, its implementation and its assessment. Almost in same manner, BPR’s five steps define in [27] which include: vision definition, process identification, existing process/system understanding, methodology, and prototype preparation [27]. Whereas, in another study [30] defines six generic phases of reengineering which includes preparation, process think, creation, technical design, social design and implementation [30]. Another BPR framework also defined six stages of BPR. It includes understanding, initiating, programming, transforming, implementing and evaluation [25]. Different authors refer BPR steps with different names but these steps are almost identical. The short description of the BPR steps is given in Table I.

A. Information Technology Role in BPR

In 1990, significant reduction in IT cost has enabled IT investment in organizations. IT provides competitive advantages to an organization; it eliminates communication barriers and speed up the work-flow of the business. BPR and IT both work together effectively to rise the performance of an organization. IT reshapes and redesigns the business and makes it more effective, competitive and flexible. IT not only initiates BPR but also make it worthwhile [31]. IT completely supports business and guides about the new dimensions of the business and its process creation. Some of the significant IT capability areas have mentioned in Fig. 7. IT mainly speeds up the work process and makes easy information access with robust infrastructure. It helps to reduce expenses/cost, provide facility of new process design and enable within and across organizational communication.

In current age of science, technology and information, running a business without IT utilization seems impossible. BPR itself also strongly endorsed IT effectiveness in the process of reengineering as Hammer and Champy refer Information technology as a key enabler of BPR [26]. In same manner, Davenport et al. also mention IT and BPR in details and suggested to view BPR as a relation of IT and business activity. They enforce broader view of BPR where IT, business activity and their relationship should be analyzed [32]. Attaran categorized IT role into three Phases which are (i) before process design, (ii) during process design, and (iii) after the completion of design. First phase refer it as an enabler, second phase take it as a facilitator and third phase refer it roles as implementer [31]. Clearly IT role in BPR is not less than a key enabler. IT can be referred as a

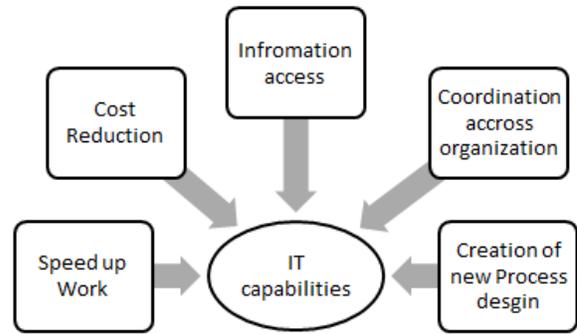


Fig. 7 IT capabilities within business perspective

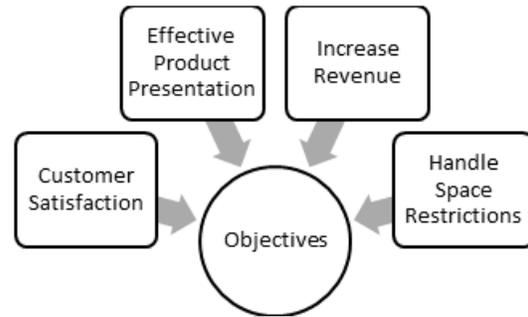


Fig. 8 Company vision for BPR

backbone of BPR that encompasses the entire business scenario, especially business processes. Current age of information has also make data integration and business process worthwhile. The main aspect of IT support to the business is business process support automation through different IT solutions. Organizations adapted numerous IT tools to reengineer different business processes. It proves the key role of IT in business process reengineering [31]. IT is integral part of BPR; it is used to analyzed and model business process and then, helps in reengineering those processes [33].

B. BPR Study in Furniture Showrooms/Outlets

There are different business exists at different scales, from small to giant enterprise, dealing in furniture manufacturing & interior design and supply. Mostly, these businesses manage showrooms to display their products in order to get customers’ attention. In this hypothetical study, it is assumed that a small scale business company namely ABC furniture Ltd., has considered that sell limited number of furniture items which include Sofa set, Tables and Chair with different color and design patterns or materials. They are currently running their business through a single outlet/showroom. Company owns small outlet/showroom to display their products and faces problem of displaying all range of products effectively and unable to satisfy their customer. Company wants to undertake BPR in order to solve their issues and become competitive in market within limited budget and within some rigid limitations. This study

follow same step as we mention earlier in this section to implement BPR in the company at showroom level.

1) *The Company Vision - BPR Planning:*

The ABC furniture Ltd. wants to display their limited products with different designs/colors effectively within limited space in their showroom. The objective is to provide more satisfaction to their customer during the customized furniture item order receiving. The company's vision for change with these objectives is as follow (see Figure 8):

- i. **Effective Products Presentation/Exhibition:** The outlet area is limited i.e., the company having difficulty to present their products effectively.
- ii. **Customer Satisfaction:** Main issue of the company is customer satisfaction. Being considering the limited space of showroom, it is not possible to display all products. Customers' desired furniture products customization is done on paper, which sometimes not satisfies customer, resulting in failed to meet customer expectation.
- iii. **Eliminate space restriction consequences:** The Company own limited area of outlet and this is not enough to display their entire product catalog. This is one of the big barriers in effective products presentation.
- iv. **Increase of revenues:** Due to poor customer satisfaction and product presentation, sales are not up to the company expectation. Therefore, increase in sale and revenue generation is also the main objective of the company.

Beside the clear vision for the BPR project, there are some rigid limitations that company can't afford to change. The limitations are:

- i. Currently limited products catalog (as Table II suggested) available for sale and company could not extend it due to limitations. It is a big hurdle in increase of revenue.
- ii. Company owns a single showroom with a backend production unit.
- iii. Limited number of employees at outlet and production unit. Company cannot afford more employees.
- iv. Limited space available for Showroom in very dense populated locality.

Although products are limited in numbers but their different design and color patterns extend their quantity which are need to be present/show at outlet effectively and efficiently, but Company failed to present them effectively at outlet due to limited physical area of the showroom. Located in very dense populated locality, with strong competitors with same products, required some kind of innovation to handle these situations/limitations. The company aim is clear about the BPR and all the four main objectives are tightly coupled with each other which are required to achieve through BPR project implementation.

2) *Fact Analysis/Process Identification:*

The first step has clearly defined the limitations and objectives of the company for BPR project. The next step is to analyze current processes and facts about the business. In order to get good understanding about current loopholes in company's work flow, work process at outlet level have modeled and products details have gather. There are limited numbers of furniture items (Table II) with different design/Shape/Style with different colors available for sale.

As the BPR intended for customer satisfaction, main focus is on processes of the selling the products. Currently there are two ways to sell furniture items at outlet. Fig 9 defined these two sell process. The first one, product based selection is simple where customer visit the outlet, select/inspect the product with no demand of alteration in product and simply make payment and received the product. In requirement based product selection (the second process), customer orders for changes in available products. This process includes below steps:

- i. Customer select sample furniture at outlet and ask for available designs/colors.
- ii. The company provides customization details (like material design/patterns and color) on paper with different sample pictures.
- iii. Customer select desired customization details and then, order for the product.
- iv. If customized product already available in production unit's stock then, it delivered to customer at outlet.
- v. If customized product is not available at stock then, product order is note down and passed to production unit. Specific delivery date has given to the customer.
- vi. After design and development of the product, it is delivered to the customer on specified date.

In direct available product selection at outlet, it is easy to satisfy the customer as product is readily available and customer requires simple selection with no question about quality/presentation of the product. However, when customer orders with specific requirements, as s/he selects customization details on paper. It is not possible to present all products with all design/colors at outlet so the company provides customization details on paper where different sample pictures of different products available and customer select their desired design and color.

Customization on paper could create confusion for customer and sometime delivered product does not meet the expectations of the customer. It is obvious that the customization of the furniture display/view on paper is not as good as the real view.

Therefore, requirement based product selection has identified as a key process for BPR implementation. Another key process which requires attention is that current space restriction at outlet hindering the company to effectively exhibit and present their products. Front display hardly wide enough that it can only show one sofa set with a table. Showroom staff managed to change front display items weekly but failed to attract customer. This situation also required to improve, therefore, BPR project should provide

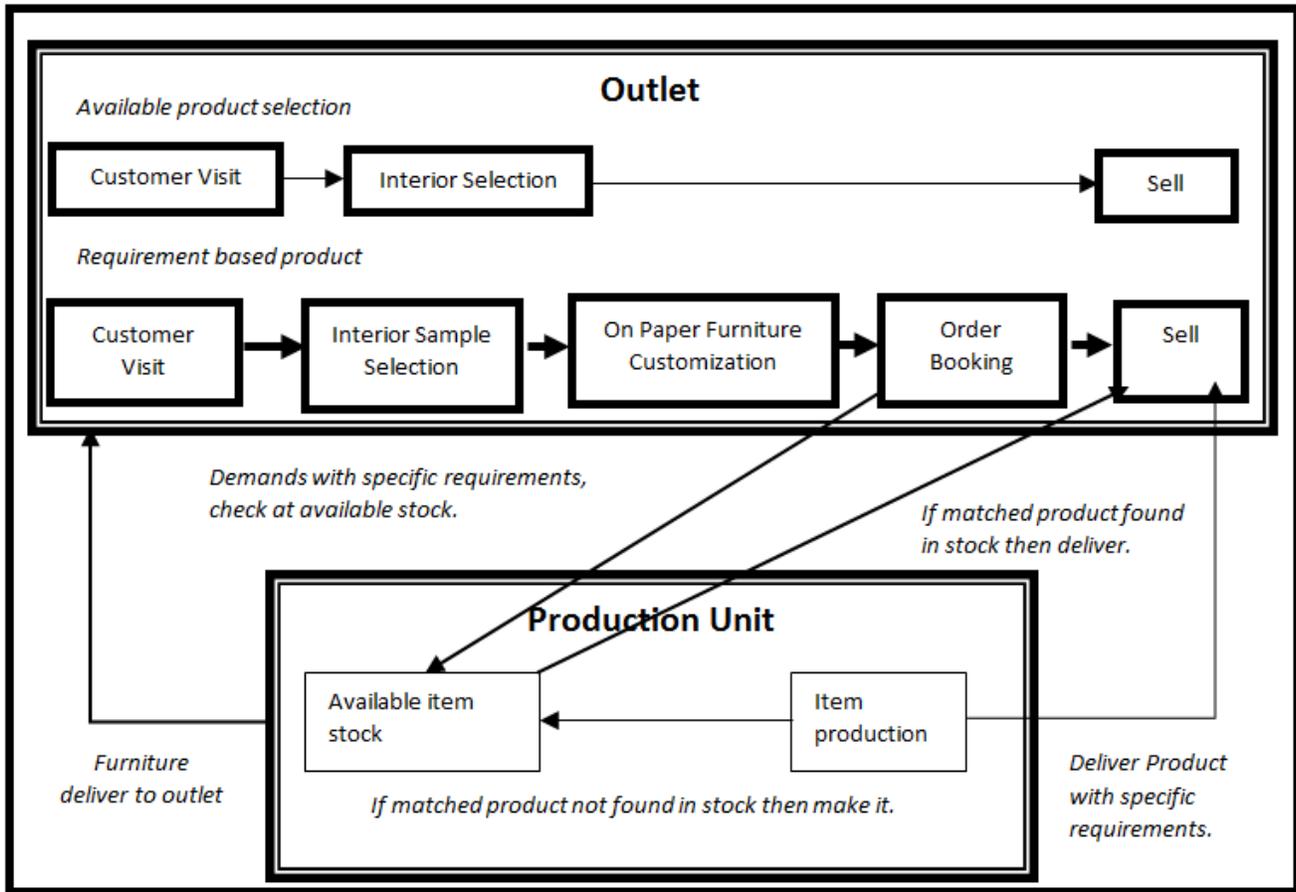


Fig. 9 Furniture Sale Cycle at Showroom before BPR

an effective way of furniture presentation and solve furniture exhibition problem.

3) *BPR Design:*

At this stage, all necessary business information, key processes and company vision about BPR clearly are defined and documented. The company’s current problems at outlet level and areas where improvement is required have

identified and analyzed which are the sell process and furniture display/presentation. Specific requirement based product selection and customized products presentation at outlet require attention in order to achieve BPR objectives which are mainly related to customer satisfaction and increase of sell/revenue.

The company’s current limitations, sell process loopholes and company’s BPR vision/aim has enabled us to decide the characteristics of IT solution. As different businesses are attached with IT, the company also require IT infrastructure with specific software application that can provide products customization details on computer along with its projection on front display of the showroom with a projected virtual reality tool. Computer generated 3D furniture’s models application with customization options will allow the company to provide more satisfaction to their clients with another great advantage of effective products presentation. Fig. 10 has depicted the expected result of 3D Furniture Customization (3D-FC) Software intervention result in the business. In the first step of BPR planning, it is mentioned that company’s main objective is customer satisfaction and effective presentation of their limited products with different customization details. In BPR design phase, it is considered that a 3D software application with a virtual reality project system can play robust role to achieve all those objective which were mention earlier in company

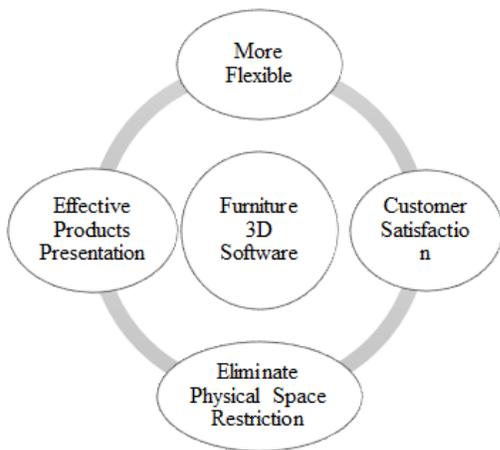


Fig. 10 3D Furniture Software Advantages

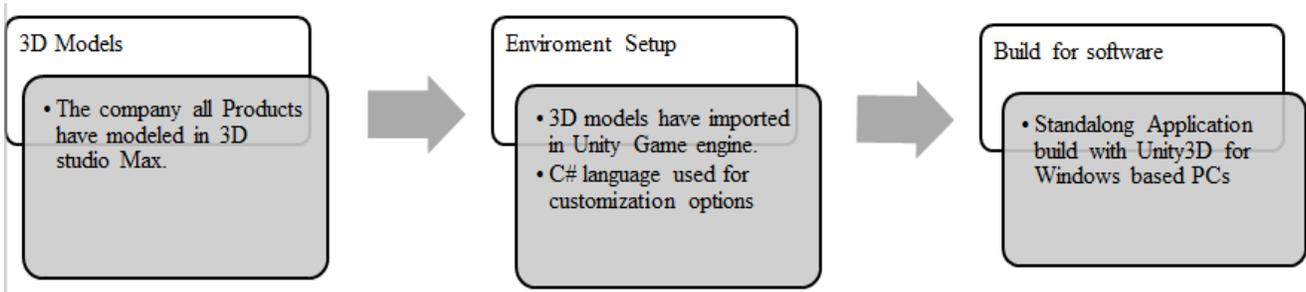


Fig. 11 3D Furniture Customization Software Development Pipeline

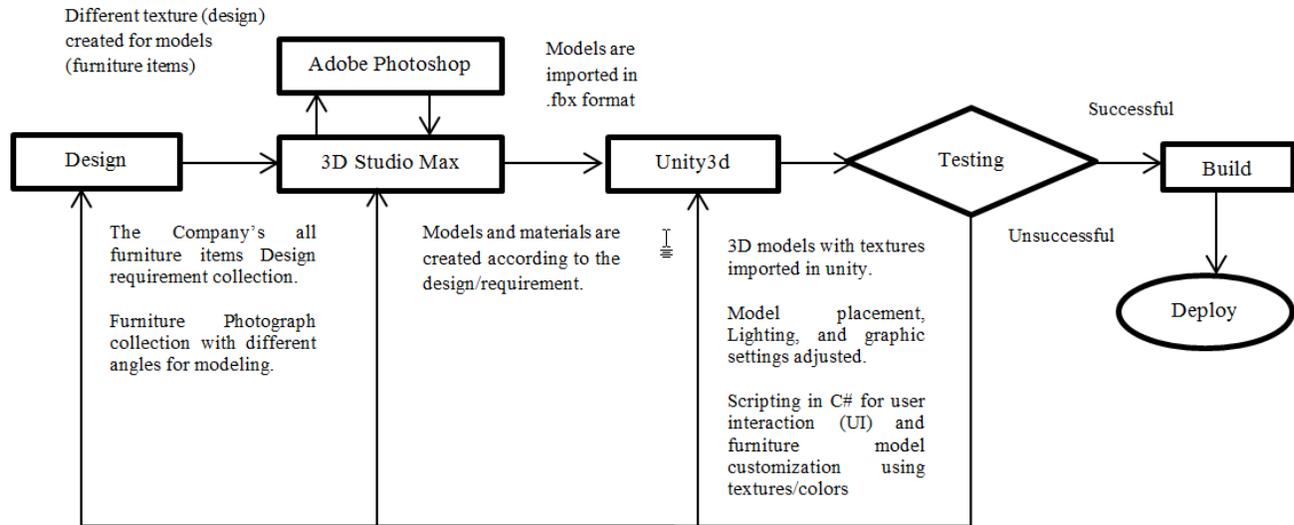


Fig. 12 Furniture Customization Software Development Technical Phases.

vision and it can address most of the problems which currently showroom experiencing.

Therefore, an IT intervention plan has designed that mainly include, a 3D furniture customization (3D-FC) software application, four computer systems with large LCDs to display 3d furniture products along with a projected reality system ImmersisVR [12] to project 3D-FC contents on front display/surface of the showroom.

a) *3D Furniture Customization Software application:*

Fig. 11 have depicted the general 3 steps of the furniture customization application development while Fig. 12 has shown all the details including tools which are used to developed the software application. First of all furniture products and their respective design images have taken so that all company products can be modeled through 3D modeling tool like 3D Studio Max [34]. 3D Studio Max is an application that is use to do 3D modeling, animation and rendering for making game world and also allow

visualization [34]. Later in the final tool of the 3D-FC software development pipeline which is called unity [13], all the models materials and their textures have imported in FBX format. In Unity3d, all models have scaled and positioned in one scene with lights settings so the models rendering become clearer and more visible and attractive. Then, C# scripting language has used to enable models selection and customization with different colors or textures. After development of the application, testing process validated the software application and final build released for the showroom. Fig 13 shows a demo screen shot of the 3D-FC application that will be deployed in showroom's computer systems in order to automate their manual working. Fig 14 show a demo that how user will customize the furniture item.

b) *Projected reality System – ImmersisVR*

Along with furniture items customization through 3D-FC software application, the furniture company also required effective strategy to present/display their furniture items in outlets in order to get customers attention. Therefore, projected virtual reality system ImmersisVR [12] has also suggested with current 3D-FC Software.

ImmersisVR, developed by Catopsys [35], transforms an entire living room into immersive support for panoramic videos and video games. ImmersisVR provides immersion

TABLE II. Furniture Catalog Of Company

Product #	Product Name	Total Available Design	Total Available Color	Total Fabric/Material Design
1	Sofa Set	7	21	15
2	Table	3	2	1
3	Chair	5	3	1

that is easily shareable with family and friends. It has ability to project any content at 180 degree and monitor/TV/tablets can also integrate in to this projection. ImmersisVR use fisheye lens projector to project the content at 180 degree and it is attached with PC's graphic card with HDMI/DVI. Another main characteristics is that it is portable, easily deployable and it integration to proposed app is incredibly simple and easy using its plug-in [22].



Fig. 13 3D-FC software application screen

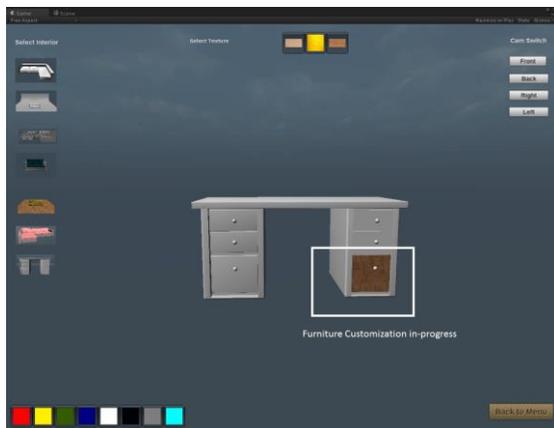


Fig. 14 Customizing the office table in 3D-FC application

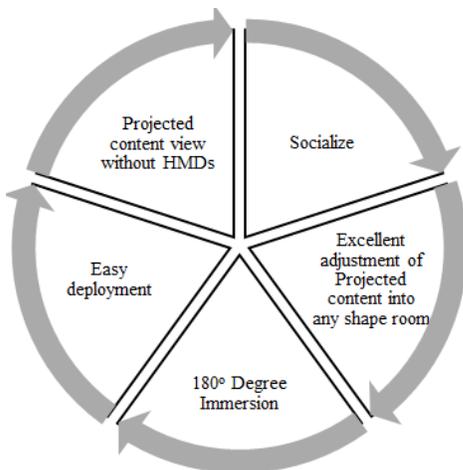


Fig. 15 Worthwhile characteristics of Immersis VR within the context of showroom

ImmersisVR qualities (see Fig 15) like 180 degree immersion with easy socializing and shareable environment make it more suitable choice within the context of showroom. Unlike VR headset (HMDs) it doesn't require any intermediate hardware to view the virtual content. Anyone, without any additional hardware or goggles, can view the projected virtual reality contents. Further, 180 degree immersion can be projected in the front display of the showroom and it is automatically adjust the projected contents according to different room sizes and shapes. Fig 16 has depicted the different size/shapes of rooms where ImmersisVR effectively projected the VR content. This thing make ImmersisVR more worthwhile within the showroom context as different showrooms physical shape varies and it is easily adoptable by any showroom. Current presented prototype application is also compatible with ImmersisVR and the 3D-FC software contents are also compatible with the system. ImmersisVR deployment will solve the issue of effective product presentation within limited space of showroom further, it will also attract customer to visit the showroom. Fig 17 depicted the typical view of expected VR projection results in this context.

c) BPR Implementation

There are three aspects of BPR implementation including software, hardware and training.

- i. **Software:** A 3D models and animation company have developed the software application which purchased by the company on SaaS (software as a service) basis. This purchasing model allow anyone to purchase software on rental basis hence, it is economical for the small business. By paying a reasonable amount monthly the company can afford this software.
- ii. **Hardware Setup:** The Company currently own only one PC for the documentation and billing purposes. To run the software application effectively and also for the integration with ImmersisVR system, four core i3 personal computers with 8GB graphic cards have purchased. Three systems have placed in outlet at three different positions so that customer can interact with it and use 3D-FC software. While another system has also placed in the main display of the showroom and it has integrated with ImmersisVR projected content.
- iii. **Training:** All employees are well-aware with computer and software application. As the user interface of 3D Furniture Customization (3D-FC) software is so intuitive and simple, a demo of the software is enough for understanding and use.

In the outlet, four systems have deployed where 3D-FC software application is running. Three systems are connected with LCD while one is attached with ImmersisVR system. All the extra furniture items have been removed from the outlet. Now, only sample furniture of all three products has placed in the outlet. The furniture items has also removed from the front display of the showroom instead ImmersisVR system has deployed (see Fig. 17) which will use to project 3D-FC furniture items on front surface of the showroom. The



Fig. 16 ImmersisVR projection adjustment into different shape of rooms. Most accurate 180 degree adjustment for showroom's front display (collected from official ImmersisVR video presentation)

projected virtual furniture items will be changed automatically with different time intervals thus, it will effectively present the all catalog of furniture items.

The IT intervention plan has slightly modified and improved the requirement based product selection cycle as Fig 18 depicted. On Customer visit at outlet, s/he can select their desired product directly from sample furniture. For more customized product (design, color customization), s/he will use the 3D-FC software application. 3D-FC software app will allow client to see real time furniture customization result in 3D (see Fig 14) hence, it will improve customer satisfaction and it will minimize the vagueness in the requirement based product selection process.

V. DISCUSSION & EXPECTED RESULTS GENERALIZATION

BPR first step clearly defined the organization's objectives where customer satisfaction, effective product presentation, revenue generation and showroom limited space impact elimination were on the highest priority. BPR implementation through 3D-FC software, computer hardware and projected virtual reality system has played the demanding role to achieve those objectives. Customer satisfaction was the top objective which was not good due to the on-paper preview of user defined customization. The customers of the company were unable to view real objects due to the physical space restriction at outlet and the company was unable to solve this limitation due to dense populated locality. The 3D-FC app allowed the company to effectively present their furniture and enable their customer to view real-time customizable 3D furniture. Further,

ImmersisVR contents also attract users to visit the showroom as it will effectively present the whole range of furniture items. IT intervention enabled the company to minimize the impact of limited physical space of the showroom. Now prime location of the outlet is used to show the ImmersisVR projected contents where user can also customize the furniture. IT intervention also brings significant reduction in employees that are used for managing extra furniture at showroom. Ultimately effective product presentation and customer satisfaction bring significant enhancement in revenue generation.



Fig. 17 An Expected view of projected virtual reality contents

This hypothetical study has conducted with keeping in mind the small business that mainly produced limited items of furniture. The small business owns a production house and an outlet in furniture market where it surrounds with giants competitors and their showrooms. As this study is hypothetical it is necessary to provide and generalized BPR implementation results so that any small-business could take this study advantages. Regarding BPR, some of findings are

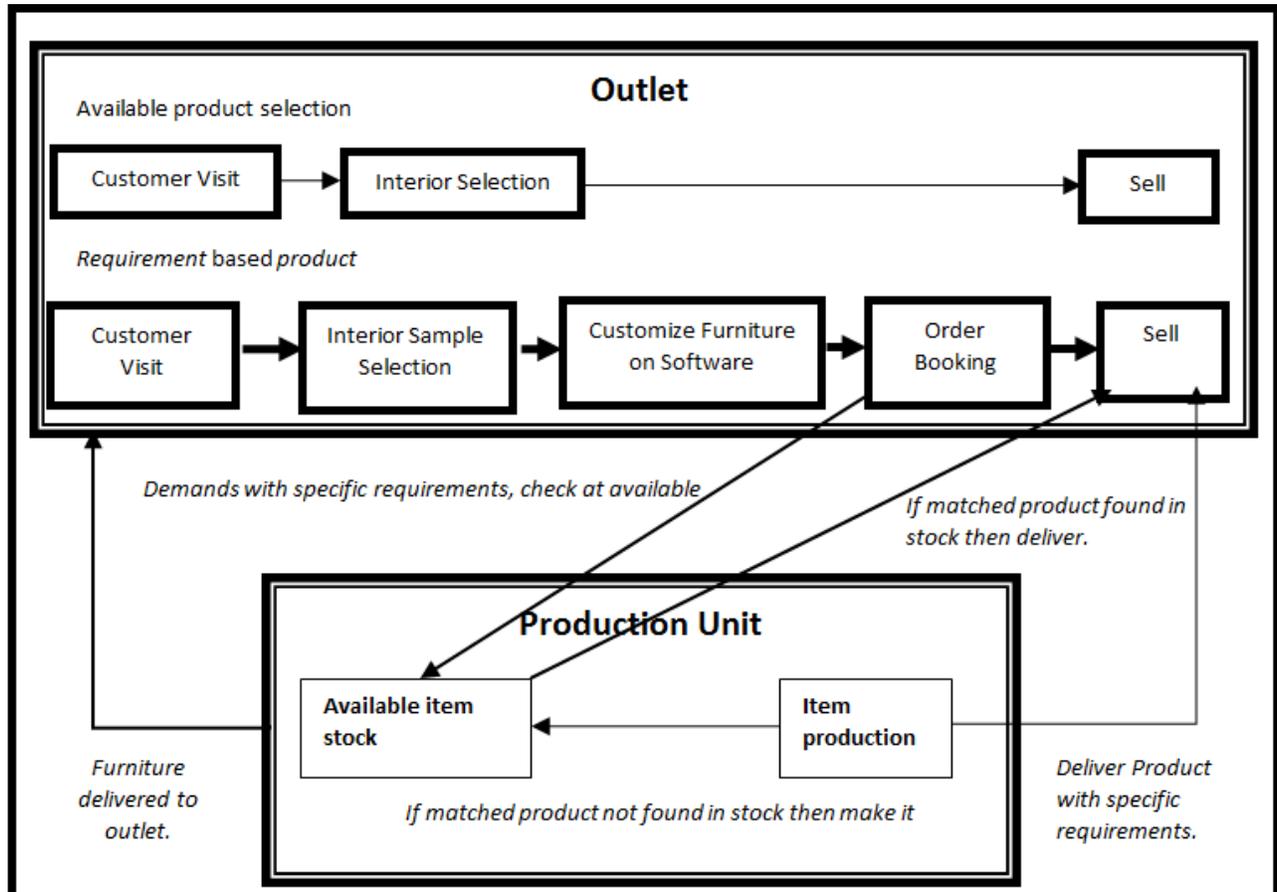


Fig. 18 Furniture Sale Cycle after BPR

worth to mention here. Some of the findings are already mentioned in different literature while some of the findings related to ImmersisVR and virtual products projection at showroom level are unique. Here are some of the general findings of the study:

- i. BPR has positive impact on small-business and it brings significant change in an organization.
- ii. BPR improves customer satisfaction.
- iii. BPR can handle versatile problems including area/location scarcity problem.
- iv. Change/Improvement in one business process can bring dramatic results.
- v. IT is critical enabler of BPR.
- vi. Simple IT intervention can play great role for business.
- vii. Modeling tools (3D studio max, Maya) and game engine (Unity3d) have great potential to help interior or furniture design companies in their business.
- viii. Large LCDs can handle location/area scarcity problems at showroom/outlets.
- ix. Projected virtual reality has enough potential to effectively visualize furniture items and attract customer.
- x. 3D software application along with projected reality system is new way to bring digitalization in conventional showrooms.

- xi. ImmersisVR is a suitable tool to digitalize conventional showrooms.
- xii. Furniture Showroom can easily adopt ImmersisVR for their showroom.
- xiii. Virtual reality project systems like ImmersisVR is most appropriate choice to digitalize showroom as it doesn't require any additional hardware to view virtual contents.
- xiv. Socialize able VR projection system is the future of future showroom design.

The 3D software application for furniture customization has played primary role to improve customer satisfaction and eliminate the poor consequences of space limitation at showrooms. Its intuitive mouse click based user interface provides real-time customization of the furniture objects. There are list of texture and color option have provided to customize any specific objects. This software application can also work with ImmersisVR and 3d scene of the application can also easily map into the front display of the furniture showroom where user can also experience real time customization result in 180 degree environment. Overall this digitalization at showroom brought significant improvements in the company through providing improved customer satisfaction along with effective products visualization. This hypothetical study results are also applicable to different kinds of showroom.

VI. CONCLUSION & FUTURE WORK

IT is the backbone of BPR and it has immense ability to tackle versatile problems and issues of small business. In this hypothetical study, virtual reality projection system has utilized to digitalized showrooms in order to solve customer satisfaction and limited space restriction problem in conventional furniture showrooms. ImmersisVR system deployment along with the proposed 3D-FC application will allow effective product presentation and better customer service with best customer satisfaction. In future, actual implementation require of the hypothetical study along with the ImmersisVR system deployment. A detail study can be carried out in the context to highlight projected virtual reality systems use at showroom level. Further, a universal frontend design of the showroom can be suggested for projected virtual reality system deployment as it is the future of showrooms and outlets.

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