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Tesis Doctoral

La escenografía virtual

(La influencia de las nuevas tecnologías en el Diseño de Interiores)

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A mi padre Adeeb y a mi madre Kawkab

A todos mis hermanos y hermanas

A toda mi familia tanto la jordana como la española

Por estar a mi lado siempre

A mi Directora Inmaculada por su apoyo

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Introducción

La propuesta del autor en el presente trabajo busca integrar diferentes disciplinas como el teatro, el cine, las artes plásticas, el diseño de interiores, la arquitectura y la publicidad, entre otras, todas ellas orientadas al desarrollo de los llamados "espacios arquitectónicos efímeros", partiendo de una base en la que convergen los conceptos de 'estructura', 'construcción' y 'comunicación', orientadas a la formación interdisciplinaria de profesionales que aporten soluciones universales a problemas específicos en el mundo del diseño de interiores. De este modo, el autor pretende con su propuesta establecer otros campos de integración en la concepción de nuevos espacios. Debemos tener en cuenta que la idea de asociar lo efímero con la arquitectura se atribuye a un hecho o situación que tiene por duración un breve espacio de tiempo, que no es permanente, pero lo efímero no se encuentra únicamente en la duración temporal sino en la idea de mutabilidad de adaptación y ligereza, multiplicidad de lecturas y capacidad de utilización diversa.

En esta línea, el estudio ofrece también en su parte introductoria una exposición de la evolución histórica del concepto de 'escenografía', desde sus inicios tradicionales pasando por la escenografía virtual y desembocando en las técnicas avanzadas a las que asistimos en la actualidad gracias a las nuevas tecnologías, las cuales han multiplicado las posibilidades técnicas y profesionales no solo en el mundo del diseño sino en múltiples ámbitos como la arquitectura, la publicidad o el cine, entre otros. Conceptos como 'realidad virtual'. 'realidad aumentada' o 'diseño 3D' ya forman parte de la rutina diaria del trabajo técnico y creativo de los profesionales en todos estos campos.

Asimismo, este estudio pretende ofrecer una reflexión prospectiva sobre cómo las técnicas virtuales en el mundo del diseño están cambiando

radicalmente la concepción tradicional del profesional del diseño (gráfico, comercial, interior, industrial, etc.) hacia un profesional capaz de responder a las exigencias de un mercado marcado cada vez más por la globalización y la innovación constante.

Otro de los objetivos de esta investigación es tratar un tema muy especializado de la práctica del uso de las nuevas tecnologías en el mundo de diseño de interiores como es la generación de escenografías virtuales. Se contemplan las posibilidades creativas de esta nueva utilidad tecnológica, con pocos años de desarrollo, definiendo los condicionantes económicos y las ventajas logísticas de producción. Su exhaustividad e interés científico puede comprobarse con algunas evidencias, en un orden determinado: Al principio, la metodología empleada tiene un carácter integrador y una ambición de triangulación y consiste en cuestionarios cuantitativos que se complementaron con entrevistas cualitativas en profundidad, a profesionales de este ámbito, especialmente a nivel autonómico. Todo ello se articula con una importante e inédita revisión bibliográfica sobre el tema.

En cuanto a la estructura del estudio, se encuentra ordenado y dividido de manera clara en los siguientes apartados: introducción, metodología, resultados, conclusiones y bibliografía, tal como es preceptivo en un artículo de exposición de resultados de investigación. En un principio, los contenidos se distribuyen de manera diacrónica por etapas en la exposición de la metodología seguida durante el estudio. Más tarde, el autor se adentró en la explicación exhaustiva por fases de trabajo de las posibilidades de la escenografía virtual en la preproducción, producción y postproducción de un proceso de diseño en el ámbito del diseño de interiores. Asimismo, durante todo el estudio se realizó una valiosa definición de términos, muy adecuada, siempre teniendo en cuenta la novedad y singularidad de la materia y su rápida transformación. Asimismo, los gráficos explicativos resultan un

elemento esclarecedor a la vez que resumen los contenidos escritos. Resulta interesante subrayar que las argumentaciones de base tecnológica no se producen como fines en sí mismas, sino que se enmarcan en un ámbito social y productivo, incidiendo en sus beneficios en relación al personal humano y a la logística de producción para la escenografía virtual.

Otra dificultad que encontramos a la hora de llevar a cabo este estudio y uno de los problemas principales en nuestro tema de investigación ha sido la escasa bibliografía. Cabe destacar que los artículos de los cuales disponemos sobre de este tema suelen ser en su gran mayoría en inglés, la traducción de éstos al español y aunque pocos, artículos del mismo tema escritos en lengua española como lengua original.

Entre los motivos que nos han estimulado para realizar este estudio ha sido la necesidad de comprender la impresión 3D como construcción aplicada en diferentes facetas del diseño, desde la producción de prototipos, modelo físico para la representación del diseño de interiores y la escenografía virtual, montajes de exposiciones, instalaciones artísticas, espectáculos u otros montajes de duración limitada. Del mismo modo, se pretende fortalecer el campo de acción con las tendencias actuales para incorporar, extender y renovar la actividad y la concepción profesional de esta especialidad.

Además, la presente investigación pretende aportar medios de conocimiento como técnicas constructivas, de comunicación y procesos creativos que permitan al profesional intervenir integralmente en un espacio determinado, así como estudiar tanto los problemas teóricos y creativos como los derivados de la gestión, producción y montaje de dichos ámbitos.

Debemos mencionar que el trabajo se apoyó en la técnica de observación documental. La escenografía virtual es una tecnología que apenas cuenta con poco más de una década de existencia. Por tanto, no se ha

estimado necesario llevar a cabo ningún tipo de discriminación temporal a la hora de realizar la selección bibliográfica.

El presente estudio puede ser útil para el equipo técnico de teatro y cine, diseñadores y creativos, directores de escena, empresas del sector, estudiantes de Bellas Artes y/o Escuelas de Artes y toda persona interesada en el diseño, creación y técnicas de la escenografía. Igualmente, está dirigido a arquitectos, diseñadores industriales, diseñadores gráficos o de interiores, publicistas, profesionales del arte y de la cultura, comunicadores o cuya profesión esté relacionada con la identidad corporativa, institucional, empresarial, técnica o con el área de diseño comercial.

Gracias a las técnicas y a los *softwares* de diseño virtual, los espacios irreales ya tienen una presencia considerable y cada vez mayor en numerosas industrias (videojuegos, cine, publicidad, etc.). No obstante, el uso de los espacios irreales en el mundo del diseño de interiores, comparado con otros campos, es muy limitado y sus posibilidades técnicas y creativas aún están siendo debatidas por los profesionales de la industria. Para dar respuesta a ello, el trabajo de campo propuesto por el autor estará dirigido a profundizar más en el uso de los espacios irreales en el campo de diseño de interiores y presentar una propuesta de trabajo real sobre cómo podemos 'convertir' estos espacios irreales en espacios reales a través de la técnica de impresión 3D, ya que se trata de una de las tendencias de mayor impacto en la actualidad en el diseño de interiores.

Metodología

La metodología de investigación seguida en esta tesis se divide en tres partes, aplicando una metodología específica para cada capítulo de la tesis doctoral debido a los diferentes temas del trabajo; presentar nuevas propuestas del uso de las tecnologías en el diseño de interiores y descubrir el impacto de las mismas tecnologías en dicho campo.

La metodología aplicada en el primer capítulo se basa en el estudio detallado de la cronología de la escenografía virtual y en la interpretación de casos de estudio analizando el mismo tema de investigación para finalmente presentar una propuesta de un nuevo uso de la escenografía virtual en el campo de diseño de interiores.

En el segundo capítulo la metodología utilizada es de tipo fenomenológica unida a la investigación documental, utilizando para ello entrevistas a profesores y profesionales del diseño de interiores, complementándolo con una investigación cuantitativa sobre una muestra de 30 estudiantes de primer año de master en diseño de interiores utilizando encuestas en papel completadas durante la clase para descubrir la influencia de la tecnología en el proceso del diseño, analizando el impacto de la tecnología durante el procedimiento.

Del mismo modo que en el primer capítulo, en el tercero llevamos a cabo una investigación en profundidad de los estudios anteriores realizados sobre espacios irreales e impresión 3D en el campo de diseño de interiores, y al final del capítulo se muestra una propuesta de nuevo uso de la impresión 3D para presentar los diseños al cliente.

Al observar la metodología utilizada globalmente, en lugar de separarla por capítulos, podemos concluir que para lograr el objetivo

dispuesto en la hipótesis se partió de un estudio del fenómeno a través de un método triangular en el que se combinan las siguientes técnicas de investigación: Investigación documental; investigación cualitativa basada en la observación y entrevistas en profundidad; e investigación cuantitativa de muestra pequeña basada en un cuestionario en papel.

Dentro de los casos de estudio hemos trabajado en los siguientes ámbitos:

-El trabajo del diseñador y el escenógrafo desde el concepto a la estrategia, centrándonos en la expresión gráfica y las ideas especiales. Estudiamos el diseño, la ambientación, la escenografía y la arquitectura. Nos hemos centrado en el proyecto y la planificación del mismo.

-Metodología y Análisis de la Dirección Artística, en el que nos centramos en la planificación y desarrollo de la dirección en el arte cinematográfica y el diseño de interiores. Para esto nos centramos en la interpretación del proyecto del director, y analizamos el proyecto cinematográfico, mediante el análisis del diseño artístico y la producción técnica.

-Técnicas escenográficas, en concreto aquellos procesos de los movimientos de la escenografía virtual y su aplicación. Estudiamos la formación teórica en los recursos técnicos del diseño de interiores y los condicionantes de su instalación. Por último, nos centramos en los requerimientos de representar un diseño de forma perfecta para asegurarnos de la posibilidad de percibir la idea del diseño tal y como es tanto para el cliente como el diseñador.

-Dibujo *CAD*, y el diseño asistido por ordenador (*AutoCAD*). Nos centramos en la creación y modificación de objetos, bloques, capas, trazados, y modelado en 3D (sólidos, superficies, modificación de sólidos y modelado). También estudiamos el uso de otros programas con la misma finalidad.

-Artes Decorativas y Ambientación. En este punto nos centramos en el mobiliario del siglo XX y las artes decorativas: madera, tejidos y otros; ergonomía y diseño ambiental. También estudiamos la influencia de las nuevas tecnologías en diseño de interiores y su impacto.

-Por último, asistimos a una serie de conferencias teórico-prácticas en las que sentar las bases del conocimiento necesario en este campo. A través de un intercambio de experiencias con especialistas en el tema, se hizo una aproximación a las nuevas tendencias de creación y producción, para llegar más adelante al reconocimiento del medio a través de actividades prácticas como visitas a diferentes estudios de diseño, talleres de fabricación de muebles y profesores de arquitectura y diseño de interiores.

Capítulo III

LA ESCENOGRAFÍA VIRTUAL: ORIGEN Y DESARROLLO

3.1. Introducción

3.1.1. Motivo y origen del trabajo

La presente investigación tiene como objetivo ofrecer al lector una síntesis de la evolución que a lo largo del tiempo ha experimentado la escenografía desde los inicios de la humanidad hasta la actualidad, dejando atrás el concepto tradicional de la escenografía –muy ligada al teatro desde sus inicios- y dando lugar a un nuevo concepto contemporáneo de la misma, con una infinidad de técnicas visuales que han constituido un amplio abanico de posibilidades artísticas y creativas en el mundo del diseño (el actual concepto de 'escenografía virtual o digital'). En la actualidad, y gracias a las nuevas tecnologías, estas técnicas fueron trasvasadas y plasmadas en múltiples terrenos como el cine, la animación, el diseño gráfico o el diseño de interiores.

Las innovaciones tecnológicas que se van sucediendo a un ritmo acelerado en la escenografía virtual cada vez tienen un mayor impacto en el mundo del diseño, lo cual ha hecho posible ofrecer unas imágenes con total naturalidad para el receptor, siendo éstas el resultado del tratamiento generado por un ordenador a partir de otras imágenes con un referente real (de ahí el concepto de 'realidad virtual').

Por otra parte, este trabajo es motivado por la ilusión y el entusiasmo del investigador en conocer más a fondo las diferentes etapas que la escenografía virtual como técnica visual ha experimentado a lo largo de la historia, desde sus orígenes rudimentarios y tradicionales hasta llegar a ser concebida en la actualidad como un pilar básico y fundamental como

herramienta creativa en el diseño de interiores, con una infinidad de aplicaciones y vertientes, como es por ejemplo el diseño 3D.

3.1.2. Estructura de la exposición

El presente trabajo constará de cuatro partes bien diferenciadas:
En la parte introductoria de la investigación, el autor comenzará con el análisis de los elementos característicos de la escenografía tradicional, con la exposición de sus inicios y su desarrollo. Partiendo inicialmente desde la civilización griega con los rituales y las ceremonias religiosas al aire libre como antecedente directo de la aparición de los primeros teatros en Grecia, pasando por el Renacimiento y la emergencia del concepto de *escenotecnia* y la edificación de espacios adaptados al espectáculo (anfiteatros, circos, etc.), hasta llegar a la máxima expresión de la escenografía tradicional durante la época barroca, con el llamado *teatro a la italiana* (o *sala a la italiana*). Posteriormente, el investigador procederá a exponer los orígenes de la escenografía virtual y los aspectos heredados de la escenografía tradicional. Asimismo, resultará de máxima importancia analizar y describir las técnicas más influyentes de la escenografía virtual en el diseño de interiores, especialmente la técnica del *Chroma Key* o 'llave de color' y la técnica de *Matte Painting* o 'montaje digital de imágenes'.

Ambas técnicas representan, desde una perspectiva metodológica, los pilares principales del presente trabajo de investigación, ya que la propuesta metodológica del autor se sustentará en la aplicación y el trabajo de campo que realizará en base a las mismas en su campo de especialidad, el diseño de interiores.

A continuación, el autor destinará la segunda parte de la investigación para la exposición y descripción de los objetivos perseguidos y los límites de la misma, así como de las herramientas metodológicas que se van a aplicar y las fases de su desarrollo.

La tercera parte de la investigación estará conformada por el desarrollo práctico de la metodología propuesta por el investigador, a través de la exposición de varias herramientas prácticas empleadas, como el trabajo de campo realizado mediante las técnicas de escenografía virtual aplicadas -como la realidad aumentada o el montaje digital de imágenes- o las entrevistas realizadas a expertos en el campo del diseño.

La cuarta y última parte será destinada para la exposición de los resultados de la investigación, antes de emitir las conclusiones finales de la misma y, finalmente, formular las recomendaciones pertinentes para futuras investigaciones a través de un análisis prospectivo de las tendencias en la aplicación de las técnicas de realidad aumentada y virtual en el campo del diseño de interiores.

3.2 Escenografía virtual: Origen y desarrollo

3.2.1. Escenografía tradicional

3.2.1.1. Definición

Partiendo desde una definición técnica elemental y básica del concepto de *escenografía*, podemos adoptar la definición más amplia y generalista de la técnica como "el conjunto de todos los elementos visuales que conforman una escenificación, sean corpóreos (decorado, accesorios), la iluminación o la caracterización de los personajes (vestuario, maquillaje, peluquería); ya sea la escenificación destinada a representación en vivo (teatro, danza), cinematográfica, audiovisual, expositiva o destinada a otros acontecimientos". (Rojas y Benítez, 2010:33) [1].

Desde el punto de vista etimológico, la *skenographia* para los griegos era el arte de describir y ordenar el teatro (*skene*, escena - *graphoo*, describir) y la evolución histórica del teatro llevará a relacionarla, concretamente, con la perspectiva y la pintura como maneras capaces de representar espacios, por lo que la concepción de escenografía se limitó a cumplir la función de decorado, al menos en los inicios del teatro en Grecia.

No obstante, esta definición no podría ser aplicada en términos absolutos, ya que cada escenógrafo adoptará según su perspectiva de la escenografía y los elementos técnicos y visuales que emplea una concepción particular de la misma.

Los espectáculos en las civilizaciones que se han sucedido a lo largo de la historia se iniciaron al aire libre, siendo las representaciones con rituales y ceremonias básicamente de índole religiosa el origen de estos espectáculos.

[1] Rojas, M. Á., & Benítez, L. M. T. (2010). *El Cine en la escuela como recurso en el área de Educación Visual: Aspectos educativos y actividades para su desarrollo en la ESO*. Wanceulen Educación.

Con la diversificación de las representaciones y sus medios de expresión (teatro, cine, televisión, animación, etc.) surgió la necesidad de adaptar y habilitar determinados espacios preexistentes, o el diseño de nuevos espacios que hagan que su puesta en escena se desarrolle de un modo óptimo, respondiendo de este modo a las exigencias del receptor.

Partiendo de esta idea el espacio escénico se consagra como el espacio definitivo en el éxito del espectáculo, resultado de la interacción simultánea de todos los elementos que lo componen, como la escenografía, el escenario, el auditorio y los elementos escenotécnicos.

Autores como María Bobes distinguen entre cuatro tipologías de espacios escénicos según su vinculación con el escenario, la obra, los actores o los elementos que conforman el escenario[2]:

Espacios Dramáticos: Espacios que crean el drama para situar a los personajes.

Espacios Lúdicos: Espacios creados por los actores, con sus movimientos en el escenario y las distancias que mantienen entre ellos.

Espacios Escenográficos: Espacios que reproducen los espacios dramáticos en el escenario a través de la decoración.

Espacios Escénicos: Espacio físico donde se representan los otros espacios.

Así pues, podríamos definir el espacio escénico como el recinto arquitectónico físico que hace posible el desarrollo de las representaciones de los demás espacios (dramático, lúdico y escenográfico).

[2] Troc Moraga, R. D. (2005). Escenografía teatral y posmodernidad. Aproximaciones para un estatuto estético de la escenografía.

Por lo tanto, debemos distinguir entre este concepto 'físico' del espacio escénico y el concepto de espacio escenográfico, siendo el espacio escenográfico o escenografía el constituido por todos los elementos creados al margen del espacio escénico, con el fin de conceptuar una representación específica a través de una colocación óptima de todos estos elementos o decorados dentro del espacio escénico.

En otras palabras, el espacio escénico y el espacio escenográfico (o escenografía) representan las coordenadas espacio-temporales del espectáculo[3] (Prenz, 2006:891).

3.2.1.2. Breve historia de la escenografía tradicional

A lo largo de este epígrafe el autor pretende profundizar sobre los orígenes de la escenografía tradicional como precursora de la escenografía virtual (o digital), siendo considerada esta última el máximo exponente de la innovación técnica y creativa de la escenografía aplicada al diseño de interiores, objeto de esta investigación.

Para poder comprender de una manera óptima la escenografía virtual de la actualidad es necesario definir y analizar la evolución de la escenografía a lo largo de la historia.

Al hablar de la historia de la escenografía se suele comenzar cronológicamente en Grecia, siendo los griegos protagonistas los primeros intentos para adaptar los espacios escénicos para ambientar las actuaciones en los teatros, como un paso adelante respecto a las ceremonias y los rituales

[3] Prenz, A. C. (2006). Cervantes entre preceptiva y espectacularidad dramática. *El Quijote en Buenos Aires*, 887-892.

religiosos que se representaban al aire libre en Occidente, que carecían de decorados y de estructuras diseñadas y colocadas en el espacio escénico para fines específicos en las representaciones.

Posteriormente, en el Renacimiento, el mismo método se convirtió en una técnica para dibujar y pintar un telón de fondo de perspectiva, resultando el descubrimiento de la perspectiva en la pintura un factor crucial en el desarrollo de las dimensiones espacio-temporales en el trabajo escenográfico. Este hallazgo hizo posible representar las tres dimensiones en una sola superficie y, desde entonces, los escenógrafos (o pintores) hallaron de este modo una solución técnica para representar sus cuadritos en escena, y recurrieron a esta técnica también para conseguir el efecto visual de lejanía[4].

Las avanzadas técnicas escenográficas virtuales o digitales a las que asistimos en la actualidad (en el cine, el diseño gráfico, etc.) no pueden ser comprendidas sin el análisis de sus raíces, primero en la escenografía tradicional y después con las sucesivas innovaciones técnicas y tecnológicas que se han ido incorporando con el tiempo al espacio escenográfico.

Las primeras obras sobre escenografía, teatro o espacios escénicos destacaron en la historia de la escenografía tradicional la figura del sacerdote, considerándole el primer actor en la historia del teatro, y a quien correspondía el papel de reencarnar al dios en su labor de enseñar e inculcar los cultos y los mitos.

De este modo, al disfraz y a la mímica que progresivamente ha creado el hombre en sus ceremonias religiosas, y más tarde con el poema, el canto o la danza, con la incorporación de la figura del sacerdote se incorporan el

[4] Correa, A. B. (2014). La perspectiva. El territorio y la escenografía renacentista en Maquiavelo. *Boletín de arte*, (35), 27-41.

decorado, el diálogo y la acción al teatro. De esta manera se consumaron todos los elementos de expresión del teatro en Grecia.

Por otra parte, la antigua escena en las representaciones en la India presentaba unas características muy primitivas: Una cortina formaba el fondo del escenario a lo largo del desarrollo de toda la representación; detrás de la misma se situaban los actores que, mientras no actuaban, se cambiaban de vestuario. Se trataba de un teatro primitivo que no contaba con bastidores ni tampoco decorados[5].

Se trataba de una especie de 'teatro mudo' en el que los actores, a través de gestos y murmullos, dejaban a la imaginación del espectador la tarea de completar a través del escenario y la actuación el mensaje de la representación. Los personajes trasportaban a través de su acción a los espectadores a los lugares más apartados, transmitiendo una nueva dimensión espacial a la percepción de los receptores.

Sin embargo, fue en el antiguo Egipto que se puede hablar del origen del arte de la escenografía propiamente dicha (2000 años a. de C.) incluso antes de los elementos que constituyeron el teatro en el Antiguo Egipto, siendo los egipcios los pioneros en el uso de telas blancas y transparentes, tanto para la ambientación y decoración como para la actuación de las danzarinas en las celebraciones (López, Dupey y Nardi, 1976:7)[6].

[5] Teatro, escenografía, espacios escénicos, historia. 2.0, https://docs.google.com/document/d/1Ik0PGzqNDvC7Fio2kE1EpNWNS-5mc-lOOWVa2tsm5vo/edit?pli=1

[6] López, D., Dupey, A. M., & Nardi, R. L. (1976). *Arte popular argentino: pueblos, hombres y formas en el arte*. Centro Editor de América Latina.

3.2.1.3. La innovación en la escenografía tradicional

Si bien consideramos el teatro griego como el más antiguo y el origen de la escenografía tradicional en los teatros, ciertamente podemos admitir que la mayoría de los elementos que caracterizan a la escenografía virtual de la actualidad tienen sus raíces en el teatro griego y, por ende, en la escenografía tradicional.

Francisco Nieva, en su extensa obra *Tratado de escenografía,* nos ofrece una síntesis de los avances que se dieron en las representaciones teatrales en Grecia, con la incorporación de estructuras técnicas y arquitectónicas que han resultado decisivas en el desarrollo de la nueva concepción del espacio escénico (físico), así como en la remodelación definitiva de la escenografía a través del decorado y la maquinaria:

"El decorado teatral vino a precisar, desde los tiempos de Esquilo, el lugar de la acción. Se trataba de un decorado muy convencional, según puede suponerse, pero cuyos vivos colores sugerían poderosamente a la suntuosidad o la pobreza, la alegría o el dolor. Al telón del fondo se añadían los ya citados *periactes*, que erigían sus prismas triangulares en los dos extremos del *logeion* y giraban sobre sus ejes para presentar, según las necesidades de la presentación, los tableros dibujados en cada una de sus caras, proporcionando también entradas laterales a los actores, además de las puertas centrales de la *skene*, cuando la acción del drama lo requería….La maquinaria era un complemento obligado en el logro de las emociones, existiendo una gran variedad de aparatos, como lo llamada *equiclema*, plataforma rodante cargada de personajes que, surgiendo de una puerta, revelaba a los ojos de los espectadores complacientes la escenas que iban a desarrollarse al abrigo de los muros; la polea, que colgaba de la *skene* y que servía para levantar por los aires, en el extremo de una cuerda, a los dioses y a

los héroes. Los *Belerofontes* y los Perseos que, prodigiosamente, aparecían sobre carros o grifos alados; el *teologeion*, en la parte alta, desde donde hablaban los personajes divinos, la *distegia* que simulaba las torres o baluartes desde donde se oteaba y se combatía y la escalera de Caronte, que hacía surgir de los infiernos los fantasmas de los muertos. Más tarde, como accesorios decorativos, figuraron, junto a los ya citados, altares, tumbas, estatuas de dioses y rocas; y luego añadieron muros, atalayas y faros. Se llegó hasta a contar con una maquinaria escénica para simular truenos y relámpagos, así como escotillones y fosos" [7] (Nieva, 2000:21).

El teatro en Grecia nace con los llamados *Ditirambo*, una especie de rituales y bailes que se celebraban en las afueras de las zonas pobladas, en honor a Dionisos[8] (Moreno Tejada, 2015:4). La construcción de las primeras escenas (*skené*) se inicia en las "*Grandes Dionisiacas*", que más tarde adquirieron una dimensión más amplia con la creación de las *oschestras*, un terreno circular de tierra lisa y compacta, con altar en su área central y un coro. Más adelante, se edificaron estructuras contiguas de madera donde se situaban los vestidores y con gradas para la situación del público.

El altar situado en la parte central de la orchestra, con la evolución de los géneros en el teatro griego (sátira, tragedia y comedia), fue disminuyendo hasta separarse definitivamente de la orchestra, quedando ésta usada de manera exclusiva para el coro.

En cuanto a la acción, se construyeron para las representaciones los *proskenion*, una especie de escenarios elevados que junto a las *skené* destinadas

[7] Nieva, F. (2000). *Tratado de escenografía* (Vol. 123). Editorial Fundamentos.

[8] Moreno Tejada, J. P. (2015). *Producción teatral: una mirada reflexiva desde el sector del teatro alternativo [recurso electrónico]* (Doctoral dissertation).

para que los actores cambiasen de atuendo, dieron origen a los primeros teatros griegos, los *Thetaron* o anfiteatros.

Los griegos adoptaron una perspectiva democrática en lo que se refiere a la construcción de los anfiteatros, de manera que se permita a todo el público escuchar y ver la representación sea cual sea su ubicación. Los asientos se colocaban en una especie de graderías semicirculares denominadas *Koilon.* La orchestra se situaba en frente de las graderías para el coro. Adyacentemente, se contruyó la *skené* (escena) con forma rectangular, dividiéndose en dos partes; por un lado, el *proskenion* o la escena propiamente dicha destinada a la actuación de los actores y, por otra parte, los compartimentos o habitaciones que se ubicaban detrás del proskenion y que ocultaban a los actores del público, las denominadas *skené* [9].

En un primer momento, la skené consistía en una especie de muro con apenas decoraciones dentro del espacio escénico. Durante la época de Esquilo se colocaron unos telones de fondo con soportes en las partes laterales del proskenion y que resultaron decisivos en la decoración y la ambientación escenográfica en Grecia, los llamados *periactos.* Más adelante, para la representación del Monte Olimpo se construyeron unas elevadas plataformas equipadas con escaleras, escotillas, etc. además de otras plataformas móviles que servían para hacer volar a los actores durante la actuación (todo ello en la época de Eurípides) [10].

La maquinaria en la reconstrucción escénica también experimentó un gran desarrollo en esta época, apareciendo las primeras grúas que permitían

[9] Vassilantonopoulos, S. L., & Mourjopoulos, J. N. (2003). A study of ancient Greek and Roman theater acoustics. *Acta Acustica united with Acustica*, *89*(1), 123-136.

[10] Patterson, J. A. (1972). Some problems of the theatre at Epidaurus. *Communication Studies*, *23*(2), 100-108.

que los actores apareciesen y desapareciesen del escenario; plataformas o soportes giratorios que habilitaban el cambio rápido del decorado; la construcción subterránea de escaleras que ayudaban a que los actores apareciesen en escena de un modo más ágil, o púlpitos elevados para la representación de los dioses.

Los decorados estaban formados, principalmente, por los *periactos* (prismas rectos triangulares, cubiertos de telas pintadas) y por cortinas pintadas que aparecían en la parte delantera del *proscenium*, o delante del *frons scenae*. El cielorraso del *proscenium* permitía un sistema de enganches y de maquinarias, con tornos y poleas, para maniobrar los telones dispuestos en el fondo.

Las maniobras con el telón ubicado delante del *proscenium* podían ser hidráulicas muchas ruinas de teatro, entre ellas las de *Vasion-* la *romaine* y la de Alba, muestran una suerte de trinchera en la *orchestra*, al pie del *proscenium*. Ligado mediante un sistema de válvulas a un curso de agua, la trinchera podía estar vacía – y, en este caso disimulaba la cortina montada sobre el bastidor de madera – o llena de petición: el bastidor se elevaba entonces a la vista de todos, al mismo tiempo que iba subiendo el nivel del agua (Surgers, 2005:24)[11].

[11] Surgers, A. (2005). Escenografías del teatro occidental. Artes del Sur.

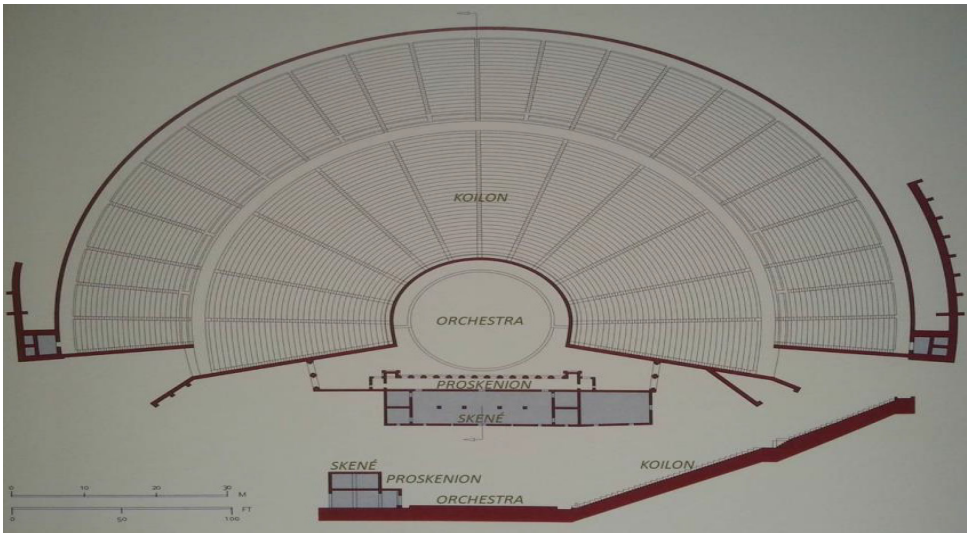

Fig.1. Teatro de Epidauro, máximo exponente del teatro griego. Tomada de Stierlin, Henry, Grecia de Mecenas Al Partenón, Editorial Taschen, 2004, e intervenida por el autor.

3.2.1.4. Escenografía en Roma: Los ludi espacios

En Roma la escenografía da un gran salto de innovación, aunque se partió principalmente de la base arquitectónica heredada del teatro griego. En Roma el teatro se concibe y se afianza como un medio de expresión destinado mayormente al entretenimiento de las masas.

Las representaciones teatrales no tenían lugar en espacios exclusivos, sino que los personajes actuaban en los llamados 'juegos escénicos' en una especie de tablado –inicialmente de madera y después de piedra- y se trataba de una estructura provisional. Los elementos que formaban el decorado se colocaban en unas puertas que se ubicaban en la parte frontal de la construcción, las llamadas '*scaenae frons*'.

Los primeros teatros en Roma destacaban por el diseño semicircular del espacio de la orquesta, a diferencia del teatro griego que se caracterizaba por una forma totalmente circular. De este modo los romanos consiguen que

la escena se aproxime de forma muy considerable al *cavea* o auditorio (Oliva y Torres-Monreal, 1997:30) [12].

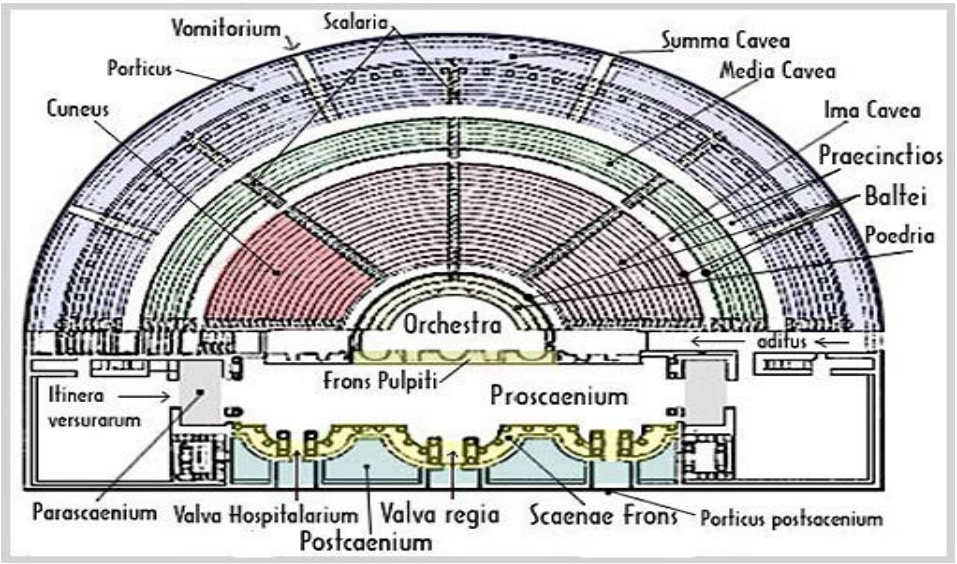

Fig.2. Estructura del teatro romano.
Fuente:http://www.malagahistoria.com/malagahistoria/teatro_romano_malaga.html

Además, los teatros romanos estaban construidos sobre sus propios cimientos, a diferencia de los teatros griegos que se basaban en obras de tierra o a través de la remodelación de una colina, siendo también unos espacios aislados totalmente por todos los lados.

Debido a que las primeras representaciones se desarrollaban al aire libre, se dieron inicialmente varios problemas en lo que se refiere a la iluminación y al sonido. Para ello los romanos recurrieron a un método más integrado en la construcción de los teatros, levantando toda su estructura del suelo y llegando a construir teatros incluso en llanuras planas. Como resultado, toda la estructura y todas las salidas y entradas podían estar integradas dentro de una especie de cueva, al estilo de los grandes teatros y estadios deportivos de la actualidad.

[12] Oliva, C. y T. M. Francisco (1997). *Historia básica del arte escénico.*

De este modo los romanos lograron crear unos teatros con un ambiente aislado para atraer más la atención del espectador y para evitar los ruidos provenientes de la ciudad. Las lonas fueron adaptadas para crear una sombra en la parte superior del teatro.

En cuanto a las propias representaciones, y para evitar confusiones para el público, se diseñaron máscaras y trajes con el objetivo de mostrar los personajes con más claridad en el escenario, elaborándose con diferentes símbolos. Los actores llevaban máscaras de color marrón para los hombres, blancas para las mujeres, sonrientes o tristes dependiendo del tipo de juego.

Los trajes por su parte mostraban al público de un modo más claro los personajes facilitando su identificación (un vestido morado para un hombre rico, una toga con bandas para un niño, un manto corto para un soldado, una toga roja para un hombre pobre, una túnica corta para un esclavo etc.).

Las mujeres no podían actuar, por lo que sus partes fueron interpretadas normalmente hombres o niños, siempre con una máscara blanca. Los actores intentaban ganarse los elogios del público presente a través de máscaras con decorados llamativos, disfraces e incluso bailes.

Algunas interpretaciones de los personajes fueron representadas por una serie de gestos perfectamente reconocidos por el público, acompañados de una música de fondo (por ejemplo, tomar el pulso a un enfermo al mismo tiempo que del fondo del escenario provenía una música de suspense o tensión).

No obstante, cabe señalar que la mayoría de estos juegos carecía totalmente de instrucciones de puesta en escena, al contrario de lo que ocurría en el teatro griego, donde la puesta en escena y las instrucciones eran cuestiones fundamentales y estrictas durante las representaciones de la época.

3.2.1.5. Escenografía en el teatro medieval

El culto religioso impera en el teatro durante la época medieval. Los diálogos cortos que eran realizados por los clérigos (los *tropos*) servían para la representación de escenas basadas en la Biblia en el interior de las iglesias.

Las escenificaciones de carácter menos religioso también tuvieron cabida en la Iglesia, con representaciones sobre los milagros de la Virgen María o los milagros de los santos; estas representaciones recibían el nombre de *milagros*. En siglo XVI se desarrollan en Francia los denominados *misterios* (siglos XIII-XVI), cuando la corriente laica de hace cargo de las representaciones dramáticas de la Iglesia y las mezcla con la tradición festiva popular. Surgen las farsas y otras nuevas formas teatrales basadas en el entretenimiento, la diversión y la comicidad, lo cual contribuyó definitivamente a la reinstauración del arte teatral como un elemento sociocultural de suma importancia [13] (Massip, 1992:15).

Durante la etapa medieval los elementos que constituían el drama resurgen con el cristianismo, y la misa adquirió un carácter dramático a través de los *oficios.* En las representaciones de la época los argumentos desarrollan sus elementos expresivos a través de la palabra, los decorados, la iluminación, el canto o los accesorios, entre otros.

Tanto el antiguo teatro romano como el griego no transfirieron al teatro medieval ninguna tradición en lo que se refiere a la dramática. En este nuevo panorama la Iglesia instaura en el teatro un nuevo sentido y una nueva concepción; en las misas se amplió la liturgia mediante la introducción de diálogos procedentes de las Santas Escrituras o de representaciones de carácter mímico.

[13] Massip, J. F. (1992). *El teatro medieval: voz de la divinidad, cuerpo de histrión* (Vol. 59). Editorial Montesinos.

De este modo, se puede afirmar que todos estos cambios en la concepción del teatro supusieron definitivamente el nacimiento del teatro moderno propiamente dicho. El coro se convirtió en el espacio más habitual de la acción, y las naves y las arcadas en los conventos se destinaron para la organización de los cortejos o las procesiones.

Por otro lado, las escenificaciones en la época fueron complicándose, y las naves presenciaron sucesivas modificaciones en lo que se refiere las estructuras ligeras y los muebles. El drama en las abadías se desarrolló sin ningún tipo de restricciones, sin notables cambios en lo que se refiere al vestuario, que en gran medida seguía siendo el eclesiástico. En el caso de los accesorios, y a pesar de los modestos recursos que se disponían para la animación de aquellos escenarios, sí que se incorporaron numerosos medios.

En el teatro medieval los temas fueron muy similares, sobre todo a partir del siglo X. Las representaciones teatrales de la época por lo general se basaban en los pasajes y las temáticas del Nuevo Testamento.

Con el objetivo de ayudar a una mejor comprensión del drama litúrgico, se llevaba a cabo una puesta en escena casi improvisada y simultánea, en la que el coro, el altar o la distribución espacial de los sillones representaban distintos espacios en la acción. De estas escenificaciones derivaban “milagros y misterios”, los cuales eran representaciones totalmente inspiradas y basadas en la Biblia y los Evangelios y que continuaron su desarrollo en el seno de las iglesias.

Cabe destacar que, a pesar de que las representaciones teatrales tenían lugar inicialmente en el interior de la Iglesia, algunas técnicas escenográficas experimentaron un desarrollo notable[14] (Valls, 1990:19):

Las *mangranas* o simplemente 'granadas', empleadas para la apertura proporcional a partir de un eje central de determinadas figuras del espacio escénico.

La denominada *arca del cielo* o araceli, una técnica basada en un sistema de poleas y cuerdas y que se empleaba como ascensor. Funcionaba para permitir la subida y la bajada de una plataforma desde la cúpula central de las iglesias.

Tanto la granada como el araceli supusieron una gran novedad en la escenografía en el teatro de la Baja Edad Media, entre los siglos XI y XV. Ambas técnicas compensaban el eje escenográfico horizontal en las representaciones, descrito por la larga pasarela que recorría el espacio desde la puerta de la iglesia y que daba entrada a los actores hasta la plataforma del eje central, situada justamente bajo la bóveda, de modo que indicaban un nivel vertical marcado por el eje de descenso y ascenso de dichos artefactos.

Respecto a la figuración de los espacios escénicos y los elementos de la representación, éstos estaban representados por el propio templo y dotados de un carácter simbólico. La tarea de introducir nuevos elementos y accesorios para la figuración dentro del espacio escénico no resultaba fácil; sin embargo, determinadas representaciones dieron entrada a algunas figuraciones rudimentarias.

[14] Valls, T. F. (1990). El espectáculo profano en la Edad Media: espacio escénico y escenografía. *Historias y ficciones (Coloquio sobre la literatura del siglo XV). Actas del Coloquio celebrado en Valencia*, 309.

Con la evolución de la escritura, la necesidad de diversificar los espacios escénicos y de innovar en la caracterización de los personajes, el decorado experimenta paralelamente un desarrollo importante durante la Baja Edad Media.

Para los efectos de iluminación, se empleaban algunos objetos que reflejaban dorados o a través de llamas. El día y la noche se representaban mediante los colores blanco y negro, respectivamente. Se diseñaron máquinas específicas para la emisión de sonidos y ruidos (lluvia, tempestades, truenos, etc.). El tablado disponía de una especie de trampillas que permitían apariciones y desapariciones súbitas de los personajes en el escenario.

En cuanto a la escenografía, la etapa medieval se caracterizó por dos tipologías de escenarios: La llamada 'carreta-escenario', que permitía mostrar a los espectadores los distintos lugares en que se desarrollaba la acción. Se trata de un escenario con una decoración en forma circular y se considera el precursor de las modernas escenas giratorias. Este escenario se situaba en la parte superior, con un espacio ocultado detrás de una cortina, donde en la parte inferior los actores se cambiaban de vestimenta.

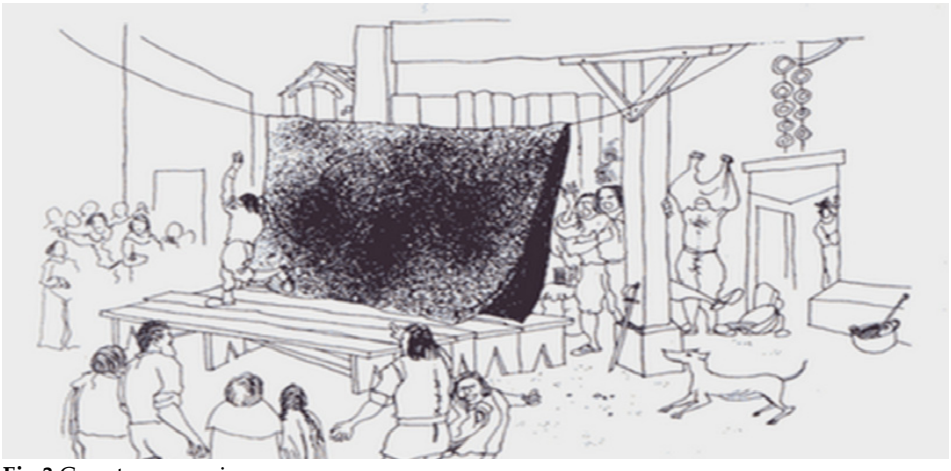

Fig.3. Carreta-escenario.
Fuente: http://teatropordentro.blogspot.com.es/2013/11/escenografia-v.html

Más frecuente fue el escenario simultáneo, una tramoya desmontable que se levantaba en las plazas. Este escenario permitía representar todos los espacios de la acción a través de elementos simbólicos y rápidas secuencias, lo cual permitía a los espectadores seguir el curso de la acción sin que medien interrupciones.

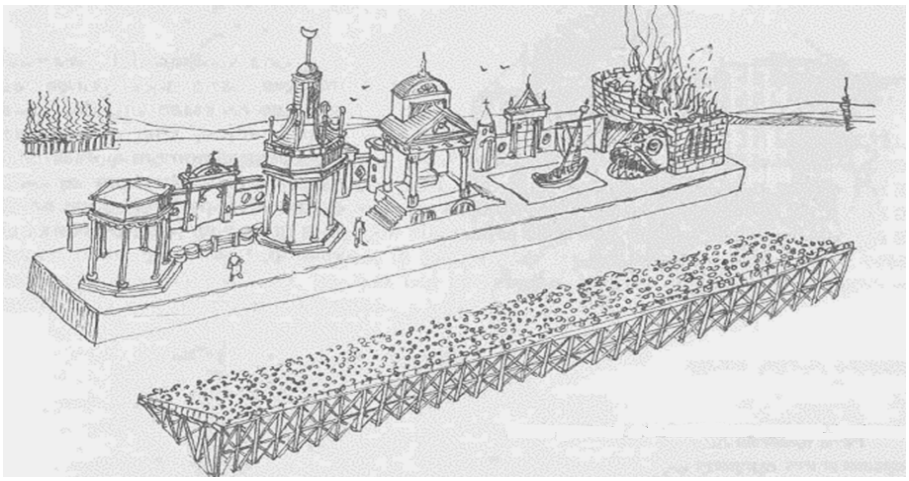

Fig.4. Escenario múltiple simultáneo. Vista general de escenario horizontal.
Fuente: http://teatropordentro.blogspot.com.es/2013/11/escenografia-v.html

3.2.1.6. Escenografía renacentista

Durante el Renacimiento (siglo XV-XVI) se empiezan a construir los primeros teatros cubiertos y destinados al desarrollo de las representaciones de forma exclusiva.

Asistimos durante la época renacentista a un panorama diferente, y en el que los escenarios son totalmente nuevos: las nuevas obras de la época exigían escenarios adaptados, representadas en su mayoría en los patios de los palacios y en las academias; sin embargo, todos ellos se basaron espacialmente en la distribución de los teatros clásicos (por ejemplo, el teatro diseñado por Andrea Palladio en 1580 para la Academia Olímpica de Vicenza). Fue de mano de Ariosto que se construyó el teatro cubierto de

Parma (Ferrara), con una capacidad para catorce mil espectadores, empleando una perspectiva lineal.

Fig.5. Teatro Olímpico de Vicenza, diseñado por Andrea Palladio.
Fuente: http://hombredepalo.com/la-ilusion-ilustrada-teatro-olimpico-vicenza-sabbioneta

Tomamos también el teatro de Sebastian Serlio (1475-1554) como un referente muy importante de la época renacentista (Gould, 1962:58): El teatro se situaba en la plaza pública de Vicenza, conformado por dos partes bien diferenciadas: una en la que se encontraba la dirección propiamente dicha, y la otra empleada como escenario. El escenario estaba diseñado en dos planos; el primero, totalmente horizontal, presentaba una elevación del suelo de 1,10 metros, destinado a la acción de bailarines y actores; el segundo plano iba inclinado y, a partir de un determinado nivel, el suelo se elevaba hasta el último término[15].

Francisco Nieva describe más detalladamente la decoración típica en los teatros renacentistas[16]:

[15] Gould, C. (1962). Sebastiano Serlio and Venetian Painting. *Journal of the Warburg and Courtauld Institutes*, *25*(1/2), 56-64.

[16] Nieva, F. (2000). *Tratado de escenografía* (Vol. 123). Editorial Fundamentos.

"La decoración se montaba en esta tarima inclinada con edificios y campiñas vistos en pronunciado escorzo, dando una sensación de alejamiento. El cerramiento final, situado delante del muro posterior de toda la construcción, era un telón pintado que dejaba a ambos lados un pasillo para entrada de actores. De este modo se obtenía un efecto escenográfico bastante acorde con la realidad. El teatro- tipo más perfecto de este estilo fue el teatro Olímpico de Vicenza" (Nieva, 2000:41).

La concepción del "espacio sistemático" del Renacimiento se evidencia primordialmente en los suelos de baldosas, continuos y convergentes bajo los cuerpos, componiendo un sistema de coordenadas en el espacio que traduce la distancia entre cosas y personas, y estableciendo la construcción de la perspectiva.

López Baltés, en su comentario sobre la obra de Santiago Vila "*La Escenografía, Cine y arquitectura*" (1997), apunta la consolidación de la escenografía durante esta época como arte y ciencia del espacio escénico[17]:

"La escenografía, en efecto, ha dejado de ser la mera necesidad de pintar decorados; ha adquirido una entidad propia y se ha convertido en el arte y la ciencia del espacio escénico, especializándose en la creación y construcción de dicho espacio. Se trata de un elemento esencial de la puesta en escena, capaz de definir, modificar o connotar por sí mismo los mensajes insertos y derivados de la representación teatral. Los postulados de la escenografía mantienen importantes vínculos y asociaciones, obviamente, con las formas arquitectónicas y sus significados, habiéndose desarrollado históricamente en el ámbito teatral y, durante el último siglo, en el cinematográfico. Este es precisamente el objeto de un estudio que, por tratar

[17] Baltés, B. L. (1998). VILA, SANTIAGO, La escenografía. Cine y arquitectura. *Historia y Comunicación Social*, (3), 487.

del sentido y la significación de las formas, continúa alimentando la tan controvertida e íntima relación entre forma y contenido. Una interesante llamada de atención sobre la escenografía, uno de los pilares de la comunicación audiovisual, así como uno de los sectores más florecientes e innovadores del teatro en la actualidad" (López Baltés, 1998:487).

Es en el Renacimiento cuando podemos afirmar que surgen las llamadas 'perspectivas escenográficas', precursoras de la amplia concepción contemporánea -y actual- de la escenografía: el decorado en perspectiva en el teatro renacentista supone un paso de suma importancia para consolidar las bases de la escenografía. A partir del siglo XVI se comienzan a pintar los telones actuando de fondo y separando claramente el escenario del graderío, dispuesto en forma de anfiteatro.

Todo ello ha sido posible gracias al redescubrimiento de la perspectiva lineal en la escenografía teatral, en la Italia del siglo XV. La perspectiva, junto con la maquinaria de efecto y la ampliación del espacio proscenio –el espacio del escenario más próximo al público- sentaron definitivamente los pilares de la concepción contemporánea y actual de la escenografía, por lo menos en el ámbito del teatro[18].

Además, esta nueva manera de llevar a cabo la escenografía originó grandes novedades en la percepción de los espectadores que asistían a las obras de la época, lo cual sirvió en gran medida en el desarrollo del sentido crítico del público.

Por otro lado, las escrituras y los géneros teatrales durante el Renacimiento experimentaron un auge decisivo gracias a todas estas

[18] Murcia, F. (2002). La escenografía en el cine: el arte de la apariencia. Sociedad General de Autores de España.

innovaciones escenográficas y las facilidades que permitían para la creación de escenarios sugestivos para el público.

Sin embargo, en la actualidad esta concepción se ha visto ampliada y trasvasada a múltiples ámbitos gracias a los avances tecnológicos y las aplicaciones virtuales y digitales de la perspectiva, como en el cine, la animación, la industria del videojuego o el diseño de exteriores, entre otros.

Por ende, estamos hablando en la actualidad de una perspectiva 'digitalizada', llegando a extremos cuyos límites y posibilidades creativas y artísticas aún están por descubrir. En el mundo del diseño la '*realidad 3D*' ya es un hecho y las innovaciones tecnológicas están perfeccionando aplicaciones en los diferentes mercados para satisfacer una demanda cada vez mayor de esta tecnología.

3.2.1.7. Escenografía contemporánea

A pesar de las sucesivas innovaciones que se han visto a lo largo de la historia, la concepción de la escenografía sufre una metamorfosis total a finales del siglo XIX.

Los problemas de orden exterior que persistían estimularon a las nuevas tendencias escenográficas para experimentar y encontrar soluciones: los telones de fondo y los bastidores ya no podían responder a la realidad ambiente que el naturalismo exigía en la puesta de escena, por lo que las habitaciones fueron cerradas mediante plafones y paredes. En cuanto a la iluminación, el aceite y las velas fueron sustituidos por el gas.

En Francia, el Teatro Libre de Antoine introduce una dosis de naturalismo mediante la colocación de una fuente real en sus representaciones. Con el surgimiento de nuevas corrientes y teorías en el teatro, la concepción estética de la escenografía va evolucionando a un ritmo

más vertiginoso; pintores emblemáticos de la época, como Redon, Denis o Lugné-Poé, adoptaron una postura basada en el simbolismo en su trabajo escenográfico. Según su teoría, la decoración debía tener un papel complementario de la ilusión por sus analogías de líneas y de color con el drama, por lo que simplemente se debía concebir como una pura y simple ficción de carácter ornamental.

Aparecen en Europa grandes figuras y talentos de la escenografía, de los que se pueden destacar Roerich, Bakst y Benois (de mano de Serguéi Diáguilev, fundador de los Ballets Rusos, 1909); en el Teatro de Arte de Moscú destaca el trabajo de su director Konstantín Stanislavski y de Max Reinhardt, mientras que en los teatros de Inglaterra destacó Gordon Craig como gran defensor del realismo en los escenarios[19].

La electricidad revolucionó el trabajo escenográfico gracias a las ventajas y posibilidades que permitía; ya se podía emplear una luz para reforzar el color, dar relieve a los elementos corpóreos en la escena, crear nuevas atmósferas y ambientes y proyectar sombras.

3.3. La escenografía tradicional como parte del diseño de interiores

La gran mayoría de estudios e investigaciones que se llevan a cabo en el mundo del diseño de interiores en la actualidad están enfocados en las aplicaciones tecnológicas de las distintas técnicas y *softwares* de diseño virtual, las cuales han sido posibles gracias al ordenador.

Así pues, y a pesar de que la presente propuesta de investigación será desarrollada en su parte práctica más adelante mediante técnicas de realidad virtual, el autor considera importante exponer brevemente cómo la evolución de la escenografía tradicional ha contribuido paulatinamente a la formación y

[19] *Fern, A. (2012). Scenic Design in the Harvard Theatre Collection. Performing Arts Resources, 29, 78-87.*

la consolidación de los conceptos en los que se basa el diseño de interiores actual.

La metamorfosis manifestada a finales del siglo XIX tanto en el trabajo escenográfico como en la ramificación de las corrientes y de las teorías sobre la escenografía en el teatro, pronto se trasladó al cine en el siglo XX. El desarrollo de las técnicas de la perspectiva en el teatro (punto de inflexión en el Renacimiento) resultó decisiva en la posterior aparición de grandes figuras de la escenografía, pertenecientes a diversas escuelas escenográficas que a finales del siglo XIX han enriquecido y contribuido positivamente en la evolución de las técnicas escenográficas.

Ya en el siglo XX, con el nacimiento de las grandes productoras cinematográficas y la invención de la electricidad, junto a la consolidación de los grandes talentos de la escenografía en los teatros de Europa, se dio el salto definitivo que supuso el fin de la concepción tradicional de la escenografía y la llegada de las técnicas avanzadas de ficción. A partir de la segunda mitad del siglo XX, la escenografía en el cine adquiere una nueva dimensión; la tecnología y el ordenador aportaron nuevas ideas y aplicaciones de los recursos escenográficos (decorados, accesorios, iluminación, etc.). Todo ello resultó un factor clave debido a la propia naturaleza del cine como arte y medio de expresión, y la gran diferencia en la percepción del espectador del cine respecto al público tradicional del teatro.

Con el cine las escenas podían ser fácilmente dotadas de realismo y/o imaginación, a través de la recreación de ambientes reales o la creación de escenarios imaginarios o irreales. Autores como Félix Murcia destacaron el

papel de la escenografía como medio de expresión en el cine de la época, gracias a su gran capacidad de información y síntesis[20].

La escenografía cinematográfica fue relacionada en sus inicios con el teatro, pero se desvinculó definidamente del teatro con la película *Cabiria* (1914) de Giovanni Pastrone, marcando una nueva forma de concebir la escenografía a través del cine, con un inmaculado trabajo basado en maquetas y efectos especiales de mano de los emblemáticos escenógrafos Camillo Innocenti, Luigi Borgnono y Segundo de Chomón. El historiador cinematográfico Miguel Dávila describe con fascinación la escenografía de esta obra que marcó un hito en la historia del cine y de la ficción[21]:

"Con respecto a la escenografía, las estructuras y los modelos de películas históricas anteriores solían constituir el fondo de la acción, con una calidad esencialmente decorativa, pero Cabiria es la culminación de un proceso constatado en los inicios del cine italiano en el que los decorados se convierten también en el espacio dinámico donde los personajes actúan y donde la cámara tiene mayor libertad de movimiento. Para ello, se necesitaban estructuras más reales, creándose gigantescas arquitecturas auténticamente construidas, y no los típicos telones usados por Méliès o el Film d'Art. El escenógrafo Camillo Innocenti diseñó los decorados a tamaño natural, con enormes armazones de madera sobre los que se colocaban paneles de cartón piedra para simular las calidades, constituyendo así cuerpos más basados en la carpintería que en la arquitectura, estructuras que no tenían que ser habitables, sólidas y monumentales, sino sólo parecerlo. Los decorados construidos en Turín coparían la gran mayoría del rodaje, aunque se recurrió también a exteriores en Sicilia, los Alpes o el desierto de Túnez."

[20] Campillo, M. E. P. (2015). *Félix Murcia y la dirección artística. Relaciones entre el cine y las artes plásticas* (Doctoral dissertation).

[21] Vargas-Machuca, L. M. D., & del Cine, H. Una visión colosal de la Segunda Guerra Púnica.

La aparición del ordenador y el desarrollo de la informática y los *softwares* específicos para la creación de efectos especiales y maquetas en el cine supusieron el cambio más radical y decisivo en el mundo de la escenografía. Si bien consideramos la escenografía en el mundo del cine una verdadera revolución respecto a la antigua concepción de la escenografía tradicional ligada al teatro, durante los años sesenta y setenta del siglo pasado se produce un cambio aún más radical; con el ordenador la escenografía pasa definitivamente a un plano virtual, un mundo de infinitas posibilidades técnicas y artísticas, en el que directores, productores y directores de arte en el cine encontraron una vía libre para relanzar su creatividad e imaginación.

Por otro lado, la influencia del ordenador dejó su huella en otras industrias en las que la escenografía y el arte fotográfico jugaban un papel esencial durante la época, principalmente la publicad. Del mismo modo, el ordenador contribuyó al nacimiento de un nuevo modelo en el mundo del diseño, el diseño gráfico, actualmente una industria polifacética que a través de innovadoras técnicas y herramientas virtuales ha tenido cabida en la gran mayoría de los medios de comunicación de masas (prensa digital, cine, televisión, etc.).

En definitiva, la escenografía virtual contemporánea ya es una realidad en el mundo del diseño, y especialmente en el diseño de interiores. Existe una necesidad urgente de satisfacer a un cliente cada vez más exigente debido a las innovaciones constantes en el sector y a los sucesivos avances tecnológicos que nos brinda la realidad virtual, lo cual obliga al diseñador de interiores a asimilar una nueva concepción de la escenografía y de sus herramientas virtuales, con una visión adaptada a un sector en el que conceptos como 'interactividad', 'virtual' o 'realidad aumentada' ya forman parte de sus estrategias de mercado y de sus técnicas de desarrollo y capacitación profesional.

3.4. Escenografía virtual

3.4.1. Definición

Con los avances y las herramientas tecnológicas de RV y RA de la actualidad son numerosos los materiales y las tipologías de escenografía de los que podemos prescindir.

La escenografía virtual o digital se puede definir como el resultado de la incrustación entre la señal de una cámara y el entorno digital creado por ordenador, que se actualiza a tiempo real para adaptarse a los cambios de la señal de cámara. Todo este proceso hace que el telespectador perciba una imagen uniforme[22].

La escenografía virtual (EV) nace durante los años noventa del siglo pasado como consecuencia de la aplicación de las técnicas de realidad virtual en el campo televisivo. A finales de esta década, las aplicaciones de la escenografía virtual se consolidan gracias al desarrollo de la capacidad de las tarjetas gráficas, las cuales facilitaban la adaptación en tiempo real del escenario virtual a los cambios que se daban en la señal de cámara.

Para que se esta actualización en tiempo real se pueda dar sin problemas, el ordenador debe conocer de manera instantánea toda la información sobre la posición y el movimiento de la cámara. Por lo tanto, un sistema ideal sería aquel que permita una mayor libertad de posiciones, movimientos y ajustes para los actores y la cámara, con una medición sin retardos y lo más precisa posible.

[22] Cubillo, E. G. (2009). El trabajo del presentador de televisión en un escenario virtual. *Revista Latina de Comunicación Social*, *12*(64), 143-150.

3.4.2. Componentes de un 'set virtual'

El set virtual hace posible la interacción de los actores con las animaciones del entorno virtual. Para que esto sea posible, el escenario virtual es creado mediante la creación de imágenes vía ordenador, proyectando un fondo virtual a partir de gráficas 3D que sustituye al espacio físico real.

Más concretamente relacionado con nuestra propuesta de investigación, el profesor Juanes Méndez, coordinador de un proyecto de la Universidad de Salamanca para evaluar las ventajas de la aplicación de la técnica llave de color en entornos virtuales titulado "*Set* virtuales de innovación docente, bajo entornos tecnológicos *chroma key*" define el concepto de 'set virtual' y describe sus elementos al detalle (Juanes Méndez *et al*., 2012:16)[23]:

• Ciclorama: consiste en un fondo o pantalla grande preiluminada, de color verde o azul. Se emplea para separar la imagen creada mediante ordenador y la imagen del personaje. Se trata del área en la que el animador se mueve (área de acción).

• *Chroma-Key* o llave de color: efecto electrónico de la sustitución de los componentes de un color (llaves) por otra imagen procedente de una fuente de señal distinta. Esta técnica comprende la introducción de objetos, actores o rótulos con fondos de un único color en otra imagen de vídeo. Los colores de los fondos introducidos deben ser verdes o azules.

El uso de la técnica llave de color de un modo óptimo implica la aplicación de una serie de principios:

[23] Juanes Méndez, J. A., Cabrero Fraile, F. J., Jiménez López, M. F., Sánchez Ledesma, M. J., & Rodríguez-Conde, M. J. (2012). Set virtuales de innovación docente, bajo entornos tecnológicos *chroma key*.

- Antes de introducir un sujeto sobre el fondo, se debe aplicar una extensa superficie de *Chroma Key* sobre el suelo y detrás de la acción.

- Se debe emplear una máscara azul que, incrustada desde la cámara, permitirá que el fondo sea apreciado dentro del área o superficie en movimiento. Todos los elementos no abarcados en el ángulo en movimiento no serán apreciados por los espectadores.

• Recortador lineal o *Key:* combina el escenario virtual con las imágenes reales. Además, permite la posibilidad de insertar y proyectar un vídeo en movimiento en la pantalla en tiempo real.

• *Tracking*: permite transmitir toda la información de la cámara al entorno virtual. Los sensores de la cámara real transmiten los datos a la cámara del entorno virtual. Este proceso hace posible que los movimientos producidos en el espacio real sean simulados por el *software* del entorno virtual.

3.4.3. Antecedentes de la escenografía virtual

Históricamente, el primer paso en el campo de la escenografía virtual fue dado por Charles Babbage. En 1883 diseñó una máquina a la que hoy llamaríamos computadora, para intentar, mediante la conversión del proceso de cálculo y de compilación de cifras en un proceso mecánico, resolver los errores que se cometían en ese campo.

Después de más de un siglo, Alan Turing propondría un nuevo tipo de computadora con muchas más capacidades que la de Babbage como la de ser capaz de comunicarse con el usuario y transmitir más tipos de datos, pero no alcanzó a completar este proyecto.

Retrocedemos al año 1842 para referirnos a un acontecimiento simultáneo a los anteriores: la aparición de las primeras imágenes

estereoscópicas en la historia de la fotografía, los daguerrotipos. La estereoscopia, que busca la ilusión de profundidad en las imágenes, ya entonces ofrecía funciones muy similares a las de las gafas 3D que utilizamos hoy, aunque con menos calidad.

Wihelm Rollmann publica pocos años después su descubrimiento de los anaglifos: imágenes bidimensionales que, al ser contempladas con unas lentes especiales (desarrolladas más tarde por Ducos du Hauron, 1891) provocan un efecto tridimensional.

Ya en el siglo XX, en el año 1939, durante la Feria Mundial de Nueva York, Fred Waller presenta el Vitarama, procedimiento consistente en emplear 11 proyectores y una gran pantalla curva compuesta de tres panales, consiguiendo un efecto envolvente para el espectador. Planteaba ciertos problemas porque la imagen proyectada contenía dos líneas que aparecían en el lugar donde se unían los tres panales y que no se podían ocultar, lo que representaba un fallo en el visionado, a pesar eso sí, de la buena calidad de la imagen.[24]

Más adelante, en el transcurso de los años 50, intentando evitar el declive de la edad dorada de Hollywood y competir con ese invento incipiente de la tv. el cine retoma los proyectos de investigación en nuevas tecnologías que le pudiesen ayudar en esa batalla.

Así toma cuerpo el invento del Cinerama de Fred Waller que pretendía potenciar la grandiosidad del cine al hacer más anchas las pantallas de las salas: el sistema consistía en filmar con tres cámaras sincronizadas y proyectar por medio de tres proyectores 35 mm trabajando en sincronía, una imagen

[24] Merian C. Cooper, 1952 *This is Cinerama.*

panorámica, incrementando su detalle y tamaño, sobre una enorme pantalla de cierta curvatura.

Mike Todd, productor de Hollywood, ayudó a Waller para crear la película documental, *This is cinerama*, que cosecho éxito en su época porque la pantalla envolvente conseguía la revolucionaria ilusión de la presencia.

La organización Cinerama produjo otros cuatro episodios centrados en los viajes: Cinerama Holiday (1955), Las Siete Maravillas del Mundo (1956), La búsqueda del paraíso (1957) y La aventura en el Mar del Sur (1958). En asociación con Metro Goldwyn Mayer realizó dos películas: El maravilloso mundo de los hermanos Grimm en el año 1961, y la segunda era, La conquista del oeste producida en el año 1962.[25]

Fig. 6. Proyector Cinerama de Fred Waller, de los que solo existían tres ejemplares en todo el mundo. Fuente: http://blog.rtve.es/webdocs/2014/12

Con todas las ventajas del Cinerama, éste también tenía algunos inconvenientes como el alto coste de producción, llevando a sus creadores a la búsqueda de una alternativa**. S**e empezaron a producir películas en 70mm filmadas con una sola cámara que se vendían como Cinerama, pero que no estaban realmente filmadas mediante el proceso original. Hay que añadir otro

[25] Henry Levin, George Pal, 1962. *The Wonderful World of the Brothers Grimm*.

gran invento de Fred Waller que interesó a las fuerzas Aéreas Norteamericanas y que pretendía ser un simulador de vuelo: un dispositivo con cinco cámaras posicionadas a distintas alturas con la intención de cubrir las áreas periféricas del campo visual humano que serviría para el entrenamiento de pilotos.

Fig. 7. Proyector Vitarama de Fred Waller. Fuente: https://www.cinema.ucla.edu/blogs/archival-spaces/2015/01/08/cinerama

Nadie puede dudar del creciente papel jugado por las nuevas tecnologías en el ámbito del diseño de interiores, especialmente en la escenografía usada para el diseño.

Todo este desarrollo de la escenografía virtual tuvo especial impacto en inventos que guardaban relación con su ámbito:

En los años 60 del siglo XX Ivan Sutherland, considerado el padre de la realidad aumentada y uno de los pioneros e impulsores de los futuros ordenadores y de lo que serían las tarjetas gráficas, crea el programa: Sketchpad "*A man-machine graphical Communications system*" consistente en un sistema de comunicaciones gráfico-humanas desarrollado por la computadora

TX-2, que además presentaba la peculiaridad de estar conectada en línea, algo totalmente novedoso durante esta época.[26]

Pocos años después, otro invento suyo, el "Head Mounted Display", un modelo de casco con visor incorporado capaz de reproducir escenarios virtuales en tres dimensiones, supondría dar el primer paso en la Realidad Aumentada.

Fig. 8. *Head Mounted Display*, modelo diseñado y programado por Ivan Sutherland. Fuente: http://blog.rtve.es/webdocs/2014/12/la-realidad-virtual-como-afectar%C3%A1-a-los-webdocs-parte-3.html

Otro inventor, considerado pionero en desarrollar la realidad virtual fue Morton Heilig, fascinado con el potencial del Cinerama de Fred Waller comenzó a investigar la posibilidad de las máquinas de simular experiencias humanas y sensoriales del modo más realista posible. Para ello en 1958 patentó un dispositivo cuyo objetivo era el entretenimiento: el *Sensorama*, consistente en una cabina que constaba de un asiento, un volante móvil, unas

[26] *I. E. Sutherland. SketchPad: A man-machine graphical communication system. AFIPS Conference Proceedings 23, 1963, 323–328.*

gafas estereoscópicas con reposacabezas, un altavoz estéreo a cada lado y un emisor de olores.[27]

Según Fred Waller "la realidad virtual es una consecuencia del perfeccionamiento de las técnicas de simulación audiovisuales, que comenzaron con las primeras exhibiciones cinematográficas."

En esta recopilación de antecedentes de la escenografía virtual no podemos olvidarnos de la estereoscopia, de la que ya se ha hecho mención brevemente al referirnos a los anaglifos de W. Rollmann. En esta línea debemos mencionar también a uno de los científicos más destacados del siglo XIX en este campo, Charles Wheatstone, inventor del estereoscopio, un aparato que permitía crear la ilusión tridimensional al contemplar imágenes bidimensionales, y que tuvo difusión comercial a través de *View Master* casi un siglo más tarde, en el periodo entre guerras mundiales.

En ese mismo camino de desarrollo de la estereoscopia se fueron sucediendo avances dignos de recordar como el del sistema *Deep Vision*, patentado por Stephen Gibson en 1970 que obtuvo mucho éxito por su capacidad de aproximación a la realidad, o más tarde con el modelo de gafas LCD *Crystal Eyes* para gráficos de computadoras desarrollado por Lenny Lipton.

[27] A. Kay. The early history of Smalltalk. ACM SIGPLAN Notices, 28(3):69–95, 1993. Also in T.J. Bergin and R.G. Gibson, editors, History of Programming Languages II, pages 511–578. Addison-Wesley, 1996.

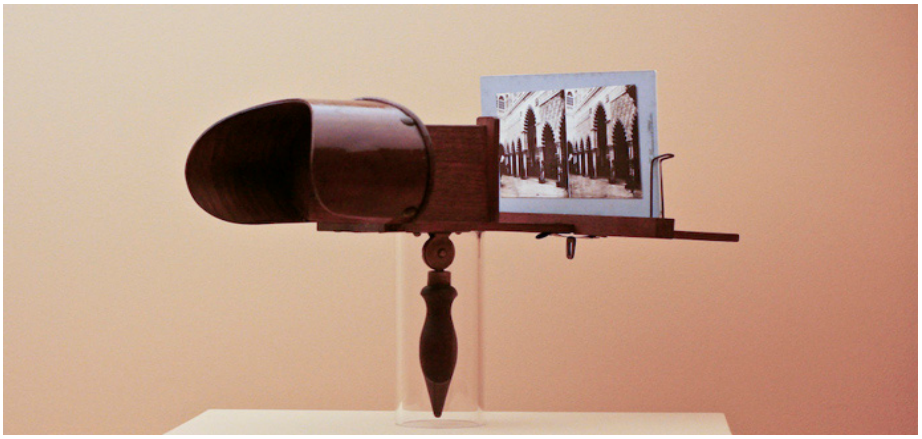

Fig 9. Gafas estereoscópicas, un modelo pionero. Fuente: http://blog.rtve.es/webdocs/2014/12/la-realidad-virtual-como-afectar%C3%A1-a-los-webdocs-parte-5.html

Consideramos ahora otro concepto que posee abundantes implicaciones con la escenografía virtual: nos referimos a la Realidad Virtual. A día de hoy abarca un campo muy amplio alimentado por multitud de inventos de disciplinas diversas.

La primera vez que se escuchó este término fue en 1989, pronunciado por uno de los pioneros de esta tecnología: Jaron Lanier que comenzó a trabajar en esta tecnología en 1980 hasta conseguir 10 años más tarde materializar sus investigaciones en un guante interactivo por el que se interesó la NASA.

Fig. 10. Uno de los primeros equipos que Lanier inventó, que consistía en una gafas y unos guantes acoplados. Fuente: http://blog.rtve.es/webdocs/2014/12/la-realidad-virtual-con-el-uso-de-las-gafas-pero-qu%C3%A9-gafas-comprar.html

No obstante, los antecedentes de esta tecnología se hallan en el primer prototipo de retroalimentador de fuerzas denominado GROPE, diseñado por la Universidad de Carolina del norte en el año 1971. En el mismo año se empezaron a fabricar a nivel comercial los primeros simuladores de vuelo con *display* gráfica en el Reino Unido, y un año más tarde sale a la luz el primer prototipo simulador de vuelos diseñados por *General Electric*.

Paralelamente, en esa década de los 70, Miron Krueger comenzó a trabajar en el *videoplace,* un sistema que permitía grabar a través de cámaras la imagen del usuario y reproducir su silueta en una pantalla capaz de reproducir otros elementos formados por el ordenador y con los que el usuario puede interactuar a través de movimientos que son analizados por el ordenador.[28]

Introducimos una pequeña cronología de los primeros sistemas de escenografía virtual, una exposición en la que el autor toma como referencia el trabajo presentado por Esteban Galán Cubillo en su tesis doctoral titulada "El uso de la escenografía virtual en la realización de un programa de televisión" (2007):

[28] Web personal de Jaron Lanier: http://www.jaronlanier.com

En el año 1991 y por primera vez, NHK utilizó un prototipo de sistema de escenografía virtual para producir *Nanospace*, un documental de ciencia. Poco después apareció el primer sistema de estudio virtual comercializado en el año 1993 cuando SGI introdujo el *Reality Engine 2,* y en el mismo año apareció la plataforma IMP, una compañía con experiencia en gráficos a tiempo real para la producción del video. También en ese año *Elecronic set* (ELSET) diseñó un proyecto europeo en el que participaron varias compañías europeas, algunas universidades y la BBC, llamado Mona Lisa. Mona Lisa pronto desarrolló una versión del sistema de reconocimiento de patrones. Y luego vendría 3DK, la que era un sistema alemán impulsada por la G.M.D.

Dos años después, en el año 1995, Orad introdujo un nuevo sistema llamado *Cyberset*, que usaba un evolucionado sistema de *tracking*, basado en el reconocimiento de patrones.

En el año siguiente la empresa SGI introdujo un nuevo sistema gráfico llamado *Infinite Reality*, un sistema que permitía aumentar considerablemente el número de polígonos permitido, y por primera vez introducía efectos de desenfoque. En el mismo año Orad introdujo una versión renovada como un sistema de reconocimiento de patrones que podía trabajar con cualquier sistema de estudio virtual.

Podemos decir que todo empezó en EESS *The Electrical Equipment Safety System*, con una base en la industria del cine en Europa. Hollywood integró todos estos avances añadiendo los inventos del siglo XX, dando lugar a la escenografía postmoderna, realizando y llevando a cabo escenas espectaculares de gran impacto, fáciles de montar y desmontar.[29]

[29]Jaron Lanier: Who Owns the Future? (presentación de su último libro): https://www.youtube.com/watch?v=XdEuII9cv-U

Así pues, la cámara y la *chroma-key* son los fundamentos de la escenografía actual, a pesar de que hace un siglo ni siquiera existirán, hoy en día prácticamente resulta inviable llevar a cabo una escena sin emplear estas técnicas. Con el presente trabajo de investigación tratamos de enfocar el papel de estas técnicas destacando las ventajas de su empleo, sobre todo la reducción de los gastos y los tiempos de realización de los espacios virtuales; y su potencial para construir escenas irreales o difíciles de lograr para el rodaje.

La evolución de la escenografía virtual y su innovación, no dependió únicamente del desarrollo de la escenografía digital, su crecimiento permitió nuevas posibilidades técnicas y creativas en otros campos. Mencionamos aquí dos de ellos, que constituyeron una base enorme para el desarrollo de la escenografía virtual:

En primer lugar, la fotografía, con un papel principal en la innovación de la escenografía virtual con sus enormes posibilidades, permitiendo la construcción de escenas irreales a través de fotogramas y capas; manipular fotos con la ayuda de la informática; construir escenas irreales o escenas que exigen un rodaje en condiciones climáticas adversas, o salvar otros impedimentos económicos.

El cine en sí, y ya en sus albores los hermanos Lumière pueden dar ejemplo de ello, puede ser considerado una evolución de la fotografía, un paso de la estática a la cinética, un fenómeno que para algunos sucede en la retina (persistencia retiniana) y para otros se produce en el cerebro (fenómeno *Pi*).

En segundo lugar, aunque no necesariamente en ese orden de importancia, la informática, gracias a sus posibilidades, por un lado, en la creación de escenas irreales y por otro en la automatización del proceso de creación artística.

A día de hoy, prácticamente todo el trabajo escenográfico se lleva a cabo de forma automatizada, por equipos informáticos especializados compuestos de ordenadores específicos.

3.5. Aplicaciones y softwares de Realidad Aumentada en el diseño de interiores

En la actualidad muchas compañías de informática están desarrollando aplicaciones en el campo de la realidad aumentada en sus diferentes sectores, ya sea en la medicina como en el mantenimiento de automóviles, aviones, trenes y muchos sectores más. Pero con toda esa innovación, todavía no han logrado las ambiciones de los diseñadores de interiores de disponer de una serie de aplicaciones que les permitan representar sus diseños mediante éstas. Y aumentar la presencia de esta tecnología en dicho campo.

Frente a esta escasez de aplicaciones en el sector del diseño de interiores, algunas compañías han optado por usar la tecnología Realidad Aumentada. Mencionaremos algunas de ellas, consideradas como las mejores aplicaciones de Realidad Aumentada en representar los diseños de interiores:

3.5.1. IKEA

Esta empresa con una de las firmas más conocidas en el mundo del diseño de interiores y especialmente en la fabricación de muebles. El trabajo de IKEA se basó siempre en la búsqueda de reducir y simplificar el tiempo y los gastos derivados de la realización de los diseños, para responder de esta forma a las exigencias que las nuevas tecnologías virtuales han impuesto en el mercado. IKEA creó una aplicación, homónima a su nombre de empresa, para su uso en sus tiendas repartidas por todo el mundo.

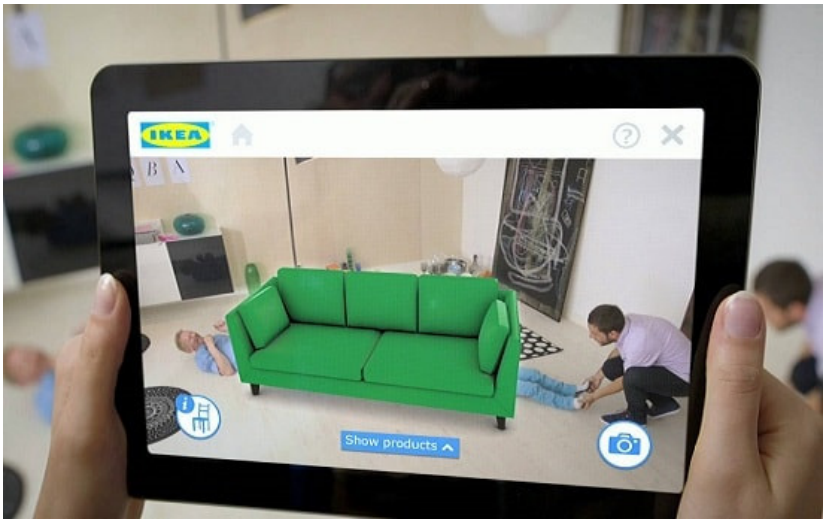

Fig. 11. Una imagen demuestra la aplicación de Ikea en la Realidad Aumentada.
Fuente: http://www.realitytechnologies.com/design

Fue desarrollada por los expertos en Realidad Aumentada en *French Company Allegorithmic,* utilizando el *Unreal Engine 4,* un sistema usado en los videojuegos y especialmente por la compañía *Epic Games.* La idea principal de la aplicación insiste en usar los espacios de los videojuegos como espacios reales para colocar los muebles y representarlos al cliente. La aplicación sigue en pruebas y sometida a muchos experimentos para lograr su objetivo: incorporar la tecnología de la Realidad Aumentada en el mundo del diseño de interiores.

3.5.2. Augment AR 3D Modeling Software

Incide más en el concepto de traducir los planos en papel al mundo virtual, la aplicación fue patentada como *Augment*, una firma que se inició creando complementos para dibujos CAD existentes y herramientas de diseño 3D. *Augment* fue creado para ayudar a los profesionales de ventas a comunicarse mejor con sus clientes, pero es especialmente útil en la arquitectura y los campos del diseño de interiores.

Esencialmente, el software se superpone a modelos 3D en el mundo real. No requiere ningún *hardware* que no sea un *smartphone* ordinario o tableta, y es muy accesible y fácil de usar. Mirando al espacio físico a través de la pantalla del dispositivo, el usuario puede añadir modelos 3D, dimensionarlos y rotarlos según sea necesario.

En el ámbito de la arquitectura, las visitas a los espacios llegan a ser fáciles de conseguir. La aplicación no tiene límites en la escala de los objetos colocados, por lo que los arquitectos y diseñadores pueden mostrar a sus clientes cómo un edificio entero se verá en comparación con sus vecinos. Para los diseñadores de interiores de hogares, la aplicación es aún más útil. Un cuarto vacío puede ser prácticamente decorado, y el cliente puede observar a través de una pantalla de la tableta, desplazándose entre las habitaciones y compartimentos para ver los muebles y la decoración propuestos desde todos los ángulos.

Fig.12. La aplicación de Augment. Fuente: http://www.realitytechnologies.com/design

3.5.3. Northern Lighting

Northern Lighting, es una aplicación especializada en el diseño y fabricación de iluminación *premium*. La empresa utiliza la tecnología de realidad aumentada para vincular sus materiales impresos en 2D, como catálogos en su sala de exposición de productos virtuales, donde toda su colección de muebles está disponible en 3D a través de la tecnología realidad aumentada.

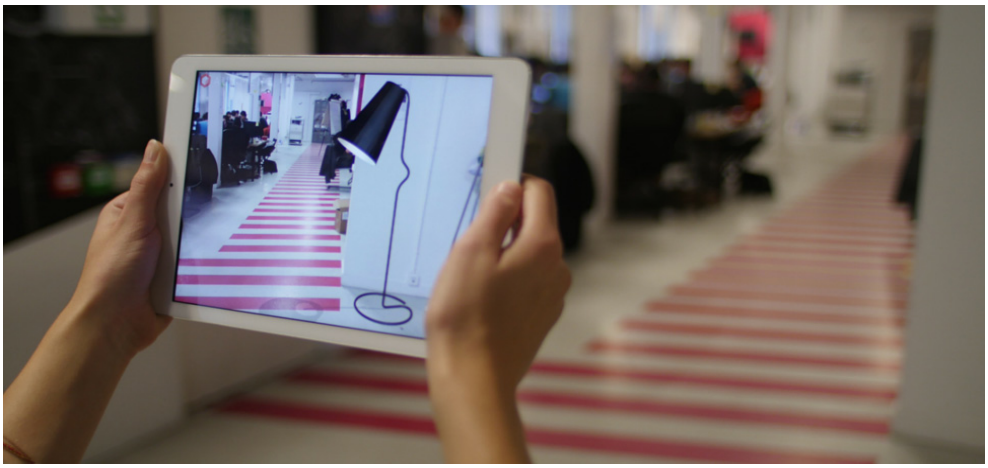

Fig. 13. La Aplicación de *Northern Lighting,* usando la Realidad Aumentada en la iluminación. Fuente: http://www.augment.com/portfolio-items/northern-lighting/

Los clientes sólo tienen que escanear los códigos de *Northern Lighting* para probar y ver todas las lámparas en escala, en modo de realidad aumentada desde la comodidad de sus propias casas antes de comprarlas. Todos los productos de *Northern Lightin* que apoyan a la tecnología de la realidad aumentada están disponibles y accesibles para los clientes de la compañía, en cualquier lugar y momento.

3.5.4. SmartReality AR App

La aplicación *SmartReality* es una fascinante convergencia de *smartphones*, realidad virtual y realidad aumentada. Diseñada para profesionales de la arquitectura y diseño de interiores, la función de la

aplicación es muy simple, los usuarios suben sus planos al servicio para convertirlos en archivos compatibles con *SmartReality*. Una vez que el archivo se carga en la aplicación del *smartphone*, los usuarios pueden escanear los planes de papel y traducirlos en RV o en RA.

El software es compatible con una variedad de RV y RA reconocibles por el sistema. En RV, los usuarios pueden literalmente caminar a través de sus planos. Este tipo de interacción es invaluable para obtener un sentido de escala y una comprensión de cómo se moverían las personas dentro del edificio.

En RA, *SmartReality* crea un modelo 3D instantáneo en una mesa u otra superficie. Ambas funciones de la aplicación representan una nueva forma emocionante para que los arquitectos interactúen con sus creaciones antes de que se construyan. Al confiar en los planos de papel, el *software* permite a los arquitectos y diseñadores saltarse la curva de aprendizaje, y utilizar sus habilidades y conocimientos ya desarrollados para actualizar sus diseños en el mundo virtual.

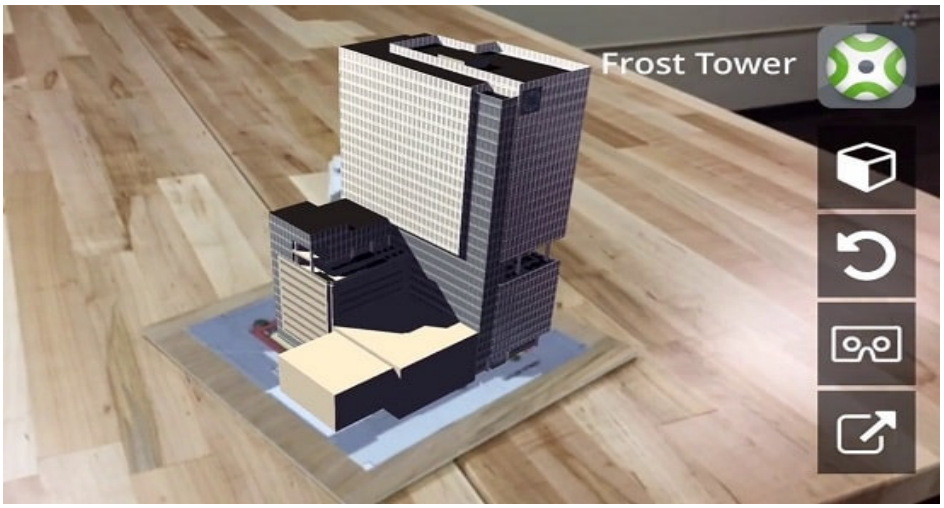

Fig. 14. *SmartReality*, una aplicación muy avanzada en el mundo de la Realidad Aumentada, imagen tomada de http://www.realitytechnologies.com/design

3.5.5. Decorilla

Fuera del espacio comercial, los decoradores de interiores profesionales también están abrazando RA y RA. Hay una serie de aplicaciones disponibles para ayudar a los diseñadores a transmitir sus ideas y la innovación tecnológica a los clientes.

La empresa de diseño *Decorilla* emplea la RA para comunicarse con los clientes, la empresa es un negocio *online*. El proceso de Decorilla para mostrar los espacios a través de la RA empieza cuando los clientes envían las dimensiones de sus habitaciones, junto con fotografías. Los diseñadores envían una propuesta digital completa con un visor de la marca de *Google Cardboard*. El cliente inserta su teléfono en el visor y puede ver un recorrido 3D de su nueva habitación amueblada.

Otra firma de diseño más tradicional aprovechando la RV es DIRTT *(Doing It Right This Time).* La compañía emplea regularmente las gafas inteligentes de *Facebook Oculus Rift* para proporcionar guías virtuales de propuestas.

Las presentaciones que incorporan el mundo virtual son altamente efectivas, ya que esencialmente pueden mostrar al cliente el producto terminado antes de gastar un euro.

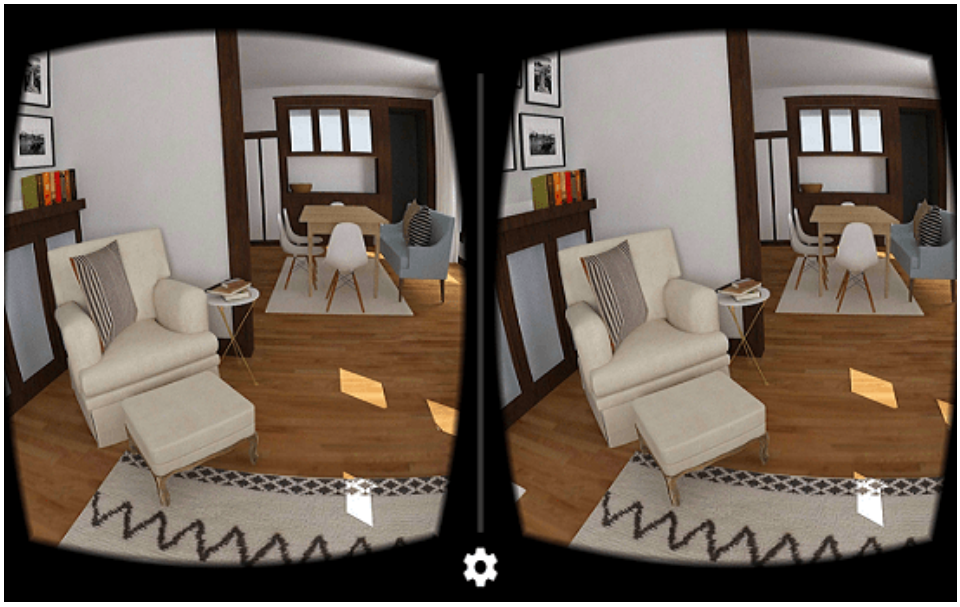

Fig 15. Una imagen muestra el resultado del proceso de la RA a través de la Aplicación Decorilla. Fuente: http://www.realitytechnologies.com/design

3.6. Realidad Aumentada

3.6.1. Definición

Tras el análisis de varias definiciones de este término, tratamos de adoptar la definición más amplia y clara del mismo. De este modo, apreciamos que el término 'realidad aumentada' tiene su origen en la realidad virtual (RV) y simplemente es una visión de un entorno físico del mundo real a través de un positivo tecnológico. En este proceso todos los elementos físicos tangibles se combinan con elementos virtuales, logrando de esta manera crear una realidad mixta con la realidad aumentada en tiempo real.

Numerosos autores e investigadores han definido la realidad aumentada (RA), cada uno desde su experiencia y su concepción de las técnicas que emplea. Larijani concibe la realidad virtual como el conjunto de las tecnologías informáticas que crean un instrumento potenciador de la imaginación mediante las capacidades del ordenador, todo ello a través de la

manipulación de datos informáticos y elementos técnicos que consiguen trasladarnos a mundos alternativos[30] (Larijani, 1993:26).

Desde otro punto de vista Larijani defiende la RV desde un punto de vista más funcional, apuntando que se trata de "un entorno en tres dimensiones sintetizado por ordenador, en el que varios participantes acoplados de forma adecuada pueden atraer y manipular elementos físicos simulados en el entorno y, de algún modo, relacionarse con las presentaciones de otros participantes del pasado, del presente o ficticios, e incluso personajes prediseñados" (Larijani, 1993:28).

En esta misma línea, Robertson defiende que la RV "es un sistema interactivo computerizado tan rápido e intuitivo que la presencia de la máquina desparece de la conciencia del usuario dejando la imagen de cuyas circunvenciones se representan en una experiencia directa"[31] (Robertson, 1993, 14).

Jorge Iván Suárez nos presenta una definición distinta de la RA, concibiéndola en función de su grado de simulación: "Es un espacio real, detrás de las pantallas, un lugar que no puedes ver, un paisaje generado informáticamente, el lugar donde residen nuestros datos informáticos, un espacio que no ocupa sitio y que se atraviesa en un tiempo cero" (Pastrovicchio, 2012)[32].

[30] Larijani, C. C. (1993). *The virtual reality primer*. McGraw-Hill, Inc.

[31] Robertson, G. G., Card, S. K., & Mackinlay, J. D. (1993). Three views of virtual reality: nonimmersive virtual reality. Computer, 26(2), 81.

[32] Pastrovicchio, M. (2012). Escenografía aumentada. Teatro y realidad virtual de Jorge Iván Suárez. *Castilla. Estudios de Literatura*, (3).

Benjamin Woolley, uno de los autores más emblemáticos de la escenografía aumentada, expone la técnica como parte de la interacción. Según Woolley, la RV "es la tecnología que se utiliza para proporcionar un interfaz entre los humanos y las imágenes computacionales. Se trata de simular todo el conjunto de datos sensoriales que constituyen la experiencia real" (Woolley, 1993, 31)[33].

El desarrollo de las técnicas de la RA nos ha ofrecido una nueva experiencia de la RV. La RA toma la idea de una experiencia inmersiva como un paso adelante, mezclando los objetos virtuales con su entorno, en tiempo real.

Muchas empresas han trabajado en el desarrollo de un auricular capaz de emitir proyecciones en nuestra realidad, pero con el avance de la RA a través de *smart phones* y gafas inteligentes, la RA ha visto una oportunidad real en el comercio electrónico. En un futuro no tan lejano, podemos esperar que los audífonos de la RA nos muestren cómo caben los trajes antes de tenerlos en la mano. Decorar su nuevo hogar, probar el nuevo maquillaje, e incluso ver cómo funcionan los productos complejos son todos los usos que la RA se coloca en una posición preferente para dirigir en los mercados minoristas del comercio electrónico.

La innovación en el comercio al por menor busca dar valor tanto a las marcas como a los minoristas, pero ninguna ha sido tan impactante durante todo el viaje del comprador como la realidad aumentada. La RA se posiciona para aumentar las ventas permitiendo a los clientes probar antes de comprar y, a su vez, reducir los retornos eliminando las conjeturas iniciales.

[33] Woolley, B. (1993). *Virtual worlds: A journey in hype and hyperreality*. Benjamin Woolley.

Los clientes quieren saber lo que están comprando y la RA les ayudará a tener más confianza en sus decisiones de compra, a la vez que proporciona diferencias cuantificables para los comerciantes en línea.

El futuro de la experiencia *omnichannel* dependerá en gran medida de la RA y ya está agregando más valor en conseguir que los compradores se involucren en las plataformas móviles de los minoristas, así como en la conducción del tráfico en las tiendas. A medida que el comercio electrónico evoluciona, también lo harán las expectativas de los consumidores. Las descripciones del producto y las fotos 360º ya no serán suficientes. Los compradores móviles querrán y esperarán la capacidad de probar productos en casa antes de comprar a través de la RA. Hoy en día casi todo lo que vemos a través de los llamados 'sistemas multimedia' está diseñado mediante la realidad virtual, como la RA y sus raíces en este campo.

Así pues, y tras más de cuarenta años desde el rodaje de la primera escena que utilizó este medio para transmitir su contenido, podemos admitir que la RA es una técnica de la RV cuyos límites aún están por descubrir, gracias a las grandes posibilidades técnicas y creativas que el desarrollo tecnológico en este campo nos brinda de forma constante. Paralelamente, no podemos olvidar el papel que juega este desarrollo tecnológico en las técnicas virtuales y su incidencia en la escenografía virtual.

La tecnología RA está entrando rápidamente en la corriente principal. Se utiliza para mostrar superposiciones de puntuación en los juegos de deportes, para la transmisión y la publicación de correos electrónicos en 3D, fotos o mensajes de texto en dispositivos móviles. Los líderes de la industria tecnológica también están utilizando la RA para hacer cosas asombrosas y revolucionarias con hologramas y comandos activados por movimiento.

Esta tecnología sigue intercalada entre los móviles y las tabletas, y uno de los objetivos de esta propuesta es empezar a utilizar la RA en las gafas inteligentes para tener una vista perfecta del diseño en el ámbito del diseño de interiores. Sin embargo, esa técnica tiene un gran uso en otros campos, tanto en la investigación como en su aplicación.

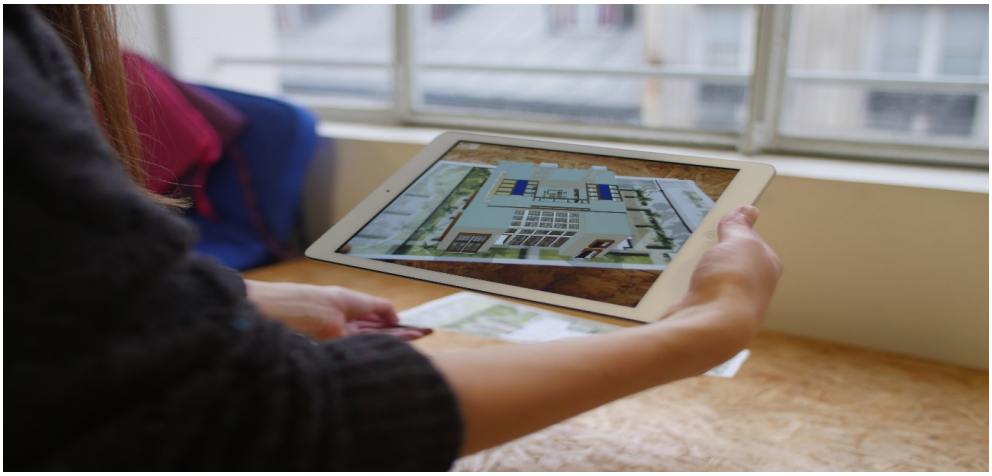

Fig. 16. La capacidad de la RA en convertir los símbolos a modelo 3D, a través de códigos especiales que el programa que muestra el modelo reconoce fácilmente, utilizando en este caso una aplicación de móvil. Fuente: http://www.augment.com/blog/wp-content/uploads/2014/12/P1030872PS.jpg

La RA y la RV son reflejos inversos de uno a otro con lo que cada tecnología busca lograr y entregar al usuario. La RV ofrece una recreación digital de un entorno de la vida real, mientras que la RA ofrece elementos virtuales como una superposición al mundo real, tal como se muestra a continuación.

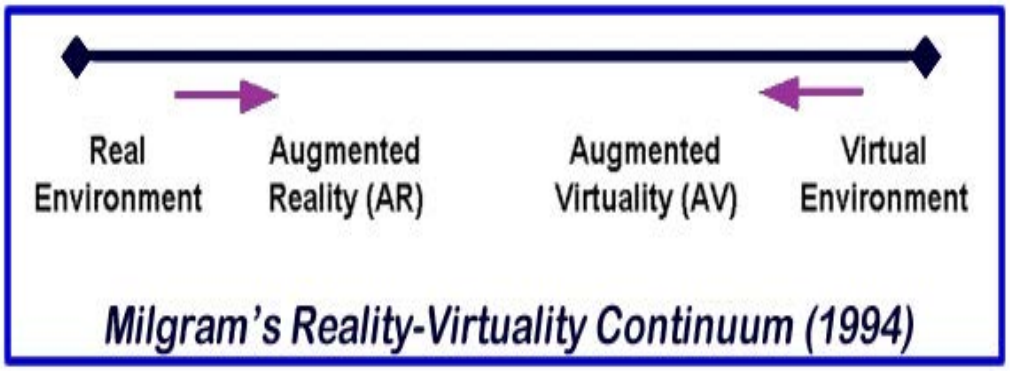

Fig. 17. Esquema ilustrativo del funcionamiento de la Realidad Aumentada y de la Realidad Virtual dentro de los campos del ámbito real y el ámbito virtual. Fuente: http://www.augment.com/blog/virtual-reality-vs-augmented-reality/

La RA y la RV se usan en tres disciplinas principales: la tecnología, el entretenimiento y la medicina:

- Tecnología: Las RA y las RV apalancan algunos de los mismos tipos de tecnología, y cada una de ellas existe para servir al usuario con una experiencia mejorada o enriquecida.

- Entretenimiento: Ambas tecnologías permiten experiencias que son cada vez más comúnmente esperadas y buscadas con fines de entretenimiento. Mientras que en el pasado parecían simplemente una ficción de una imaginación de la ciencia ficción, los nuevos mundos artificiales vienen a la vida bajo control del usuario, y capas más profundas de la interacción con el mundo real son también realizables. Los principales magnates de la tecnología están invirtiendo y desarrollando nuevas adaptaciones, mejoras y lanzando cada vez más productos y aplicaciones que soportan estas tecnologías para los usuarios cada vez más inteligentes.

- Medicina: Además, tanto las RV como las RA tienen un gran potencial para cambiar el panorama en el campo de la medicina, haciendo pensar por ejemplo que las cirugías remotas sean una posibilidad real. Estas

tecnologías ya se han utilizado para tratar y curar condiciones psicológicas, como el trastorno de estrés postraumático *Post Traumatic Stress Disorder (*TEPT).

Por otro lado, la RA y la RV se diferencian en varios aspectos, como el propósito y su método de entrega. Estas diferencias explican al usuario de estas técnicas cada técnica, su función potencial y los campos donde su aplicación tiene mayor incidencia:

Propósito: La RA mejora las experiencias añadiendo componentes virtuales como imágenes digitales, gráficos o sensaciones como una nueva capa de interacción con el mundo real. Contrastando, la realidad virtual crea su propia realidad, que es completamente generada y conducida por computadora.

Método de entrega: La RV se entrega generalmente al usuario a través de un controlador montado en la cabeza, o de mano. Este equipo conecta a las personas con la RV, y les permite controlar y navegar sus acciones en un entorno destinado a simular el mundo real.

La RA se está utilizando cada vez más en dispositivos móviles tales como ordenadores portátiles, teléfonos inteligentes, tabletas y gafas inteligentes para cambiar la forma en que el mundo real, las imágenes digitales y los gráficos se cruzan e interactúan[34] (Shaw *et al*., 2015).

[34] Shaw, L. A., Wünsche, B. C., Lutteroth, C., Marks, S., & Callies, R. (2015). Challenges in virtual reality exergame design.

Aunque RA y la RV se diferencian en muchos aspectos y cada técnica tiene su método de trabajo y su propio funcionamiento, pero en algunas cosas estas dos técnicas trabajan en la misma línea para generar nuevas experiencias.

Por ejemplo, la retroalimentación háptica -que es la vibración y la sensación añadida a la interacción con los gráficos- se considera un aumento. Sin embargo, se utiliza comúnmente en un entorno de RV con el fin de hacer la experiencia más realista, aunque toque.

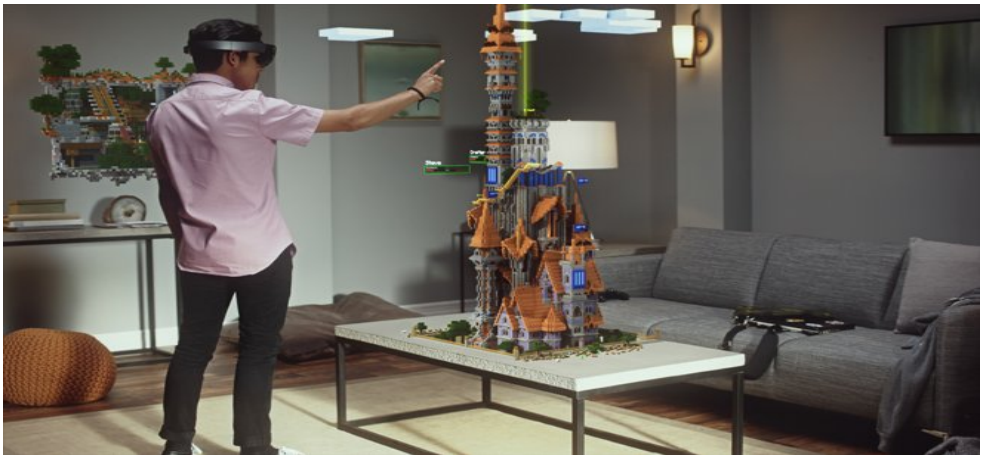

Fig. 18. Realidad Mixta: Experimento realizado en 2017.
Fuente:http://www.augment.com/blog/wp-content/uploads/2017/01/Mixed-reality-Hololens-Augment-Blog.jpg

La RV y la RA son grandes ejemplos de experiencias e interacciones impulsadas por el deseo de sumergirse en una tierra simulada para el entretenimiento y el juego, o para agregar una nueva dimensión de interacción entre dispositivos digitales y el mundo real. Solos o mezclados entre sí, sin duda están abriendo mundos, tanto reales como virtuales.

La competencia entre la RA y la RV suele ser discutida por el potencial de negocio de las dos tecnologías, pero su resultado final ha sido siempre un objetivo común: la Realidad Mixta (RM).

En este sentido se plantea una cuestión importante: ¿Alguien se ha propuesto analizar los usos prácticos de RA y RV con el fin de proporcionar una mejor experiencia para el usuario? Existen numerosas opiniones sobre esta cuestión, la mayoría de ellas señalan que cada "realidad" tiene sus ventajas, aunque todas ellas coinciden en que el grado innovación de las plataformas que soportan ambas realidades será el factor clave en el éxito o el fracaso de cualquier aplicación práctica de las mismas.

En un estudio reciente realizado por varios investigadores de prestigio en EEUU, los autores definen la RM como "la intersección de la realidad virtual y la realidad aumentada", mientras que la RA es definida como "la fusión de mundos reales y virtuales con la producción y el entorno donde coexisten objetos físicos y digitales en tiempo real"[35].

Según *SuperData Research*, el mercado empresarial de RV y RA creció de 16 millones de dólares a 17 millones de dólares americanos en 2016, previendo además un crecimiento de entre 1.600 y 3.000 millones de dólares americanos en 2020, respectivamente[36]. Sin embargo, las valoraciones y predicciones de estas industrias en términos económicos no son las únicas predicciones que se están haciendo. Los modelos de negocio de las empresas líderes en la industria también están esculpiendo el futuro de la computación,

[35] Billinghurst, M., Clark, A., & Lee, G. (2015). A survey of augmented reality. *Foundations and Trends® Human–Computer Interaction*, *8*(2-3), 73-272.

[36] Lemle, E., Bomkamp, K., Williams, M. K., & Cutbirth, E. (2015). Virtual Reality and the Future of Entertainment. In *Two Bit Circus and the Future of Entertainment* (pp. 25-37). Springer International Publishing.

mostrándonos que los interfaces más complejos están enfocados en crear plataformas abiertas.

Microsoft está apostando por un espectro completo de experiencias, dando paso a la RM. No sólo como una palabra de moda, sino como una realidad, la realidad mixta estará dominada por el *hardware* y está mucho más cerca de lo que se esperaba.

3.6.2. Experiencias de Realidad Mixta

Microsoft ha anunciado que presentará *Windows Holographic* en 2017, la versión de *Windows* 10 diseñada para aplicaciones de RM, aunque actualmente está activa en la edición de desarrollo de *HoloLens*[37].

La plataforma está abierta para la RA, aunque paulatinamente va abriendo paso a la innovación en la RM. De hecho, el sistema de *Microsoft Hololens* en la actualidad está promocionando su desarrollo en el futuro con vistas a las expectativas que irá abriendo la RM.

Craig Cincotta, miembro del equipo de realidad mixta de *Microsoft*, manifestó su opinión en *TheStreet* en relación a las nuevas capacidades de *Windows Hololens*:

"*Windows Hololens* permite lo que resulta impensable en otras plataformas, experiencias compartidas de RM en una amplia gama de dispositivos, a partir de una variedad de fabricantes de dispositivos y

[37] Chen, H., Lee, A. S., Swift, M., & Tang, J. C. (2015, October). 3D collaboration method over HoloLens™ and Skype™ end points. In *Proceedings of the 3rd International Workshop on Immersive Media Experiences* (pp. 27-30). ACM.

mediante una singular interfaz de usuario consistente y de entrada estandarizada"

Cincotta también señaló que el nuevo software de *Windows* ayudará a los desarrolladores a crear experiencias de RM que no resulten distintas a las de *Microsoft Hololens.* Este modelo se asemeja al enfoque de *Google* para RV, aunque Windows 10 parece estar completando y ayudando a crear estas experiencias RA / RM.

Fig. 19. Gafas de Realidad Mixta *Engadget*, Edición 2017.
Fuente: http://www.augment.com/blog/wp-content/uploads/2017/01/Screen-Shot-2017-01-24-at-10.23.14-AM.png

Osterhout Design Group (ODG) es otra empresa que ha presentado recientemente dos gafas de RM en el CES. Aunque las pantallas montadas en cabezales de ODG llevan mucho tiempo en desarrollo, ODG presentó los auriculares de RM más avanzados que hemos visto, detrás de los *Hololens*. No obstante, esta capacidad de oscilación entre la RA y la RV supone un valor añadido a las experiencias del usuario.

La RM para el comercio minorista atraerá potencialmente muchos beneficios tanto a los minoristas como a los compradores. En la actualidad, la RV dispone de avanzados sistemas para las compras en línea, y las empresas ya están implementando salas de espectáculos virtuales donde los

consumidores pueden navegar a través de tiendas utilizando un *HTC Vive*. La RV también está permitiendo a los compradores en línea decorar virtualmente sus salas vacías para hacerse una idea de los productos antes de adquirirlos.

Por su parte, la RA tiene un mayor interés e impacto en el comercio minorista, permitiendo a los compradores en línea probar productos en casa antes de comprarlos. La RA ha demostrado ser mucho más impactante en este mercado en la actualidad, aunque la RM supone una técnica híbrida viable en este sentido, tanto para el mercado de RV como para el de RA.

La RM en el juego puede convertirse en la industria más grande para la convergencia de RV y RA. Ya hemos visto el efecto contagioso de la RA con *Pokémon GO* y, por supuesto, el efecto de introducir técnicas de RV en la industria del videojuego. De ahí la idea del entretenimiento en el mundo de los videojuegos mediante técnicas de RV, en la que el usuario se imagina jugando en un entorno totalmente inmersivo, y en el cual tiene la opción de competir y jugar con otros usuarios de ese mismo entorno (Williams, 2016).
En definitiva, la RM ya está en desarrollo por muchos de los líderes de la industria de la RA.

Fig. 20. En varios puntos de venta de Tommy Hilfiger y AT & T, se puede probar un auricular de RA y ver espectáculos de pista en 360º.
Fuente: http://www.augment.com/wp-content/uploads/2017/01/20hilfiger-web-superJumbo.jpg

3.6.3. Llave de color (Chroma Key)

Chroma key es el término original en inglés de la técnica, y se podría definir como "el componente de la señal de vídeo que contiene la información del color, y suele ser de color verde o azul dependiendo del tipo de estudio y de las exigencias del montaje en cuestión" (*British Kinematograph Society*). En español se suelen emplear términos como 'llave de color' o simplemente 'croma' para referirse a esta técnica, aunque el término en inglés es el más común.

La técnica *chroma key* se considera uno de los pilares básicos de todo el trabajo en la escenografía, la decoración y en los estudios virtuales. Gran parte del decorado y de las representaciones espaciales, tanto en el cine como en el teatro o la televisión, proceden de técnicas avanzadas basadas en el *chroma key*.

La técnica nació para dar respuesta a numerosas cuestiones que comenzaron a plantearse, sobre todo con el desarrollo de la industria cinematográfica a partir del siglo XX. La necesidad de recrear espacios reales o de crear escenarios imaginarios que surgió en el mundo del cine, unida a las dificultades de rodaje en espacios reales y su consiguiente coste económico, supuso el paso definitivo hacia el nacimiento de esta técnica.

Fue en los años 20 del pasado siglo cuando esta técnica comienza a darse a conocer, cuando el fotógrafo Dodge Dunning inventa un sistema y lo patenta con el nombre de *Dunning Travelling Mate*[38]. Se trataba de un sistema basado principalmente en técnicas fotográficas y que fue trasladado al cine. El

[38] Hernández, J. A. L. (2011). Técnicas de implementación de cicloramas para Chroma-key sin limitaciones de color. *Trabajo final de grado, Escuela Politécnica Superior de Gandia, Universidad Politécnica de Valencia, Valencia, Espana*.

sistema se basaba en un negativo virgen de un positivo que se teñía de color amarillo o anaranjado. Durante el rodaje la luz manipulada a base del tinte se enfocaba hacia un fondo blanco, el cual estaba iluminado con foco de luz azul, de modo que el efecto visual resultante en las cámaras proporcionaba una especie de "mascarilla viviente" para la acción de fondo (Hernández, 2011, 11).

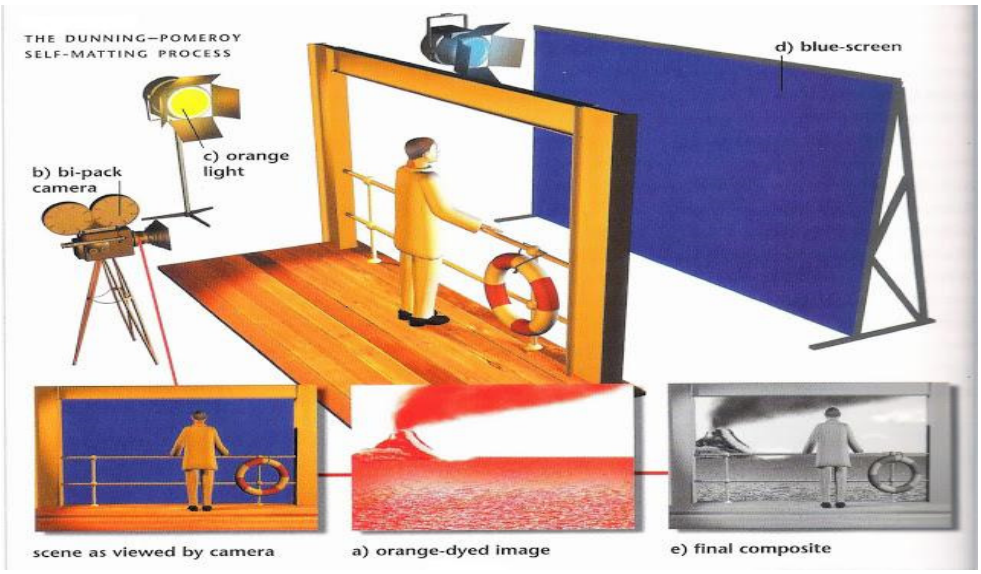

Fig.21. Ilustración del sistema *Dunning Travelling Mate*, diseñado por Dodge Dunning. Fuente: http://nzpetesmatteshot.blogspot.com.es/2013/07/king-kong-mightiest-wonder-of-world.html

Pocos años después, y con la aparición del celuloide en el cine, se dio un gran cambio en esta técnica. El celuloide como material se caracterizó por su uso sencillo y su abundancia, sin embargo, y a pesar de las numerosas ventajas creativas que inicialmente los escenógrafos predijeron con su introducción, esta técnica implicaba en sus inicios en el cine una complicada labor debido a que todos los elementos de la escenografía debían ser filmados por separado. Además, los distintos rollos de película tenían que ser integrados en un único celuloide mediante una costosa impresora óptica.

Más adelante con el nacimiento de las grandes productoras cinematográficas en EEUU especialmente, el crecimiento de los presupuestos para la producción de películas y los avances tecnológicos en las técnicas de producción y postproducción cinematográfica, el celuloide recuperó protagonismo y consolidó su presencia en el mundo de la escenografía.

3.6.3.1. *Chroma Key* como herramienta en el diseño de interiores

La revolución industrial y tecnológica a principios del siglo XX supuso un paso definitivo para el mundo de la cinematografía. Además de la innovación en las técnicas de imagen y sonido (perfeccionamiento de cámaras, dispositivos de sonido, etc.), a través del cine la escenografía y la decoración empiezan a cobrar un protagonismo cada vez mayor. Durante estos años, sobre todo los años 30 y 40 del siglo pasado y coincidiendo con el auge de las grandes productoras cinematográficas, la imaginación y el mundo irreal comienzan a ganar terreno en el cine.

Es a partir de este momento que se empiezan a perfeccionar a un ritmo acelerado las técnicas escenográficas para adaptarse a las exigencias de las nuevas películas, a través de la recreación de espacios reales o la simulación de espacios irreales durante el rodaje de las escenas.

El *chroma key* revolucionó definitivamente la labor de los escenógrafos desde sus inicios en el cine, permitiendo un gran abanico de posibilidades técnicas y artísticas al servicio de la producción cinematográfica, además de suponer un gran ahorro en los costes de producción y la reducción de los tiempos de rodaje de las escenas.

Con el paso del tiempo y con el nacimiento de la escenografía virtual -gracias al desarrollo de los *softwares* de diseño por ordenador- esta técnica ha experimentado enormes cambios, convirtiéndose en la actualidad en un sin fin de efectos visuales y especiales para el receptor, ya no solo en el cine sino en otros muchos medios de expresión en los que ha tenido cabida, como la televisión, la animación el mundo de los videojuegos.

Es más, el diseño de interiores y el gran desarrollo que ha experimentado el sector en lo que se refiere a la tecnología en la actualidad (llegando hoy en día a hablar de "realidades" como la virtual, la aumentada o la mixta) nos hace abrir un pequeño paréntesis para reflexionar desde una perspectiva más crítica sobre la propuesta que plantea el autor en este trabajo de investigación: ¿En qué medida puede la técnica *chroma key* introducirse en la concepción actual del diseño de interiores?; ¿Cuáles pueden ser las aplicaciones más viables y útiles de la técnica en el mundo del diseño de interiores?; ¿Aplicada en entornos de realidad aumentada, resultaría la técnica más útil en el diseño de interiores?; ¿Puede la técnica abrir nuevos horizontes en el futuro del diseño de interiores?.

A lo largo de esta parte de la propuesta, que coincide con la estancia realizada por el autor en la Escuela Politécnica de Milán durante el curso académico 2015/2016, tuvieron lugar varios encuentros y entrevistas concertadas con reconocidos académicos y especialistas en el mundo del diseño de interiores.

Durante estos encuentros/entrevistas el autor planteó inicialmente estas cuestiones desde un punto de vista más general, planteando ideas a los entrevistados relativas especialmente a la funcionalidad de la tecnología virtual en el mundo del diseño de interiores, sobre todo en lo que se refiere a

la llamada 'realidad aumentada'. Más adelante, el autor fue profundizando con el planteamiento de las cuestiones más específicas y objeto de la propuesta de investigación, el papel actual y las previsiones de futuro de la técnica *chroma key* en el campo del diseño de interiores.

Se trata de una técnica con unas aplicaciones muy limitadas actualmente en el campo del diseño de interiores, y no cuenta todavía con un grado de apoyo científico y tecnológico que impulse su desarrollo y su presencia en este sector.

Con la exposición y el desarrollo teórico-práctico de la propuesta de investigación y a través del tratamiento de la información recopilada en estas entrevistas, el investigador tratará de trazar las líneas generales y específicas de acción necesarias para llevar a cabo la presente propuesta de un modo óptimo, con el ánimo de ofrecer una propuesta innovadora para la innovación en el campo del diseño de interiores, y para servir como referencia clave para futuras propuestas sobre la técnica *chroma key*, tanto teóricas como prácticas.

3.7. Opiniones sobre la Realidad Aumentada

A continuación se expone, a modo de resumen, el contenido de las entrevistas realizadas por el investigador a especialistas y profesionales del campo del diseño de interiores durante su estancia doctoral en la Escuela Politécnica de Milán (curso académico 2015/2016). El investigador trató de recabar una información útil que permita conocer y analizar las diferentes perspectivas, opiniones y posturas que adoptan estos profesionales y especialistas acerca de la propuesta desarrollada en el presente trabajo de investigación.

3.7.1. Participante número uno, Andrea Ratti.

Could be very good for the clients and designer to understand better the space, if we do it in the correct way it will be great. But, how much it cost how time it need, so the result it's great, but it's not easy it's now cheap.

Según el participante, quizás esta técnica resulte eficaz para ayudar al diseñador y al cliente a entender mejor el espacio, si se hace correctamente se conseguirán buenos resultados.
Por otra parte, el coste y el tiempo que requiere el diseño influirán directamente en el proceso de emplear estas técnicas, lo cual no resultará tan fácil como parece.

3.7.2. Participante número dos, Stefania Varvaro.

I think that we can use the augmented reality in exhibition application it has advantage and in the visualizing of information to manage the content in exhibition. The possibility to use this content not keep it straightly related to physical space, we can use it for reach place its difficult to reach it.
I think there are a lot of possibilities, because simply if we have a look to our discipline 20 years ago we can say that everything it's possible with this technology, and could give a better result in special spaces in exhibition or public space, not for living space or for daily life.

La participante opina que la técnica de realidad aumentada podría servir en galerías y exposiciones, ya que simplemente ayudaría al visitante a recabar toda la información necesaria sobre la exposición. Además, cree que esta técnica podría dar mejores resultados en espacios especiales y públicos, no en espacios del hogar o de la vida cotidiana (no limitarse al plano físico).

3.7.3. Participante número tres, Marita Caninia.

I think we can use it in valorize some exist architecture (culture heritage), and regarding with interior design it's better to use virtual reality, but if they developing this technology to represent our work like architectures and interior designer could be absolutely a phenomenal work, if we can see the space like a physical space could be more useful.

A juicio de la participante, la técnica de la realidad aumentada puede ser empleada para valorar algunas obras arquitectónicas ya existentes (patrimonio cultural). Respecto al diseño de interiores, considera mejor utilizar la realidad virtual, pero si se desarrolla esta tecnología para representar nuestro trabajo como arquitecturas y diseños de interiores podría ser absolutamente una obra fenomenal. Afirma que podría ser más útil si apreciamos el espacio desde una dimensión física.

3.7.4. Participante número cuatro, Alessandro Biamonti.

Recently, we have this powerful technology, and we still see thesis for what, but obviously, in the other side you can thinks this technology can be used for prosthetics, but in daily life you can also use it to create objects. From the environments sustainability front of view, has the potential both to increase wise through objects, but also to save wise because you can do spa beds it's upon the person using the technology upon to the culture or the system, if you are in the other side still pushed to continue, the technology will be used to increase consumption, but here there is shift was less consumption, people will start to exploring this technology for decreasing consumption and imagine 3D in design it will be the same.

El participante cree que podemos aprovechar mejor este tipo de tecnología en el ámbito de prótesis arquitectónica, porque simplemente sus aplicaciones pueden resultar más útiles que en otros campos, pero que también se podría aprovechar en la creación de objetos en nuestra vida diaria. Opina también que esta tecnología permitirá proteger y mejorar la sostenibilidad ambiental, por lo que la técnica empleada de un modo óptimo podría contribuir a reducir el consumo de los usuarios, que tenderán cada vez más a explorar sus posibilidades de diseño 3D.

3.7.5. Participante número cinco, Bogdan Stojanovic.

Well, I don't have the enough knowledge about this field to talking about it, my experience in this it's no more than visit some exhibition use this kind of technology to represent some works. But in the same time, I think this technology it's the future for the interior design, I mean here the future way to represent and show to the clients the final design.

Este participante adopta la misma postura que el autor. Simplemente, opina que la técnica de la Realidad Aumentada es la técnica ideal para llevar a cabo los proyectos de diseño de interiores en el futuro, gracias a la posibilidad de mostrar al cliente el resultado final de un proyecto, y de un modo interactivo, antes de su puesta en marcha.

3.7.6. Participante número seis, Oxsana Nauso.

I think yes, could be a good support, also in practically the augmented reality can help in represent how it works, how leave the space, so it gives the action how it work, and it can be interesting.

Este participante cree que esta técnica puede ser en el futuro un gran soporte al diseño de interiores en la representación del resultado final y ofrecer una percepción completa del espacio al cliente y diseñador.

3.7.7. Participante número siete, Barbara Camocini.

I think it useful to do presentations, in Italy we used more for show off and demonstration, so you can visit your place before start construct it, today it's more for display, it will be amazing if you can apply your project in the real life, but there is a risk to go down in simulation, and we have to know the difference between the picture and the reality, when we make some design and we make renders and it look like a picture doesn't mean the reality it will be the same and vice-reserve.
Many people do confusion about that, so you have to be responsibility about this filter and how the people look to this to judge and to know defend your project otherwise everybody can be an interior designer or architect tomorrow, so the difference the manner when you defend your project.

La participante se muestra de acuerdo con los demás entrevistados respecto al uso de la técnica de la realidad aumentada para la previsualización del diseño antes de su implementación. Sin embargo, esta tarea puede resultar complicada si no empelamos la técnica del *render* adecuadamente. Se trata de que podamos defender nuestros proyectos desde una perspectiva sumamente profesional y experta a través de una aplicación correcta, y no hacer que el cliente caiga en la confusión entre lo real y lo simulado.

3.7.8. Participante número ocho, Giulia Ceppi.

I think this technology it's more connected with interaction design, and if we think in interaction de sign and augmented reality it's more about exhibitions or installations of museums and how it can help us in our daily life and change our daily life, I mean the daily task, not only the representation of designs.

La entrevistada opina que la técnica de la realidad aumentada está más conectada con el diseño interactivo que con el diseño de interiores, especialmente en exposiciones y museos. Además, cree que esto nos podría ayudar en nuestra vida diaria, y no solamente en la representación de los diseños.

3.8. Propuesta del autor como trabajo de campo

La presente propuesta trata de analizar y evaluar el uso de las tecnologías de la Realidad Aumentada (RA) y de la Realidad Virtual (RV) en modelo 3D para el diseño de interiores, usando la técnica llave de color o *chroma key* como herramienta para la representación del diseño.

Según las propias características del diseño de interiores, consideramos que el modo más óptimo de compartir el concepto de un proyecto de diseño con el cliente en la etapa de representación del diseño radica en su realización en un vívido prototipo 3D. Los prototipos 3D de espacios interiores tradicionales son creados por diseñadores y evaluados por los clientes.

El diseñador y el cliente establecen conjuntamente un modelo de espacio interior 3D en todo el proceso del diseño, creando primero la estructura interior en 3D para después elegir el método y las características de la decoración personalizada (en un sistema de RA). Un marco de referencia de un modelo complicado de decoración está diseñado para mejorar los proyectos de diseño y hacer una evaluación que garantice que el usuario pueda coordinar todos los aspectos del proyecto de diseño, y lograr un equilibrio entre la estructura y la función.

El contenido aumentado y la información sensorial de material decorativo (muebles, electrodomésticos, etc.) para decoración simple pueden simularse con equipos estereoscópicos especiales como prototipo interior RA3D en el sistema RADI, para aumentar la comprensión y participación de los consumidores en los proyectos personalizados de diseño de interiores.

Esta propuesta tiene como objetivo presentar un prototipo de un sistema que permita al usuario ver el diseño en escala real y completamente amueblado con las texturas de cada mueble, y al mismo tiempo presenta una visión completa del espacio con todos los detalles de la decoración interior, con la posibilidad de cambiar la localización de los muebles, las texturas y/o los colores mediante unos simples pasos. Todo ello permitirá al diseñador reducir considerablemente el tiempo de realización de proyectos personalizados de diseño para el cliente. Esto es, ahorrar tiempo supondrá por consiguiente un ahorro de esfuerzo y de costea, y también permitirá a los diseñadores representar sus trabajos en un prototipo más profesional en comparación con los actuales prototipos, lo cual repercutirá sin lugar a duda en la satisfacción general de los clientes. Por otro lado, este método permitirá también incrementar la creatividad del diseñador gracias a las facilidades técnicas que ofrece en la realización de los proyectos, ya que permite presentar los diseños de un modo más inmersivo e interactivo a los clientes.

El contenido de esta investigación está asociado a la percepción de los clientes de los proyectos de gestión y ejecución en el diseño de interiores. Esta propuesta representa en sí una visión de cara al futuro del mercado del sector del diseño interiorista, pretendiendo ofrecer una perspectiva clara sobre las ventajas que supondrá la implementación de las técnicas de RA en el mercado, de modo que cree un nuevo modelo de cooperación eficiente entre el diseñador y los clientes.

La representación foto-realista mediante el manejo de la información del espacio real sería un factor clave para ofrecer al usuario una experiencia ideal de inmersión en el entorno de la RA.

3.8.1. Introducción

Como bien se ha descrito, el autor propone un sistema para la representación en el diseño de interiores mediante un entorno de RA y la técnica llave de color como herramienta. Este sistema implica aumentar el espacio real con toda la información sobre la estructura del espacio, la función espacial y los materiales relevantes para el producto. En ese entorno de RA, los efectos visuales para el producto se podrán modificar por el usuario bajo la supervisión del diseñador a través de interfaces; para ello se emplearán diferentes modelos de gafas inteligentes, conectadas al ordenador del diseñador para tener así todo el proceso bajo control. Se trata de que el cliente interactúe con el diseño visualizado mediante las gafas digitales (vía ordenador) para construir modelos 3D en un entorno simulado. La estructura espacial se puede exhibir para los diseñadores y los clientes para distinguir las características estructurales y la división funcional del espacio interior. Además, los usuarios podrán interactuar fácilmente con este modelo digital y recibir comentarios de una serie de sensores y dispositivos.

A pesar de que las cámaras de profundidad no son conceptualmente nuevas, *Kinect* trabajó en su desarrollo en el mercado, de modo que en la actualidad son accesibles tanto para investigadores y usuarios en general. La calidad de la profundidad detectada en tiempo real a través de los sensores de estas cámaras, unida a su bajo coste en comparación con otras tecnologías, incrementó considerablemente la popularidad de las cámaras *KinectFusion*[39]. Este sistema desarrollado por *Kinect* ha permitido consolidar una nueva concepción del uso de los sensores en la reconstrucción de espacios irreales y

[39] Izadi, S., Kim, D., Hilliges, O., Molyneaux, D., Newcombe, R., Kohli, P., & Fitzgibbon, A. (2011, October). KinectFusion: real-time 3D reconstruction and interaction using a moving

en tiempo real, habiendo brindado al campo del diseño de interiores grandes resultados a través de numerosos estudios e investigaciones.

La cámara *Kinect* utiliza una técnica de luz estructurada para generar mapas de profundidad en tiempo real que contienen medidas de rangos discretos de la escena física. Estos datos pueden ser reproyectados como un conjunto de puntos discretos 3D (o nube de puntos). Y aunque los datos de profundidad de *Kinec*t son bastante fiables y convincentes, presentan algunos problemas de usabilidad para el usuario (por ejemplo, resultan un poco ruidosas comparadas con otras cámaras de profundidad disponibles en el mercado).[40]

3.8.2. La tecnología de la Realidad Aumentada en el diseño de interiores

La introducción de la técnica llave de color o *chroma key* en esta propuesta supone la presentación de un nuevo modelo de aplicación de la misma en el campo del diseño de interiores. El uso de sensores y marcos de espacios para concretar el espacio y facilitar el manejo de las gafas inteligentes -para ubicar y situar el diseño irreal en el espacio real- permitirá desarrollar nuestra propuesta en la práctica con un alto grado de optimización y congruencia y, por ende, obtendremos unos resultados bastante fiables.

Cabe señalar que la presente propuesta pretende ampliar y profundizar el trabajo llevado a cabo en otras propuestas e investigaciones anteriores sobre el diseño de interiores en entornos simulados, en este caso de

[40] Izadi, S., Kim, D., Hilliges, O., Molyneaux, D., Newcombe, R., Kohli, P., & Fitzgibbon, A. (2011, October). KinectFusion: real-time 3D reconstruction and interaction using a moving depth camera. In *Proceedings of the 24th annual ACM symposium on User interface software and technology* (pp. 559-568). ACM.

RA. La particularidad y originalidad en la propuesta radica en la introducción práctica de la técnica llave de color en dicho entorno aumentado, al servicio de ofrecer una nueva perspectiva y brindar una nueva experiencia virtual e interactiva diseñador-proyecto-cliente.

3.8.3. Etapas del proceso de diseño de interiores

Todo proyecto de diseño de interiores, en términos generales, debe llevarse a cabo siguiendo una serie de etapas:

1º. Inicio del Proyecto
2º. Programación
3º. Desarrollo del Concepto
4º. Desarrollo del Diseño
5º. Implementación del Diseño
6º. Supervisión del Proyecto
7º. Finalización de la Publicación

La aplicación de la tecnología durante este proceso dependerá de las propias necesidades del proyecto, es decir, la digitalización del trabajo realizado puede ser llevada a cabo mediante ordenador después de tener en mano el diseño definitivo o, por el contrario, iniciar la digitalización en las etapas iniciales después de haber desarrollado el concepto del proyecto para trasladar a continuación el diseño al ordenador (en este caso, se trabajará mediante *softwares* específicos para el diseño).

El autor de la investigación se decanta por la segunda opción, ya que considera que la digitalización durante las etapas iniciales de la propuesta permitirá tener un mayor control sobre todo el proceso de implementación

del proyecto propuesto y, además, permitirá corregir rápidamente cualquier error que pueda surgir durante el proceso.

El diseño comienza por el conocimiento de las necesidades del cliente. Desde aquí el diseñador parte inicialmente plasmando sus ideas mediante bocetos que, tras ser valoradas conjuntamente con el cliente, se concretan en un borrador definitivo, con lo cual queda fijado el concepto del diseño.

La siguiente etapa consistirá en digitalizar el trabajo a través de un *software* de dibujo 2D (*Autocad*). A continuación, con todos los detalles plasmados en el dibujo 2D, el diseñador introduce la tercera dimensión mediante el uso de un *software* 3D (3D Studio Max) distribuyendo el espacio de un modo tridimensional, fijando las texturas y los colores de las paredes de manera que el resultado sea proporcionado y en armonía con el resto de elementos del diseño. Seguidamente, el diseñador procede a ubicar espacialmente los muebles y los otros elementos diseñados –o elegidos previamente por el cliente- desde el entorno virtual, para realizar después un chequeo de todo el diseño y valorar si responde a las necesidades del usuario.

Finalmente, el diseñador convierte el diseño en imágenes realistas empleando un *software* de RV (*V-Ray*) de manera que puedan ser visualizadas por el cliente desde más de un punto de perspectiva (se visualiza el diseño tal como si fuese de la vida real).

Con la conclusión de estas etapas previas podemos afirmar que nuestra propuesta de investigación entra en juego y ya puede implementarse mediante las técnicas y el método descrito anteriormente.

3.8.4. Implementación de la propuesta. Reconstrucción de volumen 3D

La visión del investigador de crear un nuevo sistema de representación de los diseños en un entorno de RA requerirá de unas gafas inteligentes capaces de capturar imágenes en 360º y con una memoria de almacenamiento considerable para guardarlas (por ejemplo, las gafas *Oculus*). Las imágenes en 360º permitirán al usuario previsualizar el diseño completo antes de su implementación.

Fig. 22. Cuatro instantáneas de la prueba, tomadas en varios momentos y mostrando el mismo espacio antes y después de usar el prototipo. El usuario visualiza la escena a través de las gafas inteligentes. Imagen del autor.

Las imágenes visualizadas a través de las gafas inteligentes representan los diseños realizados mediante *softwares* de diseño vía ordenador siguiendo el proceso de diseño tradicional. A continuación, después de finalizar el diseño y el renderizado, el programa *V-Ray* se encarga de convertir las imágenes en reales para el usuario.

Las gafas inteligentes necesitarán la instalación de un *software* específico que permita introducir el diseño completo en la memoria, con lo cual ya será posible visualizar el diseño en 3D y como imagen real en 360º.

El espacio del diseño se prepara antes de comenzar con el uso de las gafas, empezando por colgar telas verdes o azules por todo el espacio del diseño. Los sensores se colocan en un lugar adecuado para comunicarlos con las gafas inteligentes, para que de este modo el sistema de las gafas reconozca el espacio perfectamente. Posteriormente, el cliente entra al espacio con las gafas puestas (siguiendo el antiguo sistema virtual de Ivan Sutherland) y desde allí el cliente comienza a visualizar su diseño en escala, textura e iluminación real.

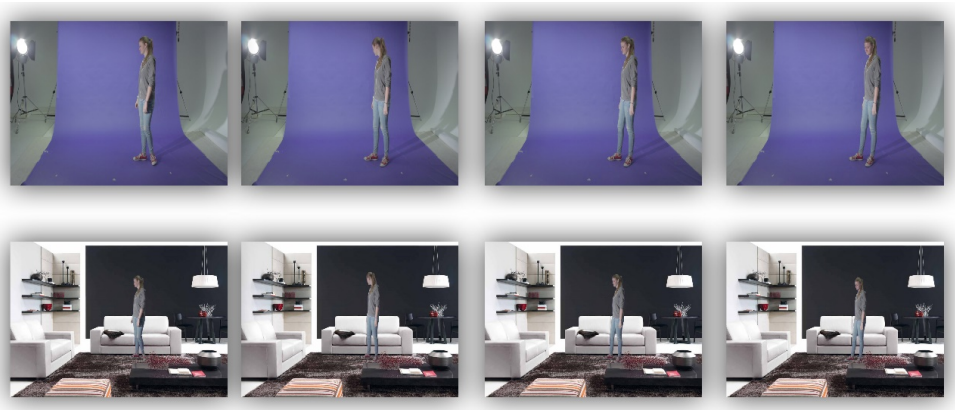

Fig. 23. Cuatro instantáneas de la prueba, tomadas en varios momentos y mostrando el mismo espacio antes y después de usar el prototipo. El usuario visualiza la escena a través de las gafas inteligentes. Imagen del autor.

Este sistema incrementará progresivamente el grado de interacción entre el usuario y el cliente antes de llevar a cabo y diseño, y permitirá también al cliente modificar los detalles que vea oportunos en el diseño bajo la supervisión del diseñador. Todo ello, sin lugar a duda, permitirá economizar los gastos y los esfuerzos para implementar los diseños, así como reducir considerablemente el tiempo de realización de los proyectos.

El sistema funcionará por la interacción entre el espacio y el diseño instalado en las gafas inteligentes mediante los sensores, empezando con la

actualización y la implementación de la información del espacio real con el procesamiento de los elementos virtuales instalados en el dispositivo.

Para que los usuarios puedan obtener el resultado de la escena renderizado óptimamente hay que tomar en consideración las condiciones de luz u objetos circundantes en tiempo real, centrándose más en el diseño realista del interior. Para lograr el resultado, es necesario reconstruir el entorno real en tiempo real y completar la iluminación global para la expresión realista de los elementos virtuales.

Los elementos virtuales prestados en realidad aumentada se diferencian de los elementos de la realidad virtual en términos de método de expresión. No sólo para minimizar la diferencia entre las imágenes virtuales y las reales, sino también para proporcionar a los usuarios una experiencia más real e inmersiva, es necesario hacer que los elementos virtuales contengan la información real en la RA. Para lograrlo, el pre-proceso de reconstrucción de volumen tridimensional deberá implementarse mediante el uso de datos de color RGB y con la información de profundidad del entorno real.

Todo el espacio se reconstruye en una estructura de volumen con vóxels que pueden almacenar los valores de color RGB y un valor de TSDF (*Truncated Signed Distance Function*) para representar la superficie de la geometría del mundo real. Un objeto virtual para ser aumentado debe estar ubicado dentro del volumen reconstruido, después de integrar las coordenadas del volumen con las del espacio virtual (donde existe el objeto aumentado). Seguidamente, el objeto virtual se procesa utilizando la información extraída del mundo real. Para obtener un resultado más realista, este sistema utiliza un método de iluminación global calculando no sólo una luz directa, sino también luces indirectas reflejadas desde el entorno real. Este

enfoque mantiene una gran diferencia con el modelo de iluminación local, que sólo considera la luz directa principal. Para obtener un rendimiento más eficaz de este modelo de iluminación se recomienda un método basado en la radiosidad instantánea[41].

3.8.5. Integración de coordenadas

Durante una estancia realizada en la Escuela Politécnica de Milán, y con el apoyo y la supervisión del Departamento de Diseño de Interiores y los técnicos del Estudio Audiovisual y Efectos Digitales en el centro, el autor llevó a cabo una prueba de la propuesta de investigación, presentando su visión sobre la técnica llave de color en la presentación de un diseño de interiores en 360º en un entorno virtual de realidad aumentada, y con la participación y colaboración de un modelo provisto de unas gafas inteligentes.

Basándose en otros estudios relativos a nuestra propuesta, el autor recomienda trabajar con los modelos RGB-D y HMD (*Head-Mounted Display*), para lograr los objetivos esperados de este prototipo. Para calcular nuestro modelo de iluminación considerando un entorno real, es necesario un ajuste preciso de las coordenadas entre el HMD y el volumen reconstruido.

[41] Keller, A. (1997, August). Instant radiosity. In *Proceedings of the 24th annual conference on Computer graphics and interactive techniques* (pp. 49-56). ACM Press/Addison-Wesley Publishing Co.

Fig. 24. Cuatro instantáneas de la prueba, tomadas en varios momentos y mostrando el mismo espacio antes y después de usar el prototipo. El usuario visualiza la escena a través de las gafas inteligentes. Imagen del autor.

La posición y la rotación de un usuario que usa la grieta *Oculus* con un sensor RGB-D se puede calcular a través de un sensor CMOS con el render virtual *World Space* de un motor *Unity*. Además, se colocará un marcador sobre una superficie plana como una pared o una mesa, lo que ayudará a obtener una posición exacta del volumen reconstruido a nuestro sistema. Si un usuario en el espacio de *Unity* detecta el marcador en la pared, los datos de volumen del entorno real pueden estar correctamente ubicados en la posición relativa respecto de la ubicación del marcador. Previamente, la posición relativa del volumen debe ajustarse manualmente para que coincida con el espacio real y el marcador también debe colocarse físicamente en la posición correcta.

Con el desarrollo y la implementación de la tecnología *Vuforia*, la obtención de todas las coordenadas en el modo render virtual *World Space* resulta una tarea menos costosa. Como resultado, la integración de tres coordenadas (incluyendo un HMD, un marcador y un volumen reconstruido) puede completarse con éxito, aunque no esté disponible un ajuste automático entre ellos.

3.8.6. Conclusiones

Mediante este modelo de representación renderizada de los diseños en 360º, los usuarios pueden localizar los muebles y los decorados creados virtualmente sin ningún tipo de limitación física, con la ayuda de las gafas inteligentes (en nuestra prueba, las gafas *Facebook Oculus*). Además, este sistema permite al usuario medir las dimensiones del espacio, de los objetos e incluso manipular los muebles libremente. A través de estas gafas, el usuario experimenta una experiencia y una interacción virtual intuitiva y natural con el diseño.

El contenido aumentado y la información sensorial del material decorativo-muebles-aparatos para la decoración se puede simular con equipos estereoscópicos especiales, como un prototipo interior AR3D en un sistema ARID para mejorar la comprensión y la participación de los clientes en un proyecto de diseño de interiores personalizado e interactivo.

Este tipo de experiencias llevan al límite el concepto de 'radiosidad instantánea', un sistema de iluminación global capaz de proporcionar a los usuarios una experiencia de diseño interior de un modo realista e inmersivo. Este modelo facilita que el usuario desarrolle una actitud más participativa en todo el proceso, entrando en contacto con el diseño y participando en la toma de decisiones conjuntamente con el diseñador.
De esta manera, el diseñador y el cliente pueden ponerse de acuerdo sobre todos los aspectos del proyecto de antemano, ahorrando tiempo y dinero en el futuro.

RV y RA ya están haciendo un gran impacto en la arquitectura y los espacios interiores de diseño de interiores, y lo han sido durante años. La incorporación reciente de la tecnología sólo servirá para acelerar la tasa de adopción, y pronto es probable que parezca extraño no recibir un paseo

virtual de un edificio o una habitación, o para ver cómo un nuevo sofá va a encajar antes de que alguna vez entre en la casa.

Sin embargo, este modelo presenta algunas desventajas en lo que se refiere a la información del mundo real. La movilidad en un entorno de realidad aumentada es uno de los factores más críticos y complicados en este tipo de sistemas virtuales. Es más, los actuales sensores de profundidad presentan algunas limitaciones en la detección de profundidad de largo alcance, lo cual influye directamente en la capacidad de reunir toda la información necesaria del espacio o la habitación en cuestión. El autor considera importante la necesidad de que las futuras investigaciones sobre entornos virtuales y sistemas de realidad aumentada en diseño de interiores evalúen la posibilidad de mejorar la experiencia de los usuarios perfeccionando la interacción sensores-sistema.

Las entrevistas realizadas a especialistas y profesionales del diseño de interiores revelan que, a pesar de que la mayoría de ellos opina que este tipo de experiencias suponen un trabajo física y mentalmente exigente, en general califican la experiencia en sí como 'agradable, original y curiosa'. El autor considera que este hecho se debe a la poca familiarización de los entrevistados con este tipo de entornos virtuales en su interacción con el sistema mediante sensores.

En esta misma línea, el autor insta a que en las próximas pruebas y experiencias en entornos de realidad aumentada se tome en consideración la importancia de que los participantes o usuarios reciban sesiones formativas para su familiarización y acercamiento a este tipo de entornos.

No obstante, y gracias a la representación altamente realista en la prueba realizada, se puede confirmar que la mayoría de los participantes mostraron unos niveles elevados de implicación y concentración en la tarea, lo cual invita al diseñador de interiores -y al usuario- a mirar con optimismo al futuro, y explotar al máximo el potencial y las innovadoras posibilidades de la combinación de una de las herramientas escenográficas más importantes -la llave de color o *Chroma Key*) con un entorno virtual de RA.

Por su parte, el autor considera de suma importancia que las futuras investigaciones sobre los sistemas ARID en diseño de interiores se enfoquen en el desarrollo de las limitadas y primitivas bases de datos que contienen la información virtual sobre muebles, aparatos, elementos decorativos o iluminación para los usuarios en este tipo de entornos de RA. Todo ello repercutirá positivamente tanto en la reducción de los costes de implementación de los proyectos de diseño de interiores mediante las técnicas de realidad aumentada como en mejora de la experiencia de los usuarios en tiempo real.

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Listado de imágenes

Capítulo IV

THE INFLUENCE OF NEW TECHNOLOGY ON INTERIOR DESIGN

4.1. Introduction

The computer aided designs have a strong impact on the sketching matters and idea generation. The work of designers, with the introduction of computer technology, has been significantly transformed in the contemporary world. Moreover, the modern tools have become indispensable in the lives of designers (Kalay, 2006; Young, 2012). The influence of computers was not felt by the interior design field until the 1970's even though they had been used in the market since the early 1960s.

The creativity and origination of design often becomes complex, when the interior designer becomes engaged in the generation of numerous innovative ideas. Since the creation of idea is vital in the design process, researchers have therefore attempted to gain an insight with the design procedures and the important set of actions associated with this process (Ulrich & Eppinger, 2003).

The ideas are initially defined and then refined with the help of sketches and they are mostly associated with the innovation aspect of design (Plunket, 2009; Purcell & Gero, 1998). A sketch is thought to be the active means to record ideas, whether it is restructuring of plans, acknowledgment of potential conflicts or exploration of opportunities (Plunkett, 2009). For designing an effective and efficient solution, these drawings play an important role in the thinking process of an interior designer (Purcell & Gero, 1998). Besides recording any emerging "mental notes", sketching methods are heavily utilized by the interior design experts to work through design ideas and details (Pable, 2007).

The world has witnessed many inventions, such as typewriters, telephones and personal computers that have changed the way people work and communicate. These items have deeply impacted the global marketplace (Steele, 2012). Thanks to new technologies, interior designers can turn a napkin sketch into a fully rendered 3-dimensional computer model, hence changing the process of designing and communicating as we know it (Johnston, 2010).

Current technology continuously changes the way people live and conduct business. In the 20th century, people witnessed the birth of inventions, which greatly impacted their daily lives, such as the automobile, the television and the personal computer. (Lawson, 2006). These revolutionary inventions' implications often went unnoticed as they were introduced into daily life progressively. In our days, with companies such as Apple introducing new useful inventions every year, new technologies are an expectation. (Lawson, 2006). An interior designer's job does not differ from many others, as it adopts and makes use of new technologies as they appear. The way interior designers do business, communicate with clients have been impacted by these technologies, as have how they generate and communicate new ideas (Kalay, 2006).

A series of decision-making steps called the design process are at the core of an interior designer´s work. These steps are: programming, schematic design, design development, contract documents and contract administration. These steps may not have changed, but the way the designer handles the task has evolved (Young, 2012).

During the design process, designer's distinctive thought processes enable them to create innovative design solutions and meet the clients' needs at the same time. This thought process, known as design thinking, generates

methods that are focused on solutions while offering innovative mindsets to explore and analyze design solutions (Adams, Daly, Mann, & Dall'Alba, 2011; Cross, 2006; Lande & Leifer, 2010; Lawson & Dorst, 2009).

The invention of computer aided tools has made the difficult and laborious tasks of interior designers very easy. In this way, they can concentrate on the creative design activities (McLain-Kark, 2000).

So far, literature is devoid of the research studies, wherein the use of design programs is referred in the design process. Nevertheless, a foundation for this study has been provided by a number of researchers. In design learning, the use of digital sketching has been explored by Meneely & Dakno (2007) while how we can bring improvements in the end user design through computers has been described by McLain-Kark (2000). Moreover, Kalay (2006) is of view that the design profession has been completely reshaped as a result of technological advancements.

Consequently, the computer aided tools have a greater significance in the lives of designers. Earlier, the application of design programs in higher education has been explored by Geist (2011), where it was found that the increased information access is the key source of benefits for the students, while findings on using the several design programs in establishing listening, observation skills and students sketching were presented by Brickley (2012).

The practitioners' use of design programs is not directly investigated by any of these studies. However, it is learned from these studies that how information is exchanged with the help of design programs. The technology is playing a central role in the actions and thinking process of designers, while the phenomenon of the design programs and processes can be better understood by gaining an insight with the idea generation mechanisms.

4.1.1. Generating and Literature Review

The existing research on this subject has been found by utilizing a number of databases. The Scopus, Web of science and Google scholar were the core databases that were used. In addition, the researchers also used some books, publications, such as, International Conference on Human-Computer Interaction, HCI, International Conference on Materials Engineering for Advanced Technologies, ICMEAT and International Conference on Machine Design and Manufacturing Engineering, ICMDME.

Different journals were employed besides searches on these databases and the given below concepts were also used.

3D Technology

Interior Design

Design thinking

Design process

4.2. Review of Literature

Besides the impact of technology on the field of interior design, the importance of design thinking for an interior designer and the process of design would be delineated by this review of literature. Moreover, this section would discuss the aim of the study and research questions posed in conjunction with the use of 3D technology in professional practice.

4.2.1. Design as Process

Design Thinking

According to Tim Brown, President of IDEO (International Design and Consulting Firm) and CEO (Chief Executive Officer), design thinking is described as a field in which the techniques and sensibility of

designer are utilized to match a people's needs with practicality and technologically achievable strategy. Lawson (2006) points out that thought processes which detect and understand design problems besides creating design solutions are included in design thinking," (p. 9). The expression about the design itself, fostering creative thinking, exploration and developing new innovative plans are collective parts of design thinking process. Creative solutions to the given problem are provided by the innovation conceiving from this thought (Connell, 2010).

According to the findings of Brown (2009), when people use the design thinking both as a business management and creative strategy, it goes together with a series of three main principles. These principles and the phases of design processes have a close similarity, i.e., without a clear beginning and end and they often intersect with each other. The three principles are "*inspiration*, the opportunity encouraging the search for solutions; *ideation*, the course of producing and testing ideas; and *implementation*, the route track that leads from the project room to the industry" (Brown, 2009, p. 16).

More innovative ideas that can be implemented into business management and product design would be produced by these processes keeping in view the motivation and needs of customers (Wattanasupachoke, 2012).

The cyclical nature of the design process is simulated by the iterative nature of the design thinking phases, where this idea is corroborated that design thinking is a fact-finding process. New information is revealed by this process when it is applied accurately (Brown, 2009). The interior designers are pragmatic, innovative, functional, imaginative, technologically driven,

culturally and aesthetically sensitive (Dohr & Portillo, 2011). "Design thinking is in fact the ability to envisage the possibilities others can't imagine, to see the things missed by others, and to show how out-of-the-box options can perform functionality" (Fisher, 2010, p. 65). A major attribute of design thinking is imagining the future, even while knowing the uncertainty of future and what it holds is not yet in reality.

A number of well-respected design scholars are of view that designers can realize the interaction of people within the interior environment because of design thinking. Due to this, the problem-solving skills of interior designers have been deeply observed by the researchers. Concerning the design process, Connell (2010) defines the design thinking as "a language, a method and a protocol" (p. 67) wherein the "planned, ingenious, applied and pragmatic goals and objectives" are analyzed by the designer (p. 68), which are presented by the design problem. This thinking process shows the insight of designers with the system and they how they perform the act of designing (Adams, Daly, Mann, & Alba, 2011).

The skillset the international community is keen to acquire is the capability of designers to think productively while mutually solving the problems (Burdick & Willis, 2011). A foundation for research into design thinking is provided by these core skills besides its various functions within design processes.

As per the outcomes of research, it has been learnt that the data acquisition procedures, from which the designers obtain the information, are thought-provoking and of greater significance within professional business sectors (Clark & Smith 2008; Dorst, 2011; Wylant, 2008).

According to the study done by Dorst's (2011), vital patterns of design thinking have been explored, which can be used by modern businesses to address their issues.

Further the working pattern of designers was analyzed besides the implementation of some of the amazing designerly practices, since open and complex problems have been managed by the designers over the period of some decades. Moreover, professional practices have been established by the designing disciplines. A particular interest is usually emerged by handling the aforesaid problems in the ways designers develop and in the way the working [problems] are handled by the design organizations (p. 522).

From the critical analysis of various ideas, the insight of designers with the innovative design solutions is revealed (Fisher, 2010). A platform for employees for the idea generation is provided by the integration of the knowledge and problem-solving skills used in the design thinking (Burdick & Willis, 2011). A number of entrepreneurs describe this phenomenon, where the consumer needs are identified, as a competitive strategy (Wattanasupachoke, 2012). While generating innovative solutions, the designer is provided with a solid ability to critically evaluate the pros and cons of ideas as a result of interconnection of design thinking attributes.

4.2.2. Process of Design

Frequently termed as "a systematic arrangement of steps or phases" (Piotrowski, 2011, p. 14).

A logical and coordinated methodology of research, exploration and knowledge integration is referred to as the design process (Kelly, 2013). By taking into account the design process, the designer is usually enabled to gain an insight with the dynamics of complex projects (Poldma, 2009).

A minor change in how the designers handle the projects has been caused by these complex undertakings. Nevertheless, there is no variation in the five phases of the design process as yet. Acquisition of written and pictorial information for its onward application in research and analysis is included in "*Programming*" and its purpose is to understand the needs of clients in a better way. The client's goals and objectives can be met by defining the limitations and project scope (ASID, 2007; Kelly, 2013; NCIDQ; Piotrowski, 2011; Poldma 2009). The design process begins similarly as that of the design thinking as both starts with understanding the client's needs (Wattanasupachoke, 2012). Besides shifting the focus from problem analysis to conceptual studies, the formulation of preliminary ideas and plans is included in the *schematic design* stage. The matrixes, bubble diagrams and sketches are used to convey the idea generation. These are some of the first visual documents that are created for client review.

In the phase of *design development*, the project is moved into decision making stages where the experts refine the ideas with supplementary detail. The creation of detail drawings is happened with the integration of materials, finishes and furniture. At this point, they produce the *contract documents*, in which specifications and construction drawings are mentioned on the basis of all previous decisions.

The final phase where the biding of project is done and construction is started is referred to as the "*Contract administration*" (ASID, 2007; Kelly, 2013; NCIDQ; Piotrowski, 2011; Poldma 2009).

Often the process of design becomes multifarious and sophisticated (Lawson, 2006). The project convolution is reflected by the complexity of the design process, which is handled by an interior designer while working with

the built environment (ASID, 2007). Ability to design is not bestowed by nature, but it is the one, which is learned and refined with practice and education (Poldma, 2009). Both the material and immaterial aspects can be observed in the design process (Poldma, 2009). Moreover, the problems in this regard can be solved in an innovative way with the help of artistic and technical knowledge.

The design process is iterative in nature, which is its beauty that empowers the designer in multiple ways. As a result of recurring design process, the designer moves through design problem in so many ways to reach the efficient and successful solution besides allocation of specific interior spaces.

The process successfully moves forward with the utilization of such phases and it is also ensured that the problem is successfully solved besides taking all the required steps (Piotrowski, 2011).

To show the development of their design solutions, the design process is used by a number of design disciplines (engineering, architecture, interior design, and so on). According to Ellen Shoshkes, "the design of the process must be given equal importance as that of the form" (Poldma, 2009, p. 8). The fundamental theme binding the industries together is the design process even though variable structure is practices by each firm.

4.2.3. Idea Generation in Design Process

The generation and development of ideas is generally assumed as the idea generation. Jonson (2005) was of the view that the fundamental element of a thought, which is visual, immaterial or concrete is referred to as an idea. In addition, idea generation is likely to trigger all the projects and

subsequently these ideas need to be defined and refined (Plunkett, 2009). The core of every design solution is the multiple thoughts put on paper that result in the generation of ideas, i.e., rough and raw. The tone for the project is set by these initial ideas. Since this tone moves forward and a foundation is provided for the design approach (Rengel, 2007).

At the commencement of the design problem, idea generation (located in the schematic design phase) is happened when the concepts are explored by the designer besides conceptual imagining of potential solutions (Dorta, 2008). The data is analyzed by the designer and suppositions are made about ideas for their further analysis while design decisions are not made during this stage (Dorta, 2008). Subject to client needs and research findings, multiple ideas are explored and analyzed at this point. Moreover, the logistics from the start is understood by its critical interior designers owing to its location within the design process (Poldma, 2009). Idea generating techniques hold greater importance, since the design creativity and innovation is fostered by these techniques (Smith, 1998).

According to Plunkett (2009) the given below is specified regarding idea generation in design:

A drawing merely doesn't hold the potential to make good interior design; it is an idea that matters. An idea is initially a vague image that exists in the imagination for a moment and subsequently the holder of that idea refines it in a series of steps. The correct detection of that image is basically the designing: Its accurate image, its exact form, its keen observation and its genuine value can only be realized after sequences of attempts are made. Progressive movement is then made in the objective decisions through which the ideas are finalized and later on these are communicated to builders in the form of instructions and to the clients in the form of drawings (p. 6).

The need to gain an insight with the idea generation process has been identified by Shah, Kulkarni, & Vargas-Hernandez (2000), Gero (2000), Shah, Vargas-Hernandez and Smith (2003). In addition, researchers have keenly observed the creative thoughts and processes used by a designer in the development of ideas (Weisberg, 1999). Ulrich and Epplinger (2003) affirm that amazing thing in design research is idea generation, often surrounded by the conceptual design process; as such an influence on the future product is not maintained by any other design phase.

The most creative drawings are believed to be the collaborative early drawings of idea generation even though all drawings have equal importance in moving forward the project. The preoccupied exploration of ideas can be further analyzed and the same is enabled by employing the design thinking methods (van der Lugt, 2005).

4.2.4. Creativity in Idea Generation

The generation of idea and creativity are directly associated with one another. According to Cox (2005), new ideas, new problem-solving techniques or ways of envisioning new opportunities are directly formed by creativity. Creativity is an indispensable ability where the idea generation has a supreme importance (Pedersen & Burton, 2009; Piotrowski, 2011). Idea development is a routine task of many interior designers, which is not an easy activity because it involves analytical and logical skills.

The creative person, the creative process, and the creative product are believed to be the three dimensions, which have been discussed in the literature based study of Dohr (1982). As per the findings of Lauer & Pentak (2008), three simple acts are emphasized in the creative process, (a) thinking, (b) looking, and (c) doing. As far as the iterative steps happening to stimulate

creative thought processes are concerned, a solid foundation is provided by both Dohr (1982) and Lauer & Pentak (2008). Imaginative thinking lies at the core of how interior designers function and generate. When a project is assigned, exploration of new methods is naturally started by the designers to create object or space. Moreover, they find logical solutions to the problems or they start transforming the existing items to bring the improvements (Piotrowski, 2011, p. 7).

For the project, new possibilities are continuously being discovered by the interior designers as they are absorbed in thought processes and subsequent exploration of idea (Plunkett, 2009). When many ideas are generated, it must be understood by the interior designer that most of the materialized ideas will not come to realization, but he makes advancements to reach a final conclusion. The current ideas would have certain shortcomings and the existing ideas would be developed by the new ones. Hence all the roles are contributing for the final design solution (Plunkett, 2009). In addition, the designer comes to know that it is not the quality of the drawing, but it is the content of the ideas that matters and produces great design.

4.2.4.1. Drawing Processes

The most effective and the quickest means to visualize the thought processes of designers is the production of a drawing and the same is indicated by the Won's (2001) study on the link between visual thinking and drawing. The structure of drawing generated by a person is generally resulted in the design thinking, idea generation and communication of those ideas.

4.2.4.2. Sketching

An ordinary way to generate, adopt or communicate ideas to a client or project team is referred to as the sketching (Dorta, 2008; Jonson, 2005). The

additional insights on the idea generation process can be obtained by a deeper interpretation of sketching and its creative processes. Meneely & Danko (2007) pointed out that the basic way to communicate creative ideas is the handmade drawings. “In the initial sketch drawn by the designers, a more refined shape is then given to their first thoughts before presenting it to someone. Moreover, “a smart way of communication with other members of the design team is referred to as the freehand sketch” (Plunkett, 2009, p. 79).

There can be a number of shapes of the drawings; initially they are more abstract. Subsequently, they are transformed into a feasible design idea. With the progress in the design process, sketches turn out to be more organized and detailed information and good understanding of the project can be acquired (Purcell & Gero, 1998). The detail drawings produced in later stages, for instance, construction drawings, are not included in the early drawings (Plunkett, 2009).

From generations to generations, the field of interior designing and architecture is witnessing the two- and three-dimensional sketches along with their useful designs. The new insights and innovative findings of the designer can be conveyed by an imprecise hand sketch. It is the preference of an artist to focus the objects by maneuvering the drawing tool (pen, pencil, etc.). To gain an insight with the specific areas, the information can be selectively filtered by the interior designer with focus being reduced from undesirable drawing details (Pable, 2007).

4.2.5. Practitioners Use of Drawings

During the design process, the design professionals use sketches for many things, such as creation of an idea, elevation, floor plan, perception or the point they are communicating. Sketches are generally connected with the

schematic generation of ideas just like the technical drawings (such as, elevations and sections), which are concerned with later design phases. Idea producing drawings should be natural, free flowing and abstract to a certain extent, through which the creative process can be indicated (Plunkett, 2009).

The vague ideas are captured by these unstructured drawings, which can only be created with the freehand sketch (Gross, Ervin, Anderson, & Fleisher, 1988).

Jill Pable from Florida State University had performed a research survey in 2007 which can be helpful in understanding the perceptions of hand sketching related to the design professionals. During the findings of survey, 86 percent of the respondents were of view that sketches should be employed while developing the design solutions, while it was felt by 76 percent of the people that designers while developing a design solution can gain an insight with the big picture through quick 3D sketch.

As far as client communication is concerned, various benefits of sketches are quoted by the experts. Besides the use of sketching, a survey on views of experts has been carried out by Pable's (2007), wherein it was indicated that "an essential dialogue with a client is provided by the sketches to communicate feel and intent" while it also provides a way to "foster innovative thoughts, cognitively manage multifaceted projects and allow productive communication with clients and colleagues" (p. 11, 19). Consequently, it was pointed out by Pable (2007) that clients become well informed as a result of this practice while explaining any design confusion, and where the immediate feedback is also prompted.

4.3. Technology in Design

4.3.1 Technology and Creativity

The long-established means of sharing information and ideas have been reshaped by the computer technologies (Kalay, 2006). The thinking patterns and actions of people within the design process have also been transformed. According to Nelson (2010), technology is somehow connected with the creativity, where each one is outperforming the other one and vice versa at one time or another. Nelson (2010) advises that the creative process is being overshadowed by the technology in last two decades, which is triggering great concern among the concerned authorities.

Most of the designers have the ability to imagine and see the pre and post stages of interior environment in the practical life (Fisher, 2010). Moreover, they have been categorized as visual and holistic thinkers. The fact that technology and tools enable the designer to still be a creative visionary is supported by the Meneely & Danko (2007). However, in the modern era, the artistic and technical means of thinking is now being utilized by the designer.

According to Nelson (2010), enhancements and uplifting of the design process can be better understood by this instinctive need to visualize the problem. Moreover, it is revealed by the history that new technology initially becomes an improvement to tasks and then an important associate. Since a key predictor of the future is none other than technology, the link between creativity and technology envisages / foresees the collaboration of interior designers with the design processes. More time can be allocated to the interior designers and their creative decision-making processes through which quality ideas are subsequently yielded with interior design practitioner's workflow being transformed by the technological advancements.

4.3.2. Technologies Role in Design Process

Technology and modern tools are completely reshaping the profession of interior design, where a key role is being played by the technology in the daily design processes (Dale, 2010). Besides the generation and transformation of ideas, the speedy disposal of tasks is now possible with the help of technology, which seemed to be an unattainable thing in previous decades. Now, it is the time of initiating a new project with a clean desk, where tracing papers are quickly diminishing and a blank computer screen has now emerged in place of old stuff (Brody 2010).

Johnston (2010) is of view that three critical roles are played by the technology in the design process, which are: automating manual processes while developing accuracy, facilitating and improving communication and ideation. The designers can now easily and efficiently accomplish the activities and task, which were laborious and took week long efforts. Great thanks to technology, which has blessed the designers in the design process. Leading-edge technologies have been integrated with the workflow based systems of the firms across the globe (Kalay, 2006; Young, 2012). In general, it is established that the interior designers have been "released from the labor of production" in most aspects of the design process (Johnston, 2010, p. 207). Nonetheless, the new comers must initially master the traditional design techniques, for instance, hand drafting as the base of knowledge, which must be afterwards integrated into digital recreations.

4.3.3. Evolution of Practitioners Workflow

Usually, the workflow of design team has not been collective, since one professional generally completes his job before handing it over to the other professional for the accomplishment of his/her task (ASID, 2007). The buildings are developed as a result of this workflow, which are readily

accepted, but provide little originality. As per the American Society of Interior Designers (2007), the relations among building systems and the team members designing and deploying those systems are recognized by the integrated and collaborative design processes" (p. 5). While establishing innovative built environments, the technical, organizational, interpersonal and managerial skills all are very important and all should be observed simultaneously.

As the design process includes different user roles, candid communication and teamwork among all team members, particularly in the early design process, has been strengthened by the introduction and integration of the BIM (building information modeling) technology in the late 1980's. As per the American Institute of Architects (2007), the design technology, erection instructions, fabrication information and logistics concerning the project management can be integrated in one database by the BIM. Moreover, a platform for collaboration throughout the project's design and construction is also provided by the BIM" (p. 10).

Constant change and evolution is being observed in the design industry, when the design professional have to generate modern designs quickly and more proficiently (Horst, 2012).

According to the American Institute of Architects (2007), the IPD (Integrated Project Delivery) "is a project delivery approach, wherein the individuals, systems, best practices and business structures are integrated into a process that collaboratively connects the insights and talents of all participants to enhance project outcomes" (p. I). Acknowledgment of the collaborative nature of the design process has resulted in the integrated project delivery and the importance of technology in the design process is

better reflected by the integral role played by each professional from the project outset. The ASID (American Society of Interior Designers) and the IIDA (International Interior Design Association) are the two significant players in the design profession, who conforming to the IPD principles have also acknowledged this change in design professionals' workflow.

Firms all over the world implement the IPD, which is beneficial for design professionals, since they can emphasize on general project outcomes by observing and fulfilling the missing links. In this regard, the professionals who were not previously involved in early design stages are included this time (AIA, 2007; ASID, 2007). Due to this transformation, the individual success is least emphasized and all the major focus is given to overall project outcomes, which yields from joint efforts. The brainstorming sessions can now be remotely conducted by the professionals throughout the world, as a result of which, inventive and well-informed design solutions are produced (Dale, 2010).

The interior designer has a diverse and collaborative working relationship with professionals irrespective of the stage of the process (Mitton, 2008). The idea exchange and immediate information is enabled through the interaction between the design team, drawings and client. Johnston (2010) is of view that one unquestionable benefit of integrated project delivery is the increased communication among engineers, a designer, suppliers and clients. In this modern time, nature of projects is often complicated with tighter budgets and inflexible time frames. Thus, efficient communication is of key importance in overall project management.

4.3.4. Software Used in Design Practice

During the course of design processes, the interior designers can use a number of available software options. According to Brody (2010), the designers have discovered five basic types of software subject to expenditures, skills and interoperability.

4.3.4.1. Microsoft Office Suite; office management tasks.

Besides data management, a set of programs for word processing, presentations and creation of spreadsheets are collectively included in the Microsoft Office Suite. A user-friendly interface is associated with all these programs, in which the users can easily perform their activities in the presence of a clean interface (Brody, 2010). To ensure easy interoperability, similar interfaces have now been incorporated by Autodesk.

4.3.4.2. Autodesk, Inc. AutoCAD; architectural drafting.

Due to enhancement and effectiveness of computer aided-drafting (CAD) jobs of making and editing handmade pictures that used to be completed in months or weeks presently take hours and days to complete (Johnston, 2010). Computer-aided drafting is considered as an accurate way of working as compared to hand drafting it ensures smooth handling while carrying out space designing. Modifying is very rapid and effective where several productions are made quickly for the purpose of distributing (McConnell & Waxman, 1999).

CAD was introduced at the start of the year 1960, though its wasn't much used in the field of engineering, construction, and structural design, these fields introduced CAD properly in the year 1980 (McConnell & Waxman, 1999). During this period, CAD evolved as extremely popular

technology because of its cost-effective software and parts. Since decades, famous application CAD known as Autodesk's AutoCAD have helped the users to carry out process of design and at the same time without affecting their arrangement (Taute, 2005). Cutting edge technology is extensively used as a drafting criterion and it has caused a wave of panic among conventional designers.

4.3.4.3. Google Sketch Up; three-dimensional sketches.

This technology is "is termed as an instinctive, simple to grasp 3-D tool which is utilized in the conceptual phases of design" (Johnston, 2010, p. 208). Its invention made it clear that AutoCAD is rapid simple means of carrying out visualization (Johnston, 2010). It helps the brain to innovate and discover new ideas, as it helps in conceptual drawings therefore since a long time it is considered as simple to operate and three-dimensional modeling technology. This technology concentrates on faces of object not on solid modeling. As a result of this feature, the size of the drawing is decreased and because of it, the designer can easily plan the design and thereby eliminating the longer regeneration time of BIM programs. It has become most preferred modeling tools of architects and designers due to its cost effectiveness (Stine, 2012). Moreover, for making drawings and helps in its effortless incorporation into Revit Sketch Up and it can be exported into AutoCAD (Stine, 2012).

4.3.4.4. Autodesk, Inc. building information modeling (BIM) REVIT software; computer modeling.

Several people can perform task at the same time on a project that aims to identify issues before starting implementation through using Building information modeling (BIM) software, like Revit (Dale, 2010; Johnston, 2010; Maresh, 2010). People who work on different aspects of one project of

drawing can now carry out modifications at the same time inside the model (Dale, 2010; Maresh, 2010).

BIM permits the designers to consider several design alternatives and all of them together.

Designers and architects can examine different models of designs with the customers due to the capability of BIM to study and demonstrate ideas of design as per Rundell (2006). Due to this, time is decreased to accomplish the agreement on a 20-particular design. In addition to this, BIM is considered as useful for converting the design mindset into competitive advantage for interior design industries (p. 4).

Each component and part of a building such as fittings, constructing and finish materials and modeled three-dimensionally giving the designers an overview of what things are required and their amount.

4.3.4.5. Autodesk. Package, 3ds MAX, Maya, V-Ray

Previously it used to be called a "3D Studio," is a 3D modeling, rendering as well as an animation software from the Media and Entertainment section of Autodesk. It is extensively utilized in the department of game development, creating visual effects in films. 2D figures can be created which help to form 3D designs by using the software these designs are used create architecture and interior models. The software comprises of an animation facility whose task is to inverse kinematics that connects the parts in order to create movement, and also includes the effect which brings a character to existence. 3ds Max was under the brand name of Autodesk's Discreet till the year 2005.

4.3.4.6. Adobe Photoshop; Photograph and Sketching Manipulation.

This technology is raster-based and supports image processing that can deal with different image formats that can generate high-quality pictures which can be utilized in several presentation drawings. Pictures can be molded in a manner facilitating the designers to deliver the accurate color, consistency and degree required by the customers by just pressing a button. Study has confirmed that designers should select the best kind of software for the project with immense care (Kalay, 2006; Plunkett, 2010). According to Plunkett (2009), designers who make use of software artistically are believed to reflect their mindsets and thoughts in a more precise manner" (p. 10).

The solution to smooth incorporation of technology is considered as the capability of the designers to make a holistic three-dimensional visual illustration of the internal surroundings and keep away from a 2D floor plan (Taute, 2005).

The research carried out by Trueman in the year 1991, the experts stated that more focus should be given to usage of technology and carrying out design projects. A competitive advantage can be gained by the company through finding out the flaws in the design and removing them by using the technology. Though, as per Trueman and other researchers, use of multiple technologies must be done in the design phase and appropriate technology must be used for the tasks.

A detailed case study was carried out by McLain-Kark (2000), he examined the usage of computer technology in designing tasks and how the above-mentioned technologies can be used. An example was given of how to make best use of technology in the project of design through analyzing its process of utilization in order to make good designs for customers by The

EPA project by Hellmuth, Obata, and Kassabaum, (HOK). The significant usage of technology in the field of interior design and how it creates a good relation among a customer and a designer by setting interior environments was confirmed by McLain-Kark (2000). Adequate usage of this technology can create a good effect on the design process.

As compared to other phases the working of the designer is different in the ideation phase. It is not observed in many of the CAD systems. Despite of several enhancements in the CAD systems in the past years, usage of traditional ideation tools by the designers is still done. As compared to CAD free hand sketching is preferred more (Bilda, 2003). Several researchers studied the contribution of sketching (Goldschmidi, 1995, 2003. Schutze, 2003).

Systems that give means for digital sketching and other things required for are constructed (Sapir, 2007) and the needs for conceptual design system are mentioned (Wiegers, 2001). Ideas can be bought into existence by the designers through utilizing these tools. These ideas assist them in thinking process and to look a person's exteriorizations and improve their visual insight. Latest options can be discovered through exteriorization of ideas and its awareness (Menezes, 2006. Straight, 1976). Reflection in an action is backed by them are explained as important for the design process (Schon, 1992. Valenburg, 2000). Designs can be created by imagining them this eliminates the use of tools and it is quite usual (Bilda, 2006. Athavankar, 1997).

4.4. History of 3D Technology on Interior Design

At the beginning of the software of Auto cad, small history regarding 3D technology on interior design is mentioned.

CAD technology is being used by the architects since the year 1980 as per the automotive engineers and aerospace. Distribution of computers used by common man and after it computers were sell by the companies for experts and the requirement of CAD departments was eliminated and enabled the designers to use them for their work purpose. After some time, the requirement of 3D professional technology was raised. In the year 1980, this technology became popular for the purpose of rendering the solid model and to make 3D representations of product as well as design components.

Developers of software manufactured software which can present the designs in a 3D format therefore removing the need of imagination of the visualization of a component in reality. Fast prototyping along with 3D printing was developed due to presence of 3D CAD.

CATIA Version 1 by Dassault Systems is known as the first well designed 3D modeling technology in 1982. It was utilized by firm of Frank Gehry in order to build and carry out testing for Disney Concert Hall in 1989. Moreover, by help of a digitizer physical models were reverse-engineered. And it was incorporated into 3D software. For the purpose of modeling the whole exterior of the complex use of CATIA was made.

With the growth of technology, organizations of interior design had a great demand for robust and secure computers which can implement 3D modeling visualization. When the first version of AutoCAD launched in 1982, the organization started work in the area of 3D modeling and turned out to be a strong competitor in the department of digital representation, system expansion along with form-finding. After it there has been large number of inventions of such software. One of it is Graphisoft's ArchiCAD which is mainly popular in Canada as well as in US, Autodesk's 3D Studio, as well as

Revit Technology Corporation's Revit. In addition to this Nemetschek AG came in the year 1997 having CAD/CAM software for CNC machining and different tools for digital fabrication coming in conventional market in coming time.

To cope with latest technology in everyday routine has led to innovating and discovering new inventions and perform more work on this aspect to accomplish the aims and to achieve cost effectiveness and save time and energy to obtain good outcomes to introduce our designers as interior designers (Article brought by HP and Intel, 2014)

It is significant to keep in mind that designers who are unfamiliar to latest technology find it difficult to handle tools and design components (Brandon & McLain-Kark, 2001). Ideas can be immediately tried by clicking a button. A distraction in this work can lead to divert mind away from the concepts of design thinking process (Dorta, 2008).

4.5. Purpose of this Study

The motivation behind this exploration study is to investigate how inside originators make utilization of 3D innovation amid the outline procedure. It is specifically compelling to break down whether and how plan professionals utilize configuration programs while producing new thoughts for a customer amid the schematic outline stage. Seeing how inside architects utilize this innovation amid the outline procedure may offer experiences on their procedure of receiving new innovation. Moreover, this review likewise offers data concerning the path in which inside outline may improve or undermine the inventiveness utilized for the era of thoughts.

4.6. METHODOLOGY

This section will talk about the subjective research techniques used to accumulate information in the investigation of how inside outline specialists utilize 3D innovation amid the plan procedure. Moreover, examining systems, information examination strategies and study impediments will be talked about. Interpretive phenomenological look into examination will be inspected, as this strategy is the establishment of the led exploratory review.

4.7. A Phenomenological Method

The reason for this examination study is to investigate how inside architects make utilization of 3D innovation amid the plan procedure. It is exceptionally compelling to break down whether and how plan experts utilize configuration programs while producing new thoughts for a customer amid the schematic outline stage. Seeing how inside originators utilize this innovation amid the plan procedure may offer bits of knowledge on their procedure of embracing new innovation. It additionally expects to decide if 3D innovation produces more work and whether this sort of innovation enables inside originators to spare time, exertion, and cash. What's more, this review additionally offers data concerning the route in which inside outline may upgrade or undermine the innovativeness utilized for the era of thoughts. What number of various 3D displaying programming do they use amid the plan procedure? Do they begin by utilizing this sort of innovation to create new thoughts for customers of do they take after the conventional procedure, i.e. beginning with a drawing or some preparatory representations for the customers or educators?

This phenomenological examine enabled the specialist to build up an understanding in view of the encounters and impression of a few people who have lived encounters with this marvel (Creswell, 2007). Phenomenology, which has its foundations in logic, was proposed by Edmund Husserl as a technique for logical investigation into the idea of cognizance or of human experience. Initially used to study reasoning and philosophy, it now traverses into brain research underscoring awareness and human discernment (MacDonald, 2001). Creswell (2007) portrays phenomenological inquire about as concentrate the significance of encounters for "a few people of their lived encounters" (p. 57). By dissecting comparative encounters through different 33 clients, a typical experience, or wonder, was characterized offering understanding on the outline questions postured (Creswell, 2007).

An Interpretive Phenomenological Approach (IPA), a rendition of the phenomenological technique established in brain research, gave facilitate understanding into the examination members' involvement with the 3D innovation from their point of view. Jonathan Smith, the author of interpretive phenomenological examination characterizes IPA as
"An endeavor to unwind the implications contained in… records through a procedure of interpretive engagement with the writings and transcripts'. Such engagement is encouraged by a progression of steps that enables the specialist to distinguish subjects and coordinate them into important bunches, first inside and afterward crosswise over cases" (Willig, 2001, p. 53).

This branch of phenomenology is worried with catching every individual member's encounters with the current subject while attempting to unwind the mind-boggling importance inside (Willig, 2001).

Interpretive phenomenological examination concentrated on chiefly open-finished, non-order inquiries questions enabling the scientist to better comprehend the member's reality. With the members being given a chance to impart their encounters to the topic, the specialist was then furnished with a chance to increase further understanding by empowering member elaboration on the topic (Willig, 2001).

Because of the subjective research outline of this review, this technique was fitting as the specialist was hoping to pick up understanding on how plan professionals utilize 3D innovation in the outline procedure and their encounters with this sort of innovation.

The reason for a phenomenological study, for example, this was to depict the marvel being referred to, as well as to decipher the implications behind it too (Creswell, 2007). 34 Phenomenology enables scientists to recognize people's impression of a reality and the truth itself (Willis, 2007).

4.8. Procedures and Research Questions

4.8.1. Participant selection

The principal sort of meetings were In –depth interviews directed with six inside plan teachers and four experts who each have their own particular studio. Every one of the meetings were done face to face, which enabled the questioner to record his discoveries. All the talked with teachers work at the University of Politecnico di Milano in Italy and the experts have their claims studios in Milano-Italy.

The second sort of meetings are semi-organized meetings of thirty understudies in the main year of Master's of inside plan at the University of Politecnico di Milano.

4.8.2. Interview Questions

Interviews led with teachers and experts utilizing a subjective research technique are by and large contained open-finished, top to bottom, unstructured inquiries that incite the members experience, conclusions and perspectives (Creswell, 2009). Interviews led with understudies utilize a similar philosophy in spite of the fact that the structure of the inquiries is changed. For this situation, the inquiries are semi-organized keeping in mind the end goal to make the inquiries simpler to answer and consequently accumulate a most extreme of information.

One of the members did not have room schedule-wise to answer the inquiries face to face as she was extremely occupied on another venture. She wanted to answer the inquiries at home. The specialist sent her the inquiries in a Word record and she sent her answers in a Word document. The various meetings with teachers and experts were directed vis-à-vis, all together for the scientist to get the greatest from the members. Each meeting kept going in the vicinity of fifteen and forty-five minutes.

On account of the understudies the meetings were led taking after a progression of inquiries and answers and the specialist was available while the understudies were replying.

Each gathering was solicited three sets from inquiries with a specific end goal to enable every member to express their feeling, perspective and possess understanding.

4.8.2.1. Group number one: PROFESSORS.

The participants in this group were asked a series of questions to better understand their use of 3D technology in the field of interior design. The first question addressed topics such as the impact of 3D technology on interior design in the final result.

The second question was: Do you think that 3D technology allows designers to save time, effort and money? (Motivate the answer).

The third question was: What would the discipline of interior design be like without this kind of technology? The fourth question was: Do you think it is necessary to learn how to master this type of technology to be a good interior designer? (Motivate the answer).

The questions of the second part of the interviews were about knowledge of this kind of technology. The first question was:

How many 3D modeling softwares do you use and which? The second set question was:

Do you think having some knowledge in this kind of technology helps to get more work? The third question was:

What value do you think students place on 3D technology as a representation of the quality of their design? The fourth question was:

How do you think students view computer technology's role their design thinking and their design products? The fifth question was:

How would you describe your own skills in terms of computer technology? The sixth question was:

How do you use these programs in your design process? Could you explain?

4.8.2.2 Group number two: PROFESSIONALS

The participants in this group were asked a series of questions to better understand their use of 3D technology in the field of interior design. The first question addressed topics such as the impact of 3D technology on interior design in the final result.

The second question was:

Do you think that 3D technology allows designers to save time, effort and money? (Motivate the answer).

The third question was:

What would the discipline of interior design be like without this kind of technology? The fourth question was:

Do you think it is necessary to learn how to master this type of technology to be a good interior designer? (Motivate the answer). The questions of the second part of the interviews were about knowledge of this kind of technology. The first question was:

How many 3D modeling software programs do you use and which? The second set question was:

Do you think having some knowledge in this kind of technology helps to get more work? The third question was:

Do you prefer to draw or make some preliminary sketches for your design first? Or do you prefer to directly start working with the programs? The fourth question was:

How would you describe your own skills in terms of computer technology? The fifth question was:

How do you use these programs in your design process? Could you explain?

4.8.3. Group number three: STUDENTS

The participants in this group were asked some questions in the form of a multiple-choice questionnaire. The other questions were open. The number of participants in this group was much higher than the other groups, which made the researcher opt for the questionnaire format in order to better understand their use of 3D technology in the field of interior design. The first question was: How would you describe your own skills in terms of computer technology?

A. Poor

B. Good

C. Advanced

D. Other (specify)

The second question was: What computer software programs do you use in your design process? The third question was:

In an ideal design process, for which activities/phases would you use digital media and for which would you use manual techniques? The fourth question was:

How do you use these programs in your design process? Could you explain? The fifth question was:

Do you think it is necessary to learn how to master this kind of technology to be a good designer?

Yes (specify)

No (specify)

The sixth question was: Which do you prefer?

A. Drawing or making some preliminary sketches for your design first

B. Starting to work directly with the software programs

C. Other (specify)

The seventh question was: What do you consider to be the benefits of using 3D technology in the design process?

A. A good display for your design

B. Saving effort and time

C. Increase in sales

D. Other (specify)

The eighth question was: Is there a specific program which you found the best in assisting you in the design process?

The ninth question was: Tell me about some of your research strategies when you need/wish to develop a new concept (object). (Based on #d technology on interior design)

4.9. Data Analysis

This investigation is to be keen on exploratory research, as its motivation is to find subjects that could in the long run be expounded in real detail in future research on the point the rationale of this examination is to enhance see how inside creators at present utilize 3D innovation in the outline procedure and for the era of thoughts.

It was the protest of the review to utilize Interpretive Phenomenological Analysis (IPA) for information investigation. IPA works with participator talk with transcripts wherein the four stages of IPA examination help distinguish suggestion and shared opinion among the accumulated information. In the initial step, the specialist read the meeting transcripts exclusively and took noticed that reflected starting contemplations and perceptions the analyst wished to record because of each meeting transcript. From that point, the second step required the specialist to recognize, name and order ideas and expressions from every individual meeting transcript by separating the segments of content. Thirdly, the scientist coordinated further structure into the individual meeting

examination by posting the recommendation and dissecting them in connection to each other. These associations mirrored the detail the member's interpreted meeting gave. The fourth and last stride blended every one of the recommendations of the meetings making a rundown table including the suggestions that catches the participator involvement with the marvel being studied (Willig, 2001).

Participator meetings were recorded, deciphered and coded as per IPA. The final product lead the scientist to conclusions in view of connections and suggestions shaped from regular participator reactions.

4.10. Trustworthiness of the Study

The purposes of dependability and legitimacy were tended to from numerous points of view. The accompanying check systems were incorporated into the review to guarantee legitimacy of the examination.

4.10.1. From the researcher's perspective

The analyst perceived being subjective with respect to advanced 3D innovation and its utilization in the plan procedure, as a business inside fashioner and inside outline instructor who as of now uses 3D innovation in many parts of his own and work life. In any case, the specialist did not wish to force, specifically or by implication, his suppositions on research members. Likewise, the specialist did not have any desire to impact examine members to answer inquiries in a way that might be false. The members in the examination that were met were fundamentally working in the area of business inside outline and utilizing 3D innovation both by and by and professionally so it was accepted a few members had comparable inspirations

to those of the analyst. Be that as it may, a few members utilized 3D innovation for different reasons, for example, a firm inclination. The analyst distinguished extra reasons that had not yet been considered.

The specialist tried to ask the inquiries in a way that did not purposefully push to interviewees to answer questions "effectively", however genuinely in view of their own encounters with configuration programs.
Inquiries were both various decisions and open inquiries, bringing about reactions from the interviewees that the specialist had not foreseen. Amid every individual meeting, the scientist saw that a few inquiries were asked that he had not at first considered. It was not the scientist's expectation to utilize an arrangement of answers to specifically or by implication inspire the members to react especially.

Above all, amid the meetings, the scientist did not examine his own encounters, conclusions, and inspirations about the subjects so as to abstain from compelling them to answer the inquiries with the "right" answers. Because of the likelihood of social attractive quality predisposition, singular meetings were directed with every member. As per the custom of phenomenology, the specialist endeavored to suspend judgment with respect to the truth of the marvel and shunned making determinations until information had been investigated and such judgments and conclusions could be found on the assurance of information (Creswell, 2009).

4.10. 2. Reflective Journal

The scientist kept up an intelligent diary all through the information gathering process. Going about as a self-reflection instrument, the diary enabled the specialist to record responses to members' encounters and discernments, the analyst's inquiries with respect to such hypotheses, and additionally developing patterns, elucidations and conclusions (Creswell,

2007). Likewise, the substance of the intelligent diary were utilized to cross reference information examination and elucidations (Creswell, 2007).

4.11. Findings

The reason for this exploration study is to investigate how inside fashioners make utilization of 3D innovation amid the plan procedure. It is specifically noteworthy to investigate whether and how plan specialists utilize configuration programs while creating new thoughts for a customer amid the schematic outline stage. Seeing how inside planners utilize 3D Technology offered bits of knowledge concerning the appropriation procedure of this new innovation. In addition, the review likewise offered data concerning the path in which innovation improved or undermined a fashioner's innovativeness used to produce new thoughts.

Furthermore, the analyst asked every one of the members from the first and second gatherings,
educators and experts, for their assessment on 3D printing and how it can help inside architects in their outlines and how it could build up the teach of inside plan. The scientist additionally solicited the members what they thought from the utilization of Augmented reality in show the last outcome in inside plan, and how it could assist us as interior planners with improving our creative energy, abilities, and deals.

4.12. Process

The members of this review were chosen in light of their involvement in inside outline and on their insight into 3D innovation amid their everyday work in this field. These members were understudies, educators and experts. The wonder of how inside creator specialists utilized 3D innovation in their work procedure, plan handle and for thought era was to guarantee that the

members would best have the capacity to advise that focal research inquiries because of their immediate, individual involvement with the marvel being studied (Creswell, 2007).

At first, all potential members were chosen from the city of Milan Italy, the chapter of the University Politecnico di Milano, included experts who learned at University Politecnico di Milano, and now each one works in an acclaimed studio.

Because of low reaction rate after the primary member enlistment, the review was extended to incorporate all experts in the city of Milan city. An extra twenty-five potential research members were reached through email, taking consideration not to incorporate members from the underlying gathering.

Follow-up phone calls and messages were directed with all members. Of those, five potential members reacted expressing they either did not presently utilize 3D innovation in the plan procedure or as of now had work plans that did not allow them to take an interest in this review. Ten members consented to participate in the review, while the staying ten did not react. After every member consented to partake in the review, they were sent the educated assent frame, a short statistic overview and guidelines to contact the specialist with helpful circumstances and dates to plan a meeting. Each meeting was directed on an individual premise to keep social attractive quality predisposition from occurring.

The survey was finished and the assent shape was marked and returned by members preceding the review. Toward the finish of each meeting, members were made a request to allude other conceivable members. The reason for existing was to make a snowball impact with a specific end goal to accumulate more qualified members for this review. Be that as it may, no extra members come about because of this demand.

Each of the ten meetings were directed by means of E-mail from Monday to Friday between eight in the morning and six around evening time contingent upon the time that was advantageous for the member. All meetings kept going in the vicinity of twenty and forty-five minutes. They were audiotaped and deciphered. Members were solicited an arrangement from open inquiries with respect to 1) their encounters utilizing 3D innovation in inside plan for general work exercises, 2) their utilization of 3D innovation in inside outline amid the outline procedure and 3) their utilization of 3D innovation in inside plan for the era of thoughts.

4.13. Context: Demographic Findings

All ten participants involved in this study were practicing interior designers who lived and worked in the city of Milan and who represented considerable authority in both business and training plan. The specimen was male and female and spoke to a scope of ages from late twenties to over fifty (see Figure 1).

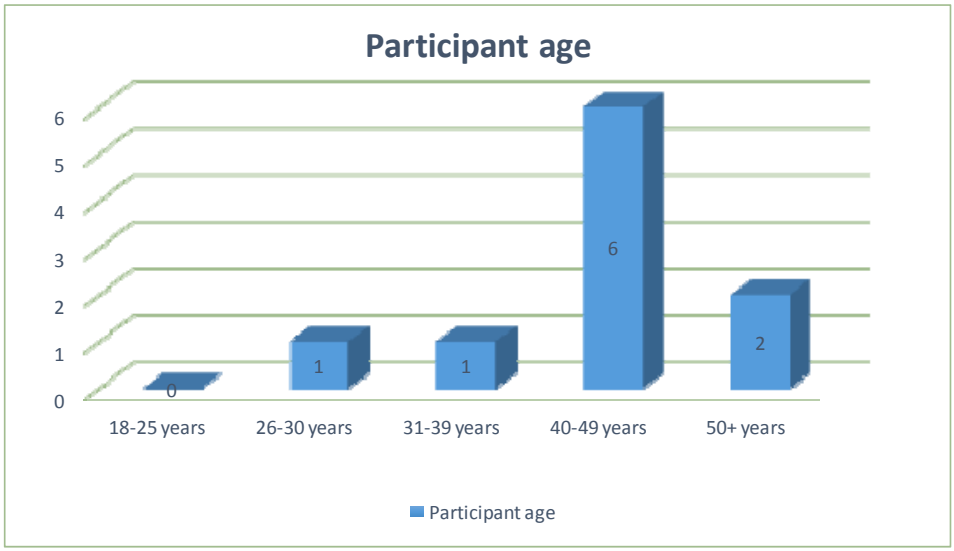

Figure 1. Demographic Findings: Participant age (10 participants)

4.13.1. Education, Employment and Experience

One of the members has a Bachelor's degree in engineering however he is filling in as an Interior creator and draftsman in the meantime in his own particular studio in Milan with his staff of inside originators and planners and two members had a Master's degree in Interior Design. They were doing their PhD postulation at the Polytechnic University of Milan while acting as colleague educators at a similar college in their claim to fame field of Interior Design. There rest of the members had a PhD degree in Design or Interior Design. A member showed that he had a double four-year certification in Interior Design and Architecture. (See Figure 2).

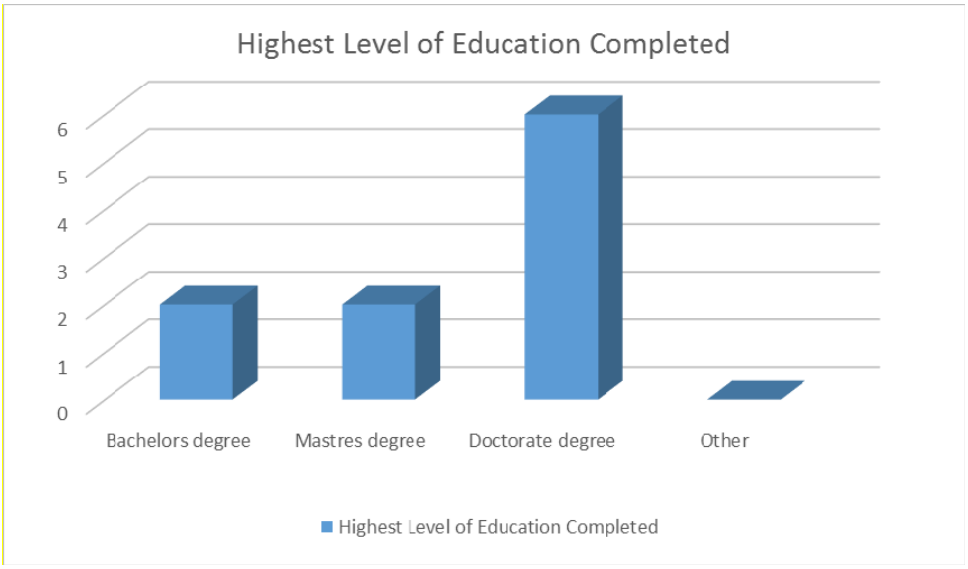

Figure 2. Demographic Findings: Highest Education Completed (10 participants)

Every one of the members had degrees from Polytechnic of Milan at the season of the meetings.

At the season of the meetings, five of members had more than twenty years of involvement in inside outline, three members had been rehearsing six

to fifteen years and alternate members had been honing one to ten years (see Figure 3).

Figure 3. Demographic Findings: Participant Years of Practice (10 participants)

The members spoke to an extensive variety of practice experience dealing with an assortment of venture sorts. The dominant part of members were entrepreneurs before they finished their PhD proposition. Four of them despite everything have a business in Milan and one of them has a major studio (see figure four).

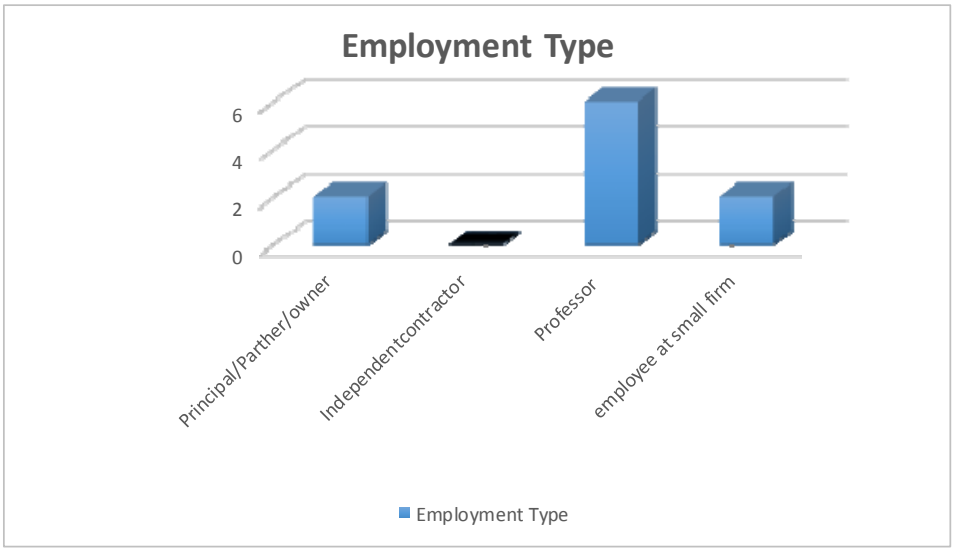

Figure 4. Demographic Findings: Employment Type (10 participants)

Each meeting was freely interpreted. In the midst of the review of the elucidations, distinctive themes created concerning the zones of interest this audit examined. Interpretive Phenomenological Analysis (IPA) exact nature of examination was used to research changed part depictions with respect to the usage of 3D advancement in inside framework. Three unmistakable stages contain the IPA technique for coding and examination which were used by the researcher to discover subjects and motivations concerning this point. At initially, gatherings were independently scrutinized and notes made recording early on thoughts and observations the pro had in light of each meeting transcript. Besides, the authority perceived, stamped and orchestrated thoughts and expressions from individual meeting transcripts by isolating the portions of substance inside. Thirdly, the examiner fused further coding structure into each individual meeting examination by further presenting subjects and continuing on explore them in association with each other. In the fourth and last stage, the researcher joined all individuals' meeting points improving diagram tables to demonstrate each rising subject

getting the individuals association with the ponder being studied (Willig, 2001).

Individuals discussed a couple varying thoughts and contemplations related to their motivations, in this way giving answers that are coded into various segments. Different individuals answered in unprecedented detail, giving responses that were more eccentric, however other part responses were clearer in nature. At the point when all coding was examined, overpowering subjects were described.

4.14. Analysis

Each meeting was independently deciphered physically then discussed and inspected. In the midst of the study of the understandings, diverse subjects created concerning the regions of interest this audit examined. Interpretive Phenomenological Analysis (IPA) exact nature of examination was used to explore particular part portrayals concerning their usage of PC development in inside layout. Three unmistakable stages incorporate the IPA methodology for coding and examination which were used by the researcher to discover subjects and motivations concerning this theme. At in the first place, gatherings were independently scrutinized and notes made recording beginning thoughts and recognitions the pro had in light of each meeting transcript. Besides, the investigator recognized named and characterized thoughts and expressions from individual meeting transcripts isolating the regions of substance inside. Thirdly, the master consolidated further coding structure into each individual meeting examination by further presenting points and continuing on 10 separate them in association with each other. In the fourth and last stage the researcher combined all individuals' meeting subjects improving summation tables to demonstrate each and every creating

point getting the individuals inclusion with the wonder being studied (Willig, 2001).

Individuals discussed a couple contrasting thoughts and considerations related to their motivations, in this way giving answers that are coded into various parts. Different individuals answered in extraordinary detail, giving responses that were additionally puzzling, while other part responses were more clear in nature. At the point when all coding was analyzed, overpowering subjects were portrayed.

4.15. Themes of Study

Two noteworthy classes formed the discoveries of this review: member inspirations and member encounters. Inside every classification, new topics and sub-subjects were recognized. The classification of member's inspirations for utilizing the PC innovation in configuration ventures included four topics: (1) correspondence, (2) data gathering, (3) business profitability. The correspondence topic had three sub-subjects that developed (1) new innovation, (2) physical model and (3) visual introduction. The topic of data social affair incorporates two sub-subjects: (1) gathering of data and (2) thought era.

Inside the class of member encounters, two subjects developed. They were (1) affect on work procedures and (2) capability of PC innovation amid configuration handle. Two subthemes risen up out of the subject effect on the work forms: (1) focal points and (2) burdens.

4.16. Participant Motivations

4.16.1. Participant Motivation Theme 1: Communication

Correspondence was a standout amongst the most widely recognized topics said with respect to inside planners inspirations for utilizing PC innovation in their work exercises. Each of the ten members talked about various attributes of correspondence upgraded by PC innovation amid individual meetings. A few sub-topics risen up out of this including (1) new innovation, (2) physical model, and (3) visual introduction to customers. By a wide margin, members saw the capacity of the PC innovation to upgrade extend correspondence as the most vital motivational component for utilizing the PC innovation in their work forms. Member Oxsana expressed,

It's imperative for the customers, additionally critical for inside architect, some of the time since you need to disclose your thought to other individuals, perhaps I can envision everything, on the grounds that I have this limit and after that I ought to be deciphered and the other individuals ought to comprehend it's exceptionally helpful truly. From my experience, our customers dependably hold up to see the model since it is exceptionally helpful for them and they require it and now it is an extremely normal utilize.

Our customers would prefer not to see draws they approach us specifically for pictures and displaying.

4.16.2. New Technology

To improve correspondence, members expressed the most incessant utilization of new PC innovation was to speak to and talk about outlines with customers, temporary workers and staff. By and large, they saw that PC innovation gave a prompt technique for keeping up contact with customers, just in light of the fact that PC innovation makes thoughts and ideas straightforward. Member Ceppi expressed,

I trust that what individuals anticipate that it will see the last outcome like that, particularly for the customers it allows them to comprehend the venture in a simple and impeccable way. We mean here rendering in high determination is the last stride, individuals hope to see pictures or what will be made.

Clearly you can't begin with the photo, you need to work to achieve the progression in which you can demonstrate your work as a photo. This work is done well ordered after the plan procedure, material, hues, and lighting.

I can state it likewise relies on upon the time and the tolerance of your customers, a large number of my organization's customers need to see three unique pictures and after that they pick the photo the like the most.

4.16.3. Physical model

Members saw that there were two critical correspondence capacities accessible with PC innovation that made PC innovation important for their work. Members examined the capacity to make a go of a building site condition did it through PC innovation to photograph catch an on-screen picture to use for future venture needs alongside the capacity to add notes before sending to customers or colleagues.

4.16.4. Visual Presentation

Another subtheme inside correspondence was the originator's capacity to utilize the PC innovation for visual correspondence and introduction purposes. For instance, members expressed this sort of innovation was profitable in expanding their capacity to obviously impart their plan idea to the customer or colleague.

4.17. Participant Motivation Theme 2: Information Gathering

The lion's share of members met saw the accumulation of data as any undertaking that includes gathering information, thoughts or materials to finish beginning outline proposition or to produce thoughts. From here, two sub-subjects developed further characterizing the utilization of PC innovation for data gathering, (1) accumulation of data and (2) thought era. Members talked about parts of both data get-together and thought era in detail. The first meaning of thought era, as characterized in the writing survey to concentrate on outlining of plan thoughts, contrasted from members' elucidations.

Collection of information

4.18. First type of participants: Professors & Professionals

In this part, the scientist examined every one of the inquiries with the members, beginning with the appropriate responses of the members and after that with his remarks and his perspective on this issue. A portion of the members favored replying by and large and they asked the specialist to comply in their answers, which begun with the sorted-out meetings by specifying the individual and the appropriate response.

4.18.1. Participant number one, Alessandro Biamonti

Architect (Politecnico di Milano, Colegio de Arquitectos de Valencia), specialized in design (practical and theoretical aspects), has been a consultant for several companies. He is undertaking a PhD in Industrial Design at the Politecnico di Milano (Italy) where, apart from being a tutor for several courses, he's developing his PhD research (Learning Spaces – Toward an Environmental Learning System for the Faculty of Design) with professors Andrea Branzi and Francesco Trabucco. With SDI of Politecnico di Milano he's involved in design research with the team of Professor Ezio Manzini. From September 2002 to January 2003 ha was a Visiting Researcher in UIAH (University of Art and Design – Helsinki) within the Product and Strategic Design Department.

He is currently teaching interior design at Politecnico di Milano. Peculiar history of design and architecture in Italy.

Question number one,

RQ1: What is the impact of 3D technology on interior design in showing the final design?

My opinion 3D technology absolutely it is a very important aid and support for devolving the field, but not for new ideas, so I think it's now important to generate a new idea but, extremely important to communicate con clients or colleges.

Question number two,

RQ2: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)

No. because if you want to do very good render you need a lot of time and money.

Question number three,

RQ3: How would be the discipline of the interior design without this kind of technology?

Exactly like how it was before the technology exists. As I said if you are not professional in use this technology do not use it, we had many experience in our classes with Italian students and intentional students, and the result was 10% just they are able to use this kind of technology perfectly and it gives them some advantages in their work and the rest it gone their work to be worse.
To be very good in software or in 3D physical model is not so far.

Discuss the three previous answers,

Starting with the first question about the impact of this technology on interior design, professor Biamonti said, absolutely it's very important to communicate with clients and show them ideas and concepts of the design, but it's not important to generate new ideas. I can see here and from my point of view that professor Biamonti follows the traditional way of design process, and we cannot ignore that professor Biamonti has an architecture background. At the same time, he does not think that use of this kind of technology in our work allow us to save time and money because if we need to get a good render design, we need much more time and money to reach it. Therefore, the time that you need to improve your skills in this software you can approaches in resolve problem in design or improve your personal skills of design thinking, and about interior design without technology. I simply think that it would exactly be like it was before. The technology is not the heart of design. It is a tool to help designers. As I have understood from my own teaching experience, only 10% of the students are able to get a professional work using this technology and it gives them an advantage to present their work better. However, the rest of the students make their work even worse.

Question number four,

RQ4: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

Well, you can control and mange perfectly this kind of technology even if you are a bad interior design that is mean have a knowledge in this doesn't mean you are a good designer, it is depending if you have an idea about what you are doing.
3D technology it is not the central of design process, it is just like a tool. Often, I ask my students to use Photoshop more than 3D modeling because simply, in 3D modeling you have to manage very well to have good results, otherwise if you are to draw a good sketch it will be better and quick than 3D render.

Discuss the fourth question,

In the fourth question, professor Biamonti, said you can control and manage perfectly this kind of technology even if you are a bad interior designer. Thus, having knowledge in this technology does not mean that you are a good designer, because design should be considered as a whole rather than separated into parts. You should have an idea about what you're doing. 3D technology is not the central part of design process. It's no more than tool to represent through.

The knowledge in this kind of technology

Question number one,

RQ1: How many 3D modeling software do you use? Which ones do you generally use?

Few, sketch up and Photoshop

Question number two,

RQ2: Do you think having some knowledge in this kind of technology helps getting more work?

Relate with have more work, of course in the professional field, so it's really important to be able to communicate with your solutions, ideas, and concepts with your clients, so in the professional field can be helped.

Discuss the two previous answers,

In the question related to the number of the software that the professor uses, he said that he uses no more than two programs just to express the idea and it doesn't matter how many programs you use if you can express your ideas clearly with a few tools. In the question related to the benefit of using these programs in getting more work, he said, of course in the professional field, so it's really important to show your solutions, ideas, and concepts to your clients through this technology. Therefore, it is helpful in the professional field.

Question number three,

RQ3: Do you prefer to draw or make some preliminary sketches for your design first or do you prefer to start directly with the programs?

It's depend the generation, I start by hand drawings, and then I try to understand physical model even draft model and relation physical spaces etc.
Then I can move to technology.

Discuss the answer of question three,

The third question in part two was if he preferred to follow the traditional design process or he has another opinion on this. He said that it depends on the generation. I normally start with hand drawings, and then I try to understand physical model, draft model, and relation to physical space. Then, I can move to technology. The fourth one was related to his opinion about the value that students give to the 3D technology as a representation of the quality of their design. He thinks that new generation has to learn how to use this technology, but it's not the only tool. It also depends on their capability. If they are good at hand drawings, they should do it by hand; if they are not good at this, they should do it with software.

Question number four,

RQ4: How much value do you think students give to the 3D technology as a representation of the quality of their design?

I think new generation they have learn and manage, but it's not the only tools, I think also it's depends in your capabilities, if you are good by hand do it by hand, if you are not doing it by software.

The quality it's not related to use the technology, the quality related to the project, so I think the best way to represent the work use many tools, to avoid many things like get a similar result of many project.

Discuss the previous answer

The fourth question was about the students' opinion about the role of computer technology in their design thinking and their design products. Professor Biamonti said that it is one of many limitations of the creative process. It is a good communication tool, but it sometimes can be a limitation in the creative process if the student cannot use the program well. In 60% or 70% of the cases, the students do what they are able to do, not what they think or imagine. It can be a big problem to change their design because they are not able to do what they imagine.

Question number five,

RQ5: How do you think students view the role of computer technology in their design thinking and their design products?

That is one of many limitations of the creative process, it´s very good communication tool, but in the creative process sometimes can be a limit, because if you don't manage very well the programs.

Between 60% to 70% you do what you are able to do not what you are thinking or imagination, so could be a big reason to change your design because you are not able to do what you are imagination.

They students did not develop because they don't know how, so it's strong limit.

If the tool became the rule of creative process, you need to know very well the tool.

So, I think each one of the designer should manage a tool, digital or manual tools, like 3D modeling, drawings, etc.

If we think the digital tools it's the only way to represent our work, we will lose.

Discuss the previous answer

They students couldn't improve their work because they don't know how to do it, and it is a strong limitation. If the tool is a part of the creative process, you need to know it very well., I think all designers should use a tool, either digital or manual, like 3D modeling, drawings, etc. If we think that using digital tools are the only way to represent our work, we will be mistaken.

Question number six,

RQ6: How would you describe yourself (skill-wise) in terms of computer technology?

Beginner user for necessary things.

Question number seven,

RQ7: How do you use these programs in your design process? Could you explain it?

In the final step if it's indeed.

Discuss the previous answers

In the last two questions related to the skills in this kind of technology and their usage in the design process, professor Biamonti says that he is a beginner use for the necessary things and he prefers to use them in the final step to finish the design.

Conclusion

In conclusion, it was interesting to hear from someone who comes from old designer generation and know his opinion about the impact of new technology in interior design. It was clear from his answers that the technique he uses to produce new ideas and make new projects is to create his own way

of teaching interior design to his students and to make them good interior designers through giving them enough space to create and think new ways to represent their work and design. However, all this into design process and design thinking and it's exactly like thinking out of the box without broking it.

We can infer from his point of view that everything in the design process is going to change, and it's impossible to retain the old method. Interior design is a discipline like many other disciplines in our daily life. The new technology changed many things in our daily life. We can say that interior design will be digitalized in a few years. We cannot predict whether this change will be positive or negative. In my opinion, it will have advantages and disadvantages like everything in our lives.

I4.18.2. Participant number two, Andrea Ratti

Associate professor at the department of design in Politecnico di Milano, teaching architecture technology in interior design courses Architect and PhD in Technical Innovation and Design in Architecture, he has been teaching and doing research activities at the Department of Design at Milan Polytechnic. He is the co-director of the master's program in Yacht Design of the Polytechnic, vice president of ATENA Lombardia (Italian Association of Naval Technology), a member of the Executive Council Assocompositi (Italian Composites Association), and a member of the Committee UNI-yacht recycling.He is also the coordinator of projects of construction and operation of the drifts of 1001 Vela, He does research on innovative technologies in the marine field.

Question number one,

RQ1: What is the impact of 3D technology on interior design in showing the final design?

I think 3D technology gives the possibility to drive from the concept to produced directly in the 3D shape, new generation of course have more confidence with this technology, because there are very use to start imagination in 3D shape through this technology, I thing this topic it is interest not only for interior design but several industrial applications like furniture design and so on, it is very important to be skilled in working in these tools.

Discuss the previous answer

Andrea Ratti, an architect from old generation, preferred to follow the traditional way of design process and design thinking with the importance of learning this kind of technology to communicate and express the ideas and represent the design through this kind of technology. He says that it is important to follow the new technology in our discipline. He thinks that the impact of 3D technology in interior design is showing the final design.

Question number two,

RQ2: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)

Yes of course, this kind of technology allow to reach in less time better result, better level of details that you can control during the design phases, and introduce less possibility to make mistakes pathing through the design out to production.

It helps us to reach a full detail in 3D physical modeling using the CNC machine for example.

Discuss the previous answer,

According to the second question in the interview with professor Ratti, he thinks that these kinds of technologies allow interior designers to save time, effort, and money in some occasions.

Question number three,

RQ3: How would be the discipline of interior design without this kind of technology?

Of course this technology quite recent, and a few years old this our imagination it was without this kind of technology, so I think new generation are unable to imagine a big space to design it without technology like us, the old generation, so it's a problem from my point of view, and we are not able to go back to the old way to imagination and do things, and many master in the field of interior design and architecture start thinking through this technology before start advanced the idea or the other concepts.

Discuss the previous answer

We can get from this answer that professor Ratti does not see a big difference between interior design with this technology or without it.

Question number four,

RQ4: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

Yes, I think so, and I think also that new generation cannot do anything else that porch this technology, because now a day the way of expression path through the possibility to manage this kind of tools or software, and it can help in approach to solve problems, so it gives the designer the possibility to control, mange, and modify the space easily, for this I think it's a good advantage for them I mean here the new generation.

Discuss the previous answer,

In the fourth question professor Ratti answered positively which means professor Ratti encourages the students to learn this kind of technology to facilitate their work in some phases in the design process.

In the second part of the interview about knowledge in this kind of technology, the first question was about,

Question number one,

RQ1: How many 3D modeling software do you use? Which ones do you generally use?

In the case the researcher needs to know the capacity of the professors in use this kind of technology, the answer come just two programs to demonstrate the idea Rhinoceros, MAX fare.

The second question in this part is connected to the first question.

Question number two,

RQ2: Do you think having some knowledge in this kind of technology helps getting more work?

Professor Ratti said, *today it's a basic requirement for many people, so I think, yes, first to get a job you have to manage this technology and then ask for another thing, so many studios ask for the knowledge of this technology, because many clients ask for that. The answer came depends the needs of the market because in this case the clients who's asked for the render part of the design, so to sell your design you have to know some of those programs.*

Question number three,

RQ3: Do you prefer to draw or make some preliminary sketches for your design first or do you prefer to start directly with the programs?

Well, when I start making a new idea I start with draw sketches by hand, but I can see that many young people are not use to do that, it's ok to start directly with this technology but in case when you have already the idea, but normally the idea doesn't come complete. So, it's an advantage, if you can imagine you can make sketches by hand or by digital tools like tablets or something else, so, doing the sketches by digital tools gives you the possibility to modify the shape easily and quickly than hand. About the change that made the introduced of this kind of

technology, I think it's not a real change in the process because both of them make the same task.

As a professor in Politecnico di Milano the researcher asked professor Ratti about his opinion in the value of 3D technology in the quality of design for the students.

Question number four.

RQ4: What value do you think students place on the 3D technology as a representation of quality of their design?

Generally, I think the student aware about the use of this technology, and in our courses we teach them how they can improve and develop their skills in this kind of technology, it's like lean a new langue to express yourself, so it's very important to learn that, and it's gives you the confidence to explain your ideas and it's gives you also the possibility to gives your ideas the right value, and now the students they are consciousness of that.

So, from professor Ratti's point of view, it's important to have some knowledge in some phases to get good results and to present good work.

It is one of the most important aspects in design process and it is considered as the base of the design process is design thinking.

Question number five,

RQ5: How do you think students view the role of computer technology in their design thinking and their design products?

Computer technology now is a part of the design process and design thinking, I increase the use of this technology because our students are consciousness about that they use it in the correct way and correct step, so they use this technology and behind it they use material and lightings, and we support them to use this technology in correct way, and we support them also to have a knowledge of the use of material in the space, and how they can transform the ideas with material to the real life.

The answer showed the importance and the role of 3D technology in design process and design thinking in our daily life.

In terms of 3D technology, professor Ratti is a beginner and a basic user. His answer depends on the penultimate question.

Question number six

RQ6: How would describe yourself (skill-wise) in terms of computer technology?

I am a beginner in computer technology comparing with the professionals, but I know the Capabilities of this computer technology.

In the last question of the interview, professor Ratti's response was very short.

Question number seven,

RQ7: How do you use these programs in your design process? Could you explain it?

Well, actually I follow the design process so I use it in the correct step.

4.18.3. Participant number three, Barbara Camocini

Barbara Camocini, architect and PhD in Interior and Exhibition Design, Adjunct Professor at the School of Design, Politecnico di Milano. She teaches at some Post Graduate Schools of Design and Architecture. Her current studies are in Interior Design and Human Environment, changing through Adaptive Reuse processes. She also identifies opportunities for urban renewal. As an architect, she is a consultant of private companies and public institutions, in projects with high cultural profile which requires extensive research and project management activities.

I think the idea to represent the project don't stop with 3D programs or technology, there are many manners to represent our work and through many media of communication, in our lab we are three professors, the first one is I, the second he's

photographer and the third one it's an expert in visual communication and graphic design.

We are working to demonstrate to the student the power of representation on photos, images and make collages between all these elements, the lab is in design but we are focused in how we can represent our work through those tools.

It's a full project to allow to student to think out of the box, and find new ways to represent their work. The graphic designer starts to analysis pictures and system of representation, the photographer explains how to manage the perspective and the depth of the images in interior design, and the architect, it's me in this case, I teach how to analysis the interior and then we start make some project like an exercise.

For me, it's not necessary to learn this kind of technology to be a good designer, there is a tool like many tools we have to explore our ideas, and they should be mange handmade drawings and sketching.

Actually, I ask the student to use sketch up to see the 3D not to render, so I like the student did different task to give them the opportunity to see the power of each one.

My point of view says, if they are very good in those software, they can use it to represent their final step, in order to get the final representation of their ideas, and to not start with that software and follow the traditional design process, so I recommended them to work with semi system of representation, so some sketches, images from another environment and put them to gather in order to build their image and the last step come the 3D rendering.

About the 3D modeling could be useful at the meddle of the process, because as we know the perspective it's most important topic, but I think in the same time the soft quality of project it's matter more sophisticate and sometime your imagination it's better than what you see in the final rendering, so you can leave the final representation step before the end not totally realistic.

Now I am not able to use any programs but in the same time I avoid to make my final design look like realistic representation, I try to use some exist sample,

because for me, use the final render look like realistic it's a limitation for the clients, simply if I show clients one final work it will cut all the option to modify the design, so I prefer to show clients less realistic design to choose one and discuss about it with samples and take the decision together designer and client.

During my entire professional career, always I try to involve the clients in choose the final design and discuss with him about material, lights, and color.

This kind of technology exist to support the student to improve their skills and to find new ways to represent their work, but in the same time manage or control this kind of technology doesn't mean you're a good designer, absolutely not, the good designer uses these tools just to support his/her work no more.

As much tool as they can, my opinion is it's not mandatory to start by hand; they can start with visual things like pictures and then start to change this, or start with drawings or 3D modeling, and from their start.

The most important thing in the design process is the idea and how you can communicate this idea and convert it to the real life, I think also it's not necessary to try a specific software to represent the project, they can use more than software to get the best way, not just software they can use many things else to represent the final design.

So, this kind of technology it's one of many manners to represent.

Discussing of the interview of professor Camocini,

Professor Camocini, preferred to read and answer the questions in general, because she said doesn't like limitations and from her point of view answering question by question could limit her answers. Starting with use of 3D technology in representation of the work to the final step of the design, she said there are many ways to represent the work and it's not necessary to follow one way. The photo has a very strong impact in representation, so we have to know the power of photos and to think out of the box, it is not

necessary to learn this kind of technology to be a good designer. Also, it's no more than tool like many tools we can use it to represent our work.

You should be really qualified to use this kind of technology and to get good results. As we know 3D modeling can be useful in the middle of the design process, but all of us play a role in lost the impact of the perspective and the main column of the design. We have to turn back to its role to make a real improvement in the discipline of the interior design. Professor Camocini doesn't have any knowledge in this kind of technology. Maybe, in the past she had some students, but she doesn't use this kind of this software. At the same time, she doesn't like the realistic render and she prefers to start with the clients step by step to avoid many mistakes and to save time and to share designing ideas with the clients.

This is a short abstract about the interview with professor Camocini. The entire interview is on the next page.

I think the idea to represent the project don't stop with 3D programs or technology, there are many manners to represent our work and through many media of communication, in our lab we are three professors, the first one is I, the second he's photographer and the third one it's an expert in visual communication and graphic design.

We are working to demonstrate to the student the power of representation on photos, images and make collages between all these elements, the lab is in design but we are focused in how we can represent our work through those tools.

It's a full project to allow to student to think out of the box, and find new ways to represent their work. The graphic designer starts to analysis pictures and system of representation, the photographer explains how to manage the perspective and the depth of the images in interior design, and the architect, it's me in this case, I teach how to analysis the interior and then we start make some project like an exercise.

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Now I am not able to use any programs but in the same time I avoid to make my final design look like realistic representation, I try to use some exist sample, because for me, use the final render look like realistic it's a limitation for the clients, simply if I show clients one final work it will cut all the option to modify the design, so I prefer to show clients less realistic design to choose one and discuss about it with samples and take the decision together designer and client.

During my entire professional career, always I try to involve the clients in choose the final design and discuss with him about material, lights, and color.
This kind of technology exist to support the student to improve their skills and to find new ways to represent their work, but in the same time manage or control this kind of technology doesn't mean you're a good designer, absolutely not, the good designer uses these tools just to support his/her work no more.

As much tool as they can, my opinion is it's not mandatory to start by hand; they can start with visual things like pictures and then start to change this, or start with drawings or 3D modeling, and from their start.

The most important thing in the design process is the idea and how you can communicate this idea and convert it to the real life, I think also it's not necessary to try a specific software to represent the project, they can use more than software to get the best way, not just software they can use many things else to represent the final design.

So, this kind of technology it's one of many manners to represent.

4.18.4. Participant number four, Bogdan Stojanovic

Bogdan Stojanovic, is a Serbian PhD student at Politecnico di Milano, Design department. He is also an architect who graduated from Politecnico di Milano. He did three master's degrees in Politecnico di Milano. Two of them are in architecture and the third one is in technology innovation. He has been working at Politecnico as an assistant professor in architecture and interior design for 5 years and writing his doctoral thesis at the same time in use of niceties to valorize in hands culture heritage regarding temporary cities.

The PhD candidate Bogdan Stojanovic's point of view is different from students of PhD in interior design who come from architectural background. Stojanovic answered the questions according to his experience in studying three masters at Politecnico di Milano.

Question number one,

RQ1: How do interior design practitioners use 3D technology when generating new ideas for clients in the schematic design phase?

Actually, I prefer to use sketches and modeling of the form using maquettes (mockups) physical model it gives you a best perception in the space in two parts.

Concept part, you can have changed quite fast, and like an architects and interior designer we can understand the space in the best way through modeling.

It seems that Stojanovic, use the traditional way in the design process with slightly different details in some phases. Using the traditional method is normal for Professor Stojanovic because he's teaching in Politecnico di Milano for 5 years, and he learnt this way from his own professors. Also, it is a good thing that all the students from Politecnico di Milano are able to follow the same way of design process.

As a designer in the professional market of interior/ architecture design Stojanovic answered the second question in the interview which is about the impact of 3D technology on interior design in the final representation as follows,

Question number two

RQ2: RQ1: What is the impact of 3D technology on interior design in showing the final design?

It has a huge impact for sure in interior design like all the disciplines, and especially because it gives us the possibility to find clients and explain better the ideas to the clients, we have a completely different perception to the space than the normal clients, so it gives us many advantages and it get our tasks more easily than a few years ago.

And committing attic his answer about the impact of this kind of technology in represent the final step, he said that, we have different perceptions of things, designer can understand better the space than normal person, so this technology came to show the normal person what the designer sees and think about the space to put the ideas closer.

Third question comes from the professional camp, so Stojanovic is able to answer a question like this as he is a professional interior/ architecture designer.

Question number three,

RQ3: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)

Yes, definitely 3D technology allows us to save a lot of time in the last phase of the project, because we can show directly the materials, texture, and lights to the clients. And gives the clients more possibility to understand the project with this we can save time and time is money so it's all connected.

Stojanovic encourages the designer to use this kind of technology to communicate with their clients better. So, he said certainly that this technology gives us the possibilities to save time, effort, and money, and to get better results in some cases.

Further to previous question, the fourth question was about what interior design would be like if we didn't have this kind of technology, and the answer came as follows,

Question number four,

RQ4: How would be the discipline of the interior design without this kind of technology?

Everything could be much slower, we'll need more time for whole design process, and the result it could be less successful because we cannot chick everything like what we do now through this technology.

Stojanovic thinks that this technology gives us tons of advantages to do our work more professionally and quick than before and using this technology can prevent mistakes during design process delivering the design until the deadline or in less time.

Last question in part one of interviews with Stojanovic was about requirement management and controlling this kind of technology in the professional market today,

Question number five

RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

I think it's not necessary learn all the technology to be a good designer, but for sure every interior designer should now how its work and what we can do with it which are the final results can reach through this technology and to be updated with all types of this kind of technology.

According to Stojanovic it is not a requirement or a main reason to be good interior designer, but you have to know some of those softwares or at least the capacities, just to imagine how the final results can be through this technology.

The second part of this interview was more practical than theoretical. The researcher asked Stojanovic about skills and habits in the design process and design thinking before, during, and after finishing the design. The first question was about his personal capabilities in using this kind of technology and the answer came as follows,

Question number one.

RQ1: How many 3D modeling software do you use? Which ones do you generally use?

3D studio MAX, Sketchup for fast things, 4D studio, ArchiCAD.

The first question in this part was the same for all the participants and the aim of this question is to know how many programs those people use when they want to generate a new product of interior design and to show the diversity of programs which the participants used. In the case of Stojanovic, he has more knowledge of this software because he is from the new generation of designers.

Second question it is very close to the first one and anterior questions, but the researcher wants something special for each question. Therefore, in

the case of Stojanovic, he answered positively because he is aware of the power of this technology in increasing the sales of our products and designs.

Question number two.

RQ2: Do you think having some knowledge in this kind of technology helps getting more work?

Definitely, could help to get more work, especially today, many people ask for 3D visualizing, and virtual reality software.

And the answer is clear that he agrees with using this kind of technology in the discipline of interior design to facilitate the communications with clients and people who do not have knowledge about interior design, and to leave everything clear, starting with concept and finishing with the final render.

Researcher asked the third question to Stojanovic as a professor in interior and architecture design, and the researcher asked him to answer the question depending on his personal experience with students and his point of view of this topic.

Question number three

RQ3: How much value do you think students give to the 3D technology as a representation of the quality of their design?

I think the student gives too much value to this kind of technology and as I think most of the student start too early with developing 3D modeling, even if they don't understand the real concept without the solid idea of the space. Sometimes, I think it's a problem many students start with technology making render in the first phase and it's give a wrong value.

The students get confused while using this kind of technology. They start to use it in the wrong moment and many of them do not follow the correct way of design process to get best results in less time and to avoid many mistakes. Thus, they need to be more cautious during the process and

develop the idea very well before starting to use this technology. They should use it reasonably.

How the students see and use this kind of technology is the fourth question in part two and the answer as follows.

Question number four,

RQ4: How do you think students view the role of computer technology in their design thinking and their design products?

As important part in design thinking in the final design product, but maybe giving to many existences at the begging to that, and they should use the normal design process.

As it is expected, students give too much importance to the role of 3D technology during design process and sometimes they use it more than they should use. They lose the control while doing too much things through technology and they forget the main things such as the concept of the design. Going back to the skills of the Stojanovic and to know how controlled computer technology through design process is and design thinking.

Question number five,

RQ5: How would you describe yourself (skill-wise) in terms of computer technology?

Good in generally, I am interested more in graphic program to represent my work like Adobe package and staff like that.

The exciting thing that Stojanovic preferred to use graphic design programs more than interior design programs in generating new ideas and concepts in interior or architecture design, is something interesting that interior design says and this confirms the importance of image in the final design.

Finishing the interview and asking the last question about the personal design process of Stojanovic and to know the value of this kind of technology which gives Stojanovic to this kind of technology the last question was,
Question number six,

RQ6: How do you use these programs in your design process? Could you explain?

I use Illustrator in the first phase for creating the schemes, diagrams, and to know what I am dealing with and how to approach the red design to divide the spaces to functional connect them, and then passing to AutoCAD after that some 3D studio Max or maybe using some collages shooting some models and maquettes and then using Photoshop and in the final phase using InDesign to packet all together.

As a professional and professor of interior and architecture design, Stojanovic mixed many techniques between digital and manual to get best results in less time, as we can observe in his answer on the previous question about how to use those programs, and the answer showed the saucepan of consciousness in the use of this kind of technology before, during, and after the design process.

4.18.5. Participant number five, Giulia Ceppi

Giulia Ceppi, is an architect and designer and a part of what he studied is a visual design assistant professor at the Polytechnic of Milano, department of industrial design, and his investigations are about the innovation in design, to make something different than what we have ever had before.

Technologies and materials are relevant. He has a company specialized in the innovation of materials and technologies in the city of Milan, many of his clients ask for a new technology to increase the sales, and he has been responsible for that for many years.

Ceppi is an architect and he has been working for many years as an architect and with interior design for the proximity of the majors of each other. It is easy to work as an interior designer if you already have experience with architecture like Ceppi has had from his personal experience in those fields he answered the following question as follows.

Question number one,

RQ1: How do interior design practitioners' use 3D technology when generating new ideas for clients in the schematic design phase?

I think it's very important but, the problem people are use now to judge interior designer in very high level of realism. Sometime when you do the work fast thorough this technology it's a mistake, 3D technology allows you to be very precise but you have to gain presage, so if you start in this way maybe you'll go in wrong direction.

In this question, we concerted in the use of technology in the design process through generating new ideas for clients, Ceppi thinks that it is a big mistake to give too much realism to a final design because we are at that point that people judge the designer through the resolution of the final result. Therefore, Ceppi supports using this kind of technology but in the correct phase in the design process and all this use should be under control to achieve the best results in less time.

Many studios now employ a computer science post-graduate to work on 3D technology considering them to be more professional in those programs, so those studios depend on these employees to make the majority of the designs and put the head of the team designer in control of this and give creativity to the design because many people ask for the final design in high resolution, and due to this fact, the researcher asked Ceppi about the impact of this technology on interior design and the answer was as follows.

Question number two,

RQ2: How is the impact of 3D technology on interior design in showing the final design?

I believe that people expect it this to see the final result like that, especially for the clients it gives them chance to understand the project in easily and perfect way, we mean here rendering with high resolution it's the last step, people expect see picture or what will be realize. Obviously, you cannot start with the picture you have to work to arrive to the step to show your work like a picture step by step following the design process, material, colors, and lighting. I can say also it's depend of the time and the patient of your clients, many clients of my company they need to see three different pictures and then they pick up the picture which liked more.

Ceppi said that people now expect to see pictures not designs, so when you show them the design directly they will ask you for the pictures because many of them think this is the design and they do not even understand how we have achieved this (meaning here the image), so now it is easy to convince clients without this kind of technology, and the advantages of this technology is showed in the materials, colors, and lights which we will use in the real design.

Depending on the answer of the third question from professional architect and interior designer such as Ceppi, we can confirm that this technology allows us to save time, effort and money, or Ceppi will negate that it is very important for new designers or the respectively newly graduated the value of time in using this kind of technology, and for this the researcher asked,

Question number three

RQ3: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer) *From one side, for sure because it's easier to make correction and integration, but from another side the risk when everyone known that everything it's easy to change and start thinking this picture it's the design, so if you are not strong in the process in you don't expelling well the idea*

could make problems for you it will be never ended story and specially in your clients they not easy to take decision.

If the clients know that it is easy to change small or big details they will always ask you to change, and it caused confusion for both the designer and clients. It is one of many disadvantages of those programs, but at the same time we cannot ignore the power of it in resolving many problems faced by the designer.

Design in general and specifically interior design like so many discipline changes with the industrial revolution and with the ingress of technology in our daily life and too many disciplines including interior design, the researcher asked Ceppi, how we can imagine interior design without technology.

Question number four,

RQ4: How could be the discipline of the interior design without this kind of technology?

Obviously, you have to balance between what is virtually and what you seen in the screen and what is real for this always we make samples, so it's important to bring physical models with materials, so you have to balance the realism with material staff to explain better the design.

Ceppi talked about the balance between what we see in the image and what could be real, giving us a small example between virtual design and physical design, so, we cannot ignore the role of the physical model in showing materials and small details.

We cannot separate technology and interior design, not even design in general, nowadays technology has a huge impact on the design process that we cannot ignore it, so how an interior design works without this kind of technology, it is important to be a good designer,

Question number five,

RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer) *I believe that it's a tool today, personally I have persons doing that work, I am an interior designer and architect but I am not able to use 3D technology, so I have an experts persons who knows do that.*

Actually, Ceppi said that it is not that important but for the fresh interior designer it could be, in his case he has a team for things such as this, but in other cases it is not easy to find someone else to do this work, so he learned how important it is for the first few years and then get some help from your team to do things like this.

As we did in the majority of interviews, the second part is about personal knowledge in technology on design in general and particularly in interior design, and just to show in the final part of this study how those people whether professors or professionals use this kind of technology during the design process, starting with the first question about programs they use. Question number one,

RQ1: How many 3D modeling software do you use? Which?

Personally none, I don't use any programs, but I have people in our office doing this work.

As we can see Ceppi does not use any kind of these programs, but at the same time he has a team which does this work after receiving the outline e from Ceppi, and this affirms the need to know how it works and is managed at least because there are many designers who cannot find people to do this, and specially at the beginning of one's career.

The next question is connected with the first one in this part of the interview, which the interviewer asked Ceppi, if managing programs and software helps to increase the work and the answer was as follows.

Question number two,

RQ2: Do you think having some knowledge in this kind of technology helps to get more work?

I think not to get more work, but I belief you have to know the use of this tools and to be updated.

Ceppi thinks that it does not increase the quantity of work, but as an interior designer he believes that you have to be able to use it and be updated about all of this technology, and you should have some knowledge about it just to give you the capability to imagine how the design could be if we do it through using those programs.

The third question is about the practicality using the technology before, during and after the design process from a personal point of view, and in the case of Ceppi it was as expected, he uses the traditional way with small changes.

Question number three,

RQ3: Do you prefer to draw or make some preliminary sketches for your design first? Or you prefer to start directly with the programs? *Yes, I am using the traditional way, but in the same time I have to know the capacity of those programs.*

It is obviously the importance of this kind of technology for all the participants whether they are students, professionals or professors, and the target of all these clients. Sometimes this technology finds the best way to communicate with each other in a much easier and simpler way.

The researcher asked Ceppi, as a professional, about the role of those programs during the design process when they asked him to generate a new project.

Question number four,

RQ4: How do you use these programs in your design process? Could you explain?

I think it's depends project by project, strategies of design, design thinking with a lot of research and mapping, analyses. We start with layout programs and visual design not with 3D modeling and to look what other are doing and comparing and do more research in analytical phase before what you are sketch you have to understand what you are sketching and the next step start shaping what you want to do, in the second step you can use programs like Sketchup or something like this and then go on with blue print design and so on.

Ceppi clearly explained how they start and in short, step by step how they deal with new projects using the correct design process and with the help of technology to achieve the best results which satisfy the clients and designer, and how it is important to do a little research about the project and not to depend on the information which we get from the client and choose the correct strategies and make analysis and all the necessary steps to get the best design.

4.18.6. Participant number six, Trocchianesi Raffaella

Trocchianesi Raffaella. Architect and industrial design researcher at the dip.INDACO, Faculty of Design, Politecnico di Milano. She lectures, design and mainly research on the topic of interior-exterior design and Communication in design for the enhancement of cultural heritage where he gained experience at national and international level. Associate professor at Politecnico di Milano/ Dipartimento di Design. In the case of professor Trocchianesi, the interview was carried out differently, it was not face to face or by phone, the interview was a set of questions sent by e-mail and the answers were received by e-mail too, because professor Trocchianesi was too busy with her students, courses and investigations. She answered many more questions than others and she spent enough time on this.

According to her responses to questions, the researcher is going to analyses all her responses and discuss them starting with the first question about practitioners of 3D technology on interior design during design process when they need to generate new ideas for a new project.

Question number one,

RQ1: How do interior design practitioners' use 3D technology when generating new ideas for clients in the schematic design phase?

The 3D technology allows to represent in a clear way some solutions in terms of distribution, volumes (relationship between empty and full), but I think that above all in the phase of concept generation it is important to use both the digital technology and the analogic communication register (sketches, collages, maquettes and so on) mixing digital and analogic representations.

Professor Trocchianesi sees that this technology allows us like designers to show our designs in a clear and simple way, to let clients understand better what we think about the space, but at the same time and according to professor Trocchianesi, we cannot ignore the role of the anagogical communications register by following the traditional way of design, thinking and design process which approaches all the power from 3D technology to improve our design.

In the second question about the influence of this kind of technology on interior design in showing a final step or rendering version of design, from her point of view as a professor and professional architect and interior designer, it is important when she wants to evaluate the designs of students.

Question number two,

RQ2: How is the impact of 3D technology on interior design in showing the final design?

The impact represents a quite delicate matter we can indeed consider three kinds of issues:

1. about the communication: the graphic landscape related to interior design world is more and more focused on a kind of representation that has to appear "definitive" and perfect. This aspect makes the client in a "risky" perspective because it tends to expect a tailored and concluded solution and he is not interested in the concept process, furthermore any changes and modifications seem easy to do.

2.about the project: 3D technologies are changing the way to generate shapes and structures, some 3D software can give shape to very complex structures; we can recognize this design attitude in several archistars' approaches.

3. about the process: 3D technologies allow to easily verifying the working process.

Professor Trocchianesi has a different point of view about the impact of 3D technology in the field of interior design, she had divided the answer into three main issues each one of those issues depends on a specific point of view. The first issue was about showing the aesthetic use of this kind of technology in getting good results but at the same time she does not hide her fears from it, and referring to her answer, point one, could be riskier in the design and specially if the clients know that this image can be changed easily and could ask for more time to change the design and the real concept or the main idea can be lost after all of these changes.

Professor Trocchianesi confirms that 3D technology is a principle part of the design process now and specially generates new ideas for new projects and she said this technology has changed the way of thinking and building shapes.

From professor Trocchianesi´s point of view the ingress of this technology to this field helps to verify the work process easily and finds problems and resolves them quickly and that this one of many benefits of those programs.

As we know, time is more valuable than money, and saving time means saving effort and money. The third question asked to professor Trocchianesi was as follows.

Question number three,

RQ3: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)

It depends, usually yes.... above all in terms of effort (of course new technologies allow fast changes in the drawing process), but the idea has to be clear independently from the tool.

We are all agree that the role of technology came after the ideas and the concepts and at this point I think like a researcher in that technology cannot help us to be creative, but perhaps after this step, technology can have a very strong role in developing ideas through showing all the ideas via technologies using shapes, and it is clear that technology helps us a lot to get the design in less time and in better represented way in which anyone can understand it. Professor Trocchianesi agreed with us that this technology can help us to save time, effort, and money, and they are the three important things for the designer during the work process.

Technology has changed many fields and now we cannot imagine those fields without this technology or those programs, interior design is one of those fields which has had a big impact from technology, the next question was.

Question number four,

RQ4: How could the discipline of the interior design be without this kind of technology?

The story of interior design well expresses this situation.... we can see several masters that worked in the past and gave shape to several interiors.

Professor Trocchianesi said, every period has had special tools and techniques for representing work, so in the past they found many ways to represent their work suitable to those periods and its needs.

Back to the necessity of learning this kind of technology, the fifth question came to ask professor Trocchianesi about the necessity to use and control those programs in building a good career in interior design and to have enough experience to know how it works on the market.

Question number five

RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

No, it's not necessary, this is just a tool (except some cases see RQ2 point 2). Of course, it's an important skill to know but it doesn't measure capabilities of designers.

It is a tool, and it is not necessary to be a good designer, in this way professor Trocchianesi answered the question, but at the same time she does not ignore the role of this technology in improving this discipline, and according to her answer, it is not a measure capability of a designer, it is no more than skill to help designers to express their ideas better and more easily than before and makes the communication easier between the designer and client.

As we have seen in the previous interviews, the second part of this interview is to know the knowledge of the professors in using and controlling this kind of technology and how they use it in the work progress.

The knowledge in this kind of technology

The numbers of programs which you can control is not important, however, the importance of mastering some of them is.

Question number one,

RQ1: How many 3D modeling software do you use? Which?

I don't use any 3D modeling software.

Clearly and without any arguments, professor Trocchianesi said she does not use this software, and this confirms her answer in the question number five about the necessity to learn those programs to be a professional interior designer.

This question is related to question number five, but this time the researcher asked this to know if this technology can help designers to increase their work, and the answer came positively, because nowadays many studios ask for those capabilities and skills in using this kind of technology.

Question number two,

RQ2: Do you think having some knowledge in this kind of technology helps to get more work?

Yes, several studios ask this skill.

So, we are a bit lost in whether we should learn it or not, to be a professional interior designer it is not necessary to use this technology but if you need to work in studios it is fundamental in the list of requirements, and amongst those opinions, the better one from multiple perspectives is learned to avoid many critics specially if you have just graduated.

The third question is continued from the first question in tow about the importance of using and controlling this technology, and here the researcher directly asked if it achieves more work or not.

Question number three,

RQ3: Do you think if you have some knowledge in this kind of technology you will get more work?

If you are a junior designer yes because several studios ask this skill, if you are a senior designer it depends because you can create a inter-disciplinary and inter-abilities team.

The answer came to complete the previous answers, showing recently graduated interior designers how it works on the market outside the

university, and it is one of the goals of this study. As we said before this technology can improve your skills in designing and your imagination.

The design process and how designers follow it, was the fourth question, and if professor Trocchianesi follows the traditional way, or if she created her own special design process.

Question number four,

RQ4: Do you prefer to draw or make some preliminary sketches for your design first? Or do you prefer to start directly with the programs?

For sure I prefer to draw and make some preliminary sketches.... Guido Nardi (Architect and professor of technological design culture at the Politecnico di Milano spoke about the "heuristic project" that is the process of generating ideas through sketches directly from the mind to the hand.

As we expected, the traditional one is the way which professor Trocchianesi used for generating new ideas, here and in this question professor Trocchianesi, specially mentioned the Heuristic project of professor Guido Nardi, who said that it is the process of idea generation through sketches directly from the mind to the hand.

Students or future designers are the most important research sample in this study there. The next question is the center of this study for the student and how they give the importance of this technology from the point of view of professor Trocchianesi.

Question number five

RQ5: What value do you think students place on the 3D technology as a representation of quality of their design?

Students give too much importance to this tool.

Students give too much importance to this tool, this is the answer of professor Trocchianesi for this question, as she said before it is no more than a

tool, but the students give it too much value in their design work process, which caused defects in the design process for the new generation.

The design thinking phase in which students bring their ideas for new projects, the question here was if students use technology during this phase or not, and if they are using it, how?

Question number six,

RQ6: How do you think students view the computer technology's role in their design thinking and their design products?

Students overestimate the value of computer technology's role.

Students exaggerate using this technology in the design process, because they simply think that by using this technology they will achieve better work in less time, even this is correct in some cases, but the role of this technology has come before design thinking, when we are already generating the ideas and deploying them.

Referring back to the professional use of this technology and asking professor Trocchianesi about her skills in computer technology in its discipline, the next question came as follows.

Question number seven,

RQ7: How would you describe yourself (skill-wise) in terms of computer technology?

My technical ability in terms of computer technology is an average value.

Depending on the answer of professor Trocchianesi, she has the average value, which means she has the capability to express her ideas and do her work using computer technology.

Lastly, and to finish off this interview the question was about the personal use of those programs in the design process and which programs she also used.

Question number eight,

RQ8: How do you use these programs in your design process? Could you explain?

I usually use illustrator, InDesign, Photoshop both in the concept design process and in the final communication project.

As we can observe, professor Trocchianesi, uses graphic programs and she relies on them entirely in her projects for the students or external market.

4.18.7. Participant number seven, Laura Galluzzo

Laura Galluzzo, PhD in Design, Research Fellow at the Design Department and Contract Professor at the School of Design of the Polytechnic of Milano. Her PhD research was about 'temporary living' specially in the context of mega-event. The PhD involved a term as an exchange student at Middlesex University in London and one at TU Delft. In the last years, she designed the interiors and services for the Expo Village for Milan in 2015, and she was project manager of the last Cumulus Conference in Milan, The Virtuous Circle (June 2015). Now she is working at camp US, a Polisocial research project, and Human Cities, European research projects; both of them on the Social Innovation field. During her degree in Interior Design she studied as an exchange student at RISD in Providence, RI, USA. In 2008, she completed an internship as an interior designer in Paris, at CXT Architecture. After that she worked for two years as a set designer for Sky TV with Bestudio, in Milan. Then she worked as a tutor in numerous workshops, classes and studios in Interior and Service design at the Polytechnic of Milano and other international schools of design. In 2013, she founded My Homing with Angela Ponzini, a collaborative web platform designed to bring together demand and supply of services for (con)temporary inhabitants in order to make them feel at home even in a foreign context.

Participant number seven answered the question as follows;

About the 3D technology on interior design from our point of view with students usually they used 3D technology in the second part of the design process, I mean in the representation phase not in the design phase, in the last years probably because they improve knowledge about 3D technologies and the programs, software, probably they used 3D technology before, and this is strange, because probably they don't used in prob way the technology and the software, so they directly draw and models something, it's not preformed to design for project they are working on.

I think it is really important to understand, when is the right moment in some way, because it is important they do not start at the begging with technology, let the first thing that they do connecting with models, probably it is better if they respecting in some way in order, so, the 3D modeling is something it is really useful, but it is not the first step, so probably it is not often of time.

When we use 3D technology and modeling during the design process in specially to represent your project in the space in interior design, I think could be really useful, because sometimes the students cannot understand from plan or drawings, something in 3D it's clear and easy to understand, so I think it's very important not to use it like a tool of representation, also like a tool that can help student to understand spaces and their projects.

If we can speak not only about 3D technology but also about 3D modeling in general like physical modeling or also the prototyping, I think could be really interesting, because the idea of working 3D it's really connecting to space and it's something very difficult for the student at the begging to understand the space has three dimensions, and I think it's very important and the technology but not only the technology I mean also the physical model, mockups, and prototyping could be really helpful to understand better the dimensions of the space, and specially the relationship between people and spaces, so human and space.

Just a suggestion maybe to understand better which's the different when the people work in 3D technology but also with 3D not also technology but with models, mockups, and prototyping could be interesting.

I think it's really important for the discipline of interior design, because you asked if they are important on not, I think yes, for sure and allow the interior designer to save, maybe yes.

Could be interesting to match more ability in the knowledge of 3D technology with the process and project to be a good designer.

Here in Politecnico di Milano, we teach more 3D modeling for our students and we give them all the abilities to do that, because many of them learn the 3D technology by themselves.

It's really important to have some preliminary sketches, and not also sketches or drawing even also physical model for the shapes and designs to understand the space and the directly you can work with 3D software.

In the last years, the students increase a lot of knowledge and skills in use this kind of technology,

It's important to learn it to be a good designer but with limits in the using of this kind of technology.

This incorrect using of 3D technology on interior design it impacts all the student of design and especially the first-year student; they use free drawing programs to make the sketches. So, it's important to put limit for those students to start with sketching, drawing, and discussing about the project, so, they have to follow the design process in some way.

I was using this kind of software when I was in the university, but now I am not able to use it at all, have many years haven't use this kind of technology.

Discuss

The interview with professor and researcher Galluzzo Laura, was a little different, she asked the researcher to answer in general not to following questions, she had read all the questions and then she began to answer as it is written with the comments and opinion of the researcher.

The role of this technology is stated in the second phase which means it is in the represented phase, because normally the first phase is for design thinking and to generate new ideas and developed them, obviously in the last years the use of this technology has improved our knowledge in 3D technologies, programs, and software.

The problem which many professors are facing now is that students start directly with software which causes them to miss the creative part of the design and it is not preformed to design projects they are working on, which means the majority of those projects which took the same way of the design process are far from the correct way. It had to have similar results in the final representation or in the final render.

Students should know the correct way to use it and understand it, because as we observe in many designs the incorrect way of using this kind of technology derives from the design to be useless and even worse, and the mistakes at this point is the order in which the designer used the technology, like starting directly and at the beginning with technology which would entail defects in the design process and a big understanding of spaces and ideas and miss the connection between ideas and concepts about the real design.

They have to start connecting with physical models to understand the spaces better, 3D modeling is something really useful for designers but not at the beginning, it is not the first step often of time, using this technology during the design process in representing projects that in the space of interior design could be really useful to help students understand and see the spaces better.

Sometimes students cannot understand plans from drawings, so we use 3D modeling to show them spaces more clearly which are easier to understand. It is important not to use it like a tool of representation, but also like a tool that can help students to understand space and projects. 3D modeling, physical modeling, and prototyping are so interesting and useful to help us to

understand space better and give us, like the designer an easier way to communicate with dimensions.

Basically, the idea of working with 3D is really connecting to space and it is very difficult for new students at the beginning to understand that the space has 3 dimensions, but with the help of this tool, we can teach them this in a very simple manner, and so they can evaluate the relationship between people and space or in another way mankind and space, models, mockups and prototyping. It is really important for this field at the level of education or work.

It could be interesting to match more ability in the knowledge of 3D technology with processes and projects to be a good interior designer, for the new generation and to meet market requirements, it is necessary to learn and understand how it works and its capabilities of this kind of technology. As a professor at the Polytechnic of Milano I have noticed the huge increase of using technology in this field because we are teaching more 3D modeling whether physical or virtual, but at the same time it is really important to have some preliminary sketches and not only sketches or drawings even physical models for shapes.

In recent years the knowledge and skills of this kind of technology has increased which indicates the importance of it nowadays; in some occasions it is really important to learn it well to be a good designer because of their important role of clarifying the ideas and concepts for clients, such as having a positive role in the design process could be playing a negative role if we use it in an incorrect way which will impact all students of design and specially first year students in using free drawing programs to make sketches.

It is really important to put limits for students who start sketching, drawing and discussing, and support them to follow the design process in some way, I personally experienced being a teacher at the Polytechnic of Milano, and how I received my education there was completely perfect, I was

using this kind of technology in the correct and necessary moment, when I was a student, but now I am not able to use it at all as many years have gone by without using this technology in my daily work.

4.18.8. Participant number eight, Oxsana Nauso

Oxsana Nauso, is an architect, she graduated from Moscow in architecture, and then she decided to continue her studies in interior design at the Polytechnic of Milan, her PhD topic was about the contemporary ruins, and she would analyze how interior design could change these banded buildings or cities. If architecture does not work in this case, how can interior design help.

The interview with Oxsana was a little bit different, because she came from a background of architecture and she continues her studies in interior design. She is interested in how interior design can help architecture change the banded buildings, starting with the first conventional questions like all the interviews about practitioners of interior design generating new ideas.
Question number one,

RQ1: How do interior design practitioners' use 3D technology when generating new ideas for clients in the schematic design phase?

In interior design, it's complicate to use the technology at the begging, because I need to understand and imagine somethings, make some sketches after that I prefer start with model, but sometimes I can use the 3D programs to create the space, after that we can put the furniture and so on.

But, I think in architecture and productive design we can use this programs at the begging.
We made the model and then we discussing more in productive design.

According to Oxsana's answer, it is complicated to directly start with technology for interior design because at this moment you do not have any idea or imagination about the project, so it will be difficult for the entire project if started in an incorrect way, and about her personal use she said that she preferred to follow the normal way starting with sketching and modeling.

At the same time Oxsana as an architect thinks this kind of technology can be used at the beginning, because she thinks that for architecture and productive design it is not that important to make sketches and demonstrate the first steps like in interior design, in the case of architecture and productive design, making models and discussing them, it is more useful than doing sketches or drawings.

About the influence of new technology in the field of interior design and its consequences, the second question was as follows.

Question number two,

RQ2: How is the impact of 3D technology on interior design in showing the final design?

It's very important for the clients, but also important for interior designer, sometime because you have to explain your idea to another people, maybe I can imagine everything, because I have this capacity and then I should be translated and another people should understand it's very useful really.

From my experience, our clients they often waiting always for see the model because it's very useful for them and they need it and now it's very common use.
Our clients they wont to see sketches the ask us for images and modeling.

The answer came to express the importance of this software nowadays, because as Oxsana said, not everyone has the same capacity to understand preliminary sketches or drawings, so this technology facilitated clients with a better understanding about the design, and gives clients the possibility to

discuss with designers by understanding the spaces, from another point of view Oxsana said that, clients nowadays expect to see images and 3D models, physical or virtual, which makes this technology something fundamental in our work.

As a designer in a studio in the city of Milan, and from her personal experience, the researcher asked Oxsana if she thought this technology helped her to save time in general, and the answer came as follows.

Question number three,

RQ3: Do you think that 3D technology allows interior designers to save time, effort, and money? (Motivate the answer)

Yes, I think so, sometimes in models you can test something, you cannot understand it in real life, so we have to make mockup, usually we make the models to make tests and then we make the mockups, because if we start from the begging with mockups it'll cost a lot.

Yes, I think so, this was the first part of the answer from Oxsana, she said by using this technology we can make a lot of tests in one space to see correctly how it works, to avoid many mistakes and let clients see the design in a much clearer way. This answer regards her experience working in the field of interior design.

The next question is related to the previous question about the main role of this technology in the career of interior designers and it is related to the question about the impact of this technology on interior design too, but from another aspect.

Question number four.

RQ4: How could the discipline of the interior design be without this kind of technology?

Actually, I cannot imagine the interior design with this kind of technology, its fundamental; the one who need to work should be able to manage this kind of technology.

We have arrived at the point in which interior designers and architects cannot imagine their discipline without this technology as Oxsana said at the beginning of her answer. It is fundamental to whoever wants to work in this field and have some knowledge and skills, because basically nowadays the majority of interior design studios ask for their abilities and specially for newly graduated students.

The needs to learn this kind of technology could help interior designers or be something additional for interior designers. The next question is similar to the previous questions but the purpose of it is different.

Question number five,

RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

Yes, I think so, but really, it's not fundamental, but sometimes I can see good interior designer doesn't use this kind of technology, he/she has to find one to understand the idea very well from the designer to convert it to 3D modeling through technology to show it to the clients, but good interior designer who's the one has the idea and he/she is able to explain to his/her colleagues

Good interior designer could explain the idea to someone, so the most important thing is the idea.

The answer here was answered a little differently to previous answers, Oxsana responds here that it is not that important to construct a designer, designers should have the idea which is most important in our field, even she expressed that the previous question could be fundamental for us as interior designers to learn and manage this kind of technology to get work and to translate our ideas to clients, so you must have someone who has the capacity to understand your ideas and to convert it to real life as Oxsana said, so this

technology does not make good interior designer, but it helps designers to be more professional and give them more possibility to express their ideas in better ways in less time.

The knowledge in this kind of technology

Professional interior designers or architects should know how many programs make the design and are normally professional designers able to use this kind of technology.

Question number one,

RQ1: How many 3D modeling software do you use? Which?

3D studio, cinema 4D, Archicad

Oxsana as an architecture/ interior designer uses three programs for 3D modeling and software for 2D drawings which allows her to express her ideas perfectly.

As Oxsana confirmed having some abilities and skills in this kind of technology can help us as designers to save time and so on, but having some knowledge could be a good reason for getting more work and then increasing everything.

Question number tow

RQ2: Do you think having some knowledge in this kind of technology helps to get more work?

Yes, I think so. But when you are in the begging, but then when you get the experience it's not necessary, but for the begging designer it's very important thing.

Oxsana agreed with the majority of the interviewers, that it is important at the beginning of a career, but then you can get work normally even if you do not have those skills and abilities in this kind of technology.

Going back to the design process and use of this kind of technology during the work process, which way is better, following the traditional way of

the design process and design thinking or inventing something new or suspending the project.

Question number three,

RQ3: Do you prefer to draw or make some preliminary sketches for your design first? Or do you prefer to start directly with the programs?

Well, it's depending, sometimes I make sketches, but if I have already the idea I start directly with those programs.

The first step in the design process when you receive the project is to start analyzing the data which you have, and then start the phase of design thinking to get the ideas and develop it. Oxsana said if she already has the ideas of the project and the imagination about how she can make it real, she can start directly with the software, without any need of sketching or drawing.

Referring back to personal skills and abilities, the researcher asked Oxsana about her skills in using computer technology.

Question number four

RQ4: How would you describe yourself (skill-wise) in terms of computer technology?

I think it's depend the practice, even if you have some certificates, the most important thing here it is the practice or the time which dedicate to improve your skills on this kind of technology, y skill it's low I have like 7 years without using this software specially 3D studio MAX,

I am using ARCHICAD and I am very good user.

From the point of view of Oxsana, skills in this kind of technology comes from practice, so it is how much time you dedicate to this technology and how you can get a good or worse level in it. It is exactly like driving a car. It all depends on how much one practices with a little bit of skill.

The final question is about the phase which Oxsana starts using this kind of technology when she generates new ideas for projects and which program she used.

Question number five

RQ5: How do you use these programs in your design process? Could you explain?

It's depending of the complexity of the project.

Oxsana thinks every project could have a different use of this technology, and they all depend on the complexity of the project, so sometimes she starts using technology at the beginning and in other projects she cannot do without sketches or physical models, so there are no specifications or ideal time to use them. It all depends on what we are doing and in which phase we are.

It is affected by many elements like difficulties or problems which we can be faced with during the project, in all phases from receiving it to carrying out the project.

4.18.9. Participant number nine, Stefania Varvaro

Stefania Varvaro, an architect at the Polytechnic of Milan, teaches interior design at the faculty of design and works as an architect at the same time.

3D technology in general is a good opportunity for our work in all phases of it.

Interior design practitioners whether professors, professionals or students, have to know how they can use this technology during the design process and design thinking.

Question number one,

RQ1: How do interior design practitioners' use 3D technology when generating new ideas for clients in the schematic design phase?

To the clients to have an idea about the first approach that can help their requires, and it could be useful to have the possibility to have access to 3D technology.

According to the answer of professor Stefania, clients also need to have some knowledge about this technology, because it helps them to fulfill their requirements in the project, and at the same time it is useful for everyone whoever it may be.

As in many projects the last step or the finishing touch is the most important step, because clients are simply not interested in the process which derives to the last step, and normally they do not even ask about the process. Therefore, interior design consists of those specialties. The next question came as follows.

Question number two,

RQ2: How is the impact of 3D technology on interior design in showing the final design?

For showing the final design, I think even for the 3Dtechnology as a physical model, we have to think about 3D technology as an abstraction not to obtain the real material or the physical reality; it's to be remaining as a tool.

The role of 3D technology in showing the final design is no more important than a physical model, so depending on the answer of Stefania, we have to use this technology just to have an abstraction about the project in a 3D virtual model not to obtain the real material, because this technology is no more than a tool to help us.

Time is one of the most important things in our daily life, and as many studies this technology could save time which means saving effort and money, and the question here is as follows.

Question number three,

RQ3: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)

Maybe if the person has a good skill in 3D technology, could be useful to save time, effort and money.

But if have another person to do that you have to trust about him and to communicate about your ideas about what you want to show for your clients.
So, if you are able to do that by yourself it could be useful to save money and time, but if you don't could be a small problem for you.

The answer was like many answers from professors, you have to be good in using this technology to save time, effort, and money, but on the other side you need more time than normal. In this case, you need someone to make this work for you and this person has to be trustworthy for you to carry out your ideas and concepts, so it is better to take advantage of this technology to achieve those targets to save time, effort, and money.

If they had not invented this technology it could have changed interior design or it might not have had that much impact in this field.

Question number four,

RQ4: How could the discipline of the interior design be without this kind of technology?

I think could be impossible now, because all the discipline of interior design has a base in the 3D representation, if you're not able to realize this kind of technology you have to look to another alternative like mockup.

We adopt all this technology to our work process to improve our abilities and skills, so this technology has given us a lot of advantages to achieve this. Nowadays, we cannot imagine interior design without this technology, but if you are not able to use it, you have to look for some alternatives such as mockup…etc.

The next question is related to the previous and both feed into the same direction, about the importance of this technology nowadays.

Question number five,

RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)

I think we need to have an idea about how the technology could work, it's not necessary to do that by yourself, if you have a good designer who knows this kind of technology and you trust, otherwise you how long do it take to representation in stand of other.

According to her answer, it is not a fundamental element to be a good or bad designer, but at least you have to know the minimum of those programs or how it works to take the possibility of imagination and the capacity of this technology, or deliver your ideas in a clear way to someone who is able and has the possibility to use this kind of technology.

The knowledge in this kind of technology

Professors do not normally use this kind of technology in their daily work. Is professor Stefania like them or is she using some of those programs.

Question number one,

RQ1: How many 3D modeling software do you use? Which?

I use basic AutoCAD and Sketchup.

Based on her answer, professor Stefania is a basic user of this technology, because she depends on other people to do that part of the work.

The abilities in this kind of technology could increase work for interior designers or it is no more than a tool to complete projects in faster way rather than the traditional way.

Question number two,

RQ2: Do you think having some knowledge in this kind of technology helps to get more work?

Yes, it could be useful, but it's depends the target of your clients and depends the number of the people who work for you and the dimension of your office.

Professor Stefania confirmed this fact, but she said it depended on your clients and what they ask for, so there are no constant rules of that.

Asking professor Stefania about her personal way when generating new ideas for projects and which way she prefers to use them.

Question number four,

RQ4: Do you prefer to draw or make some preliminary sketches for your design first? Or do you prefer to start directly with the programs?

For sure, It's necessary draw preliminary sketches.

Professor Stefania preferred to follow the traditional way, starting with some preliminary drawings and then so on, to get the perfect way to develop your ideas through sketching, drawings, and discussing, and all those steps are far from technology, technology comes later.

As a professor at the Polytechnic of Milan for many years, she gives us the real value which students give to this kind of technology during the design process, and doing some projects for their studies at the university.

Question number five,

RQ5: What value do you think students place on the 3D technology as a representation of quality of their design?

I think it's a plus thing if the student learns this, but they don't have to lose the perception of the traditional way of representation, plans, sections, and elevations, and skip them to have it through 3D technology, they have to do both of them. Otherwise you don't have the control in your design project, so the traditional way of design process plus 3D technology.

Students do not have the possibilities to control all the design process using one thing, manual or digital way, they should use both of them to produce good work, because technology is something additional for them but it is not fundamental, so they have to continue using traditional ways in representing results with some help from technology but they cannot just rely on technology. When we are talking about technology here we mean 3D programs.

Continuing from the previous question about interior design such as a field study for students whether a bachelor degree, a master or PhD doctorate, they start the idea generation for projects, so they can use this technology in the first steps of the design process and design thinking.

Question number six

RQ6: How do you think students view computer technology's role in their design thinking and their design products?

For the student, I think it's really important, but they give to 3D technology the biggest importance.

The same issue is those students give too much importance to this technology, and they forget the main role of the manual way, which would entail defects in the design thinking and then design process.

This could produce bad results if we have some technical defects in the base of the design process, so students they should learn this technology, but they should learn when they can use it too.

As an important part of the design process and as an interior design professor, we need the role of computer technology of interior design which could be used, and for this next question it came as follows.

Question number seven,

RQ7: How would you describe yourself (skill-wise) in terms of computer technology?

My skills in this kind of technology it's very low, usually ask somebody else to do this kind of work and we control the process together, we focused in the technique thing to show it to the carpenter.

Professor Stefania does not have the skills to carry out her project, so she normally asks someone to do this work, but she relies on the workflow step by step to control everything, during the work process.

This question is about personal use of this technology, but in the case of professor Stefania she does not use this kind of technology, so her answer came as follows.

Question number eight,

RQ8: How do you use these programs in your design process? Could you explain?

It's useful during the design process, even to show the idea at the begging to the clients but to realize the physical space at the end it's another staff, because it's impossible to fell and to have the real dimensions in 3D technology and it's impossible to have the correct perception of the space.

It is a fundamental step now to show clients the design through this 3D technology, but at the same time we cannot ignore the role of the physical model, the correct perception we cannot receive through 3D technology, we need something physical with real material to feel and receive the correct perception of the space, so we have to work with both aspects, virtual and physical to have the best result.

4.18.10. Participant number ten, Marita Caninia

Marita Caninia, an Associate Professor at the Department of Design at the polytechnic of Milan teaches Industrial design in different courses. She is

an architect and has been working in the robotics field for ten years. She did the theses in bio design, design of process and was able to use devices.
Professor Caninia preferred to respond all the questions freely without limitation of answering, starting with her experience working and then teaching at the Polytechnic of Milan for many years, and working on many research projects in Italy, Europe and on an international level.

Starting to analyses her answers and make some comments on it, this is how it went.

When I was a student, this technology it was none discovered yet, they draw everything's by hand, thinking, making sketches, and it was a totally different from now.

From my point of view and her experience in the class, the most of students think through technologies, they don't think about the shape or interaction with people, but they think how this shape is realizing through software.

This confirms what many professors said before. A few years ago, this technology did not have any kind of role in the design thinking or the design process and it was totally manual by hand.

The researcher asked Professor Caninia if this kind of technology put some limitation on the creativeness of the students and she said, *YES*. The researcher continued his questions. If these students do not know how to use this kind of technology they will change the shape or the form.

She said, *absolutely YES, the shape follows the possibility of the software. The researcher comments on her respond saying, the technology controlled the designers not the designer controls the programs, if you meant that.*

Commenting on Caninia's answer, technology can destroy the idea or the concept of the design. If students feel that they cannot make their design using computer technology; they start to change it, ignoring the main idea of the design which leads to this point of those technologies controlling the designer and lose all the creativity part of the project and this could change all

the design process, because the shape simply follows the possibility of the software.

From didactic experience we won't that, the students go through follow the steps of the designs process, we stop them and ask them to draw their ideas and follow the steps of design process, they have to analyze user contest and then think about the problem of the people.

The researcher asked again if the new generation of designers start with sketches? Do they start directly with software?
She answered, *software, and we stop it them now*, the researcher commented if technology has changed the design process, the researcher explained how the design process was a few years ago.

The professor Caninia said, *for change their approaches, we want they use mockup, sketches, and so on because they start with technology and we say no. it's not the correct way.*

Professor Caninia´s answered that during her didactic experience she taught many students and she always tried to ask students to make sketches and sometimes she obligated some students to do it, to avoid making mistakes in the design process, and she said to the students, we are not able to see anything on computers, we just see and discuss the work which is done by hand and with some pictures to make the idea clear.

They are faults, this is what said the colleagues of professor Caninia and her students, *there are three main steps, before they finish the class, the assistance professors leading a studio base course with product designers' students and they are fouls to go through three main steps. If you leave them free, they say okay. The challenge is to design something for old people, if you leave them free the design will come without technological idea with a shape design with technology paint. In the science studio, the effort to go through steps think to the findings of this person, identify the context, describe the person, and the activities, so there are several steps*

which apply them no through design straight away through digital technology, but to focus on the person, the context, and the action. And finally, they will have only and the end they had to put unity to approach digital technology.

Professor Caninia´s colleague had added some comments. He said we must not leave the students alone and we should control them step by step following the design process which is the correct way to get good results. The idea will come without any concept and they will not be able to develop it either, so as we observed before, the design will be produced without concept or idea and they will not be able to develop the idea because they are limited on their skills and abilities in some programs in which they know how to use and control more or less.

Canina said, *just to skip this dangers way to use the technology, when we arrive to concept step, one of the requirements was, we want to see drawings, sketching, and mockup, nothings on the laptop. We will not check any work on the laptop.*

For us it's the methodological approach.

As we cleared in the previous comments, we do not accept any digital work, we need to see physical drawings to discuss; like that professor Caninia applied her methodology on the class, asking students to follow this way.

How was the reaction of the students? Did they hate this?

In the first step, it's very frustrating for them, but some students they appreciate, since moment we don't saw any digital work, and we saw that they are able to explain their idea through mockup or sketching even pictures also collage, but the student has a find the way to explain his/her idea.

Because, if they can choose the technology they'll think in the final shape, how it'll be.

As everything in this life, the first experiments are difficult, but then students become accustomed in that way and they are very well aware of the

value of this way when they start working in the real market, dealing with clients and so on.

Do you think this kind of technology has made a big impact on this generation of designers?

Yes, of course, many of them think through this technology.

But it's very important the teaching path, because it's very important they understand to be a designer understand the process not understand technology.

They are design students not information technology students, which means learning how to design is a fundamental element in a designer´s career, but technology is something helpful to us, but not a principal thing in the design process, so design first and then design technology.

Do you agree that many people say, now, we do not have a designer, we just have people who know how this kind of technology functions and they use it very well (We don't generate)?

I think that this is what makes studies different between the good and bad designers.

Professor Caninia thinks that, maybe these strategies which follow some studies can give clients the correct perception about good and bad studies and designers, because it is so easy to know how to work with ideas and concepts and conversely.

Do you think this kind of technology is necessary to be a good designer?

You have to know the technology apart to all what I said before. You have to be a good designer and then learn this kind of technology, it is a tool no more, the good designer uses the technology like a tool not like fundamental thing, and it's a tool to give you the possibility to explore otherwise, the other things if this is the only one way.

From the point of view of professor Caninia, a good or bad designer is not related to technology, design is creativity and skills, if you are good in these things you can be a good interior designer. Therefore, technology is no more than a tool to help us to explore better ideas and show clients, helping them to understand the design better because clients simply may not have the capabilities to understand this.

Should it just be the final steps to represent the work?

Canina´s colleague said,

A friend of mine is a graphic designer; he was a basic in the way he could express himself by digital drawings, a count digital drawings, but he was using it in way powerful way, so was a tool that was enabling him, he wasn't good be hand, because he never been good by hand, but he's very good through the tablet, but his philosophy was I am a graphic designer, I am using this tool the most functional way, because I can express myself through this tool, but obsessively he becomes just to make funny staff, it's not anymore a tool the way you think, more than the way you express yourself, so the tool shouldn't replace you, the tool should be minds through as you can express yourself, abilities, and your thoughts.

We have some very useful experience here of one of our colleague´s friend, who is a graphic designer. He is using this technology in a fundamental way because he does not have the capability to draw and make sketches by hand, so he is using this technology as a fundamental element in his design process which confirms that this technology could be more useful than actual hands in some special cases like weak skills in drawing, but at the same time you have to know how you can control it in a unique way to express your ideas and keep your use of these tools under control.

The tool is powerful, the digital tool, you can fix things, you can see straight away with solid wall, with 3D software, you can see the shape while by drawing you're just guessing somehow, so it's powerful too.
But obviously, it is top to you in person if you're conscious in away what happened in front of you.

As they clearly stated before, professor Caninia and her collogue assisted conscientiously in using this technology. It is very important to use it at the correct moment in the correct way, and it is very useful because it can produce a 3D shape in a few hours. Therefore, from this 3D digital shape you can achieve a good perception of spaces.

Our colleagues say this is a cube generation, because he said if people it's not a good designer uses the technology to build the cubes for all things.
The manly effect is through technology, technology as made accessible action that previously were probably or backs bad in professional, this is also what we are investigating, so previously being in architecture, interior design, and product design meant you are good in both technical in final drawings and so on.
Through digital technology, now you can more easily do this even if you didn't attend to classes or courses, you have many resources to learn this by yourself.
Mows the risk that more people can fell you're a designer or an architect even if you didn't missteps correctly.

One of the bad things about this technology is that it is accessible to many people. this could be an advantage or a disadvantage simply because if we have many people who are able to use this technology, it could be a risk for this field of work and it could replace the interior designer as there are people who are willing to receive less money than designers.

The researcher did many visits to more than one architecture/ interior design studio, and he found that many people work like architects or

designers even though they do not have any kind of studies about these two disciplines, but people who have a career in computer science and know how to use and control this kind of technology.

One of the past possibilities to do this only if you everything in mind where your conscious and you're able to do everything before it was more difficult to think and conceptualize and communicate all the steps. While now through this technology you do it more easily.

Now there is more of a pro-creation than any ever before which has caused all this to return and give technology more value than creativity.

So, possible it was no accessible in the past to the once have this in mind, and now you give the potential to the people. But obviously, dose did make the person an architect or interior designer but this mean the person is a technician.

As a small conclusion of Cantina's comment, all those people are technicians, without any kind of creativity, and they will stay like this.

But I think it's related to final solutions as Professor Canina said, because that take stander the element and make space, do not do anything very innovative, I think this is the difference between designer and technician, is like if you want a wonderful the house you can ask to architect, if you want a house you can ask some bricklayers to do that. It is different the result, simply because the architect builds the house according with your dream or vision, needs, or something else you want.
Stander way it neither is not related to your vision.

The results are demonstrated by the technician and the designer, simply because designer or architect work is based on knowledge and experience, and many studies even bricklayers work according to their weak experience, so it is easy to note in the results.

They ask the researcher if he think the problem it is the tool or how they use it.

Well, the tools, by this we mean the software, is not the problem, yet a big invention for us who work in this field, the problem is how we use it, let it take our place and let it control us, or however we use it to control it.
And it is meant to help us in our design process, not to replace us.
Based on my experience as an researcher in this field I answered as it wrote before, and the answer I built up during many years of investigating and working with interior designers and dealing with design studios.

They suggest and advice the researcher to read the book under the title of Design when everybody design by Ezio Manzini, He is an Honorary Professor at the Polytechnic of Milan.
It contains many important things such as everyone using Google sketch...etc. to draw their spaces.

But I think the different it's the knowledge you put in this, as Caninia said. How you manage the process, and the impact to this challenge the role of design that's not the one who controlled the hall process and design and producing things, but, how I can someone else who's want to be a designer, even if he or she not qualified to be a designer.

Because the digital technology enables people to draw and produce things by themselves, at least the designer can help them to do it in the most appropriate way, affections, affective, and environment speaking, and social speaking.

Here it depends on one's creativity and their dedicated experience to demonstrate if they are a good designer or not because everyone can make designs but the question here is if those designs are useful or just results of the computer technology experience.

Do you think this kind of technology can save time, effort and money?

For sure dose, but the risk if that another people there are not an interior designer can use the same tools to appear as interior designers, so we have more competitive than before. The completion is higher because anyone can be an interior

designer including this kind of technology. Not only the once for drawings but also the internet, now you can make a video yourself and show your portfolio make pieces through 3D printing and so on, you have the tools to make anything, if you're not an expert, even you didn't learn about this or never went to the university to learn that. So, as an interior designer you have idea to compete with this people or you decide to help them and do it in the most appropriate way.

The most important thing is not saving time, effort and money, but the design. Normally the quality of the design demonstrates the capacity of the designer which makes a difference comparing a technician to a designer. We have to develop our concepts and ideas about technology and its impact to get the maximum potential from technology in this way.

Do you think learning this kind of technology can help us like an interior designer to get more work?

Obviously, the requirement is higher now, you know when you see thing in architecture Zaha Hadid work, obviously the stand now people expect all architects is like Zaha Hadid, because they used sort of software technicians and you can do incurable things and when you do with house possibility defections of clients and not matt, because they expect anyone a wonderful house, so in average an architects and designer they limited a push peon it was in the past, it's give you more work if you know and can manage it.

Nowadays competition is greater than any time before, so you have to know many things about your discipline, and many designers have changed their way of thinking with clients through showing them realistic images about their designs, which obligates us to learn this kind of technology not to achieve more work but to be on the same level as market requirements.

4.19. Idea Generation

Additionally, utilizing PC innovation for gathering data, participants likewise announced utilizing the PC innovation for creating thoughts. All through member meets, the methods in which configuration professionals' utilization the PC innovation for thought era differed from the writing survey meaning of the demonstration of drawing. Participant interviews uncovered the PC innovation was being utilized for the era of thoughts, however members created those thoughts by utilizing on the web apparatuses and projects to manufacture thoughts upon, as opposed to portraying. Members demonstrated that between half - 75% of the time they utilized PC innovation to produce thoughts rather than conventional techniques utilized beforehand.

Online assets as web journals, makers, magazines, and thought and idea era configuration programs all were talked about by participants as important devices to thought era.

4.20. Participant Experiences

Two subjects in regards to members' encounters utilizing PC innovation in the outline procedure rose up out of meeting information. The two experience subjects were (1) the effect on work procedures and (2) capability of PC innovation amid configuration handle. Inside the subject of effect on work forms, two subthemes rose: (1) preferences and (2) impediments. Every one of the ten members communicated differing encounters and recognitions, some more grounded than others, of their own capacities to effectively utilize the PC innovation for inside plan related errands. Most communicated a powerful urge to reinforce abilities in utilizing the PC innovation; however, members additionally showed time restricted

them in doing as such. Participants essentially demonstrated they were keen on partaking in this specific review to increase extra learning and knowledge on how other inside outline experts are as of now utilizing PC innovation.

4.21. Participant Experience Theme 1: Impact on Work Processes

4.21.1. Advantages

Various advantages of the plan projects were rehashed every now and again all through member interviews giving awesome understanding on the outline programs convenience in the plan procedure. Among the many points of interest members examined about utilizing configuration programs, they transcendently talked about the capacity to get to web at whatever point required. Regardless of whether on an occupation webpage, at a customer meeting or individual duty, the capacity to have moment web get to expanded members' multi-entrusting capacities.

4.21.2. Disadvantages

A few restrictions of utilizing the PC innovation in the plan procedure were examined. The principle reason members expressed with reference to why they felt the PC innovation was restricted their practice was time limitations. The greater part of members talked about the absence of time they needed to take a seat and discover, then learn, new projects supporting their plan exercises while proceeding to maintain their business.

Most of the participants remark that this sort of innovation put a few constraints for the understudies and educators and lessens the limit of speculation in valuable arrangements, and commit understudies to change their thoughts relying upon their abilities in this sort of innovation which mean lose the imaginative piece of the plan procedure.

4.22. Potential of Digital Tablet during Design Process,

The capacity the PC innovation needs to alter expert work process was talked about by all members. Also, specialists examined the PC innovation capacities to enlarge their occupation execution, supplementing their longing to propel their insight and expertise with the PC innovation. The greater part of members concurred they are as yet taking in the boundless conceivable outcomes the PC innovation needs to consistently improve configuration forms.

Consistent combination of the PC innovation into configuration procedures was examined by all participants. Like building data displaying programming, for example, 3D programs, most of the participants communicated the yearning to further expand this work style with utilization of the PC innovation.

At every gathering close, individuals were allowed to add extra information they expected to impart to regard to their usage of PC advancement in the arrangement methodology.

4.23. Summary

The reason for this examination study was to investigate how inside outline professionals use PC innovation amid the plan procedure. Specifically, noteworthy was if and how outline specialists are utilizing the PC innovation while creating new thoughts for the customer inside the schematic plan stage. All participants in this review saw numerous advantages concerning the utilization of PC innovation in the plan work environment and amid the outline procedure. Two noteworthy classes formed the discoveries of this review: member inspirations and member encounters. Inside every

classification, developing topics and sub-subjects were recognized. The classification of member's inspirations for utilizing the PC innovation in configuration ventures included four topics: (1) correspondence, (2) data gathering, (3) business efficiency. The correspondence subject had three sub-topics that developed (1) new innovation, (2) physical model and (3) visual introduction. The subject of data social event incorporates two sub-topics of (1) accumulation of data, and (2) thought era. Inside the class of member encounters, there were two topics that rose. They were (1) affect on work procedures and (2) capability of configuration projects amid configuration prepare. The topic, affect on the work forms, had two subthemes that developed: (1) favorable circumstances and (2) disservices. Incidental remarks, not clear in subjects, included such remarks as the issue of being innovatively tested when utilizing the PC innovation and individual inclinations of PC innovation capacities for work utilize. The larger part of members saw that upgraded correspondence was the spurring element for utilizing a PC innovation for their inside outline business.

Correspondence was a standout amongst the most widely recognized topics specified that identified with inside fashioner's inspirations for utilizing PC innovation in their work exercises. Every one of the ten members examined various qualities of correspondence amid individual meetings. To improve correspondence, participants expressed the most successive utilization of PC innovation was visual portrayal with customers, contractual workers and staff.

For the most part, they saw the PC innovation gave a prompt technique for keeping up visual contact with the venture group. Proceeding with the correspondence cycle, members examined the apparent estimation of sending staff to the last stride of the venture which accomplished to give quick venture or customer data. The expanded venture bolster, through

moment correspondence streamlined the venture correspondence handle and expanded venture productivity.

The last subtheme inside correspondence was the capacity of the architect to utilize the PC innovation for visual correspondence and introduction purposes. For instance, members expressed the PC innovation is favorable in expanding their capacity to plainly convey their plan idea to the customer or colleague. A few members said that their customers react better to utilizing this type of visual correspondence than more customary strategies beforehand utilized. The PC innovation was seen to improve visual correspondence if combined with another yield gadget: a projector or TV. Also, as the architect smoothly explored through drawings and archives customer alters could be immediately joined as substance was talked about.

The dominant part of members met saw data assembling as any errand that includes gathering information, thoughts or materials to finish beginning outline proposition or to create thoughts. Member discourses demonstrated that accumulation of data utilizing PC innovation preceding task begin was a noteworthy utilization of the PC innovation in the plan procedure. Much of the time, members expressed that social event and archiving on the web data better encouraged their undertakings. The capacity to quickly get to data participants expected to direct business, was something all creators much of the time talked about. A few members talked about the advantages of looking into material particulars or having the capacity to reference past customers' venture while being at work site, in a customer meeting or travelling.

Additionally, utilizing PC innovation for gathering data, members additionally revealed utilizing the plan programs for creating thoughts. Member interviews uncovered the outline projects were being utilized for the era of thoughts, yet members produced those thoughts by utilizing on the web instruments and projects to fabricate thoughts upon, instead of portraying. Two participants at present utilized the computerized tablet for

drawing purposes; despite the fact that members not right now utilizing the advanced tablets portraying abilities communicated a future craving learn. Online assets as sites, producers, magazines, and thought and idea era programs all were examined by members as important apparatuses to thought era.

All participants saw the PC innovation as an advantage for the outline specialist while finishing customer ventures. In any case, they felt the full abilities of the PC innovation are yet to be figured it out. The lion's share of participants emphatically concurred that PC innovation will, sooner rather than later, confront higher request in the outline commercial center. They likewise accepted, with particular projects, that the PC innovation will be additionally coordinated into the day by day practices of an inside originator.

4.24. Second type of participants, STUDENTS

In this part, we carried out a study on master's students at the Polytechnic of Milan, the questionnaire had two types of questions, (1) quantitative and (2) quantity. Each part of this question was analyzed individually based on the question and the predicted answers, the students answered the questionnaire during class with permission from the professors. Some of the students did not answer them and they left the questionnaire blank, and some of them answered some questions and left others unanswered.

In this study, we analyzed all the data which we received from the students through the questionnaires, starting with the received answers and then made some comments on it. All participants' answers are stated as received.

The questions in this part were open questions which gave students the opportunity to answer as they wanted.

RQ3, in an ideal design process, which activities/phases would you use digital media and what aspects would you use manual techniques?

1. Manual – conceptual sketches, ideas

Digital- final presentation

2. in every phase

3. for the conceptual part – manual (drawings, sketches)

For plans, sketches, elevations- cad

For 3D – Sketchup- 3D Photoshop-render

4. I'd draw sketches at concept level, later it'll be all digital.

5. Sketches, brainstorming and research in hand and digital use starts.

6. Manual techniques, in order to sketch an idea and understand a space (using physical models) digital media in order to do the final work

7. For the first step I use manual techniques for sketches and brain storming. For the details and last step, I use digital programs to prepare the design for the presentation.

8. I think at the first you have to use some manual techniques and the middle of the concept you can use digital media.

9. Finalization as 3D rendering

10. Always 50/50

11. When I have a clear idea of concept. Then I use Photoshop. It's while the concept is clear. Then I use 3D max to design space.

12. After set the plan, I'll use digital media. When I need poring over my scheme, I'll use manual techniques

13. Digital media- predesign, presentation, plan drawing, modeling

Manual- sketching

14. 3D max for rendering and after Photoshop InDesign for the graphic presentation.

15. For me, it depends on the situation but for example digital media: parts of the presentation, animations.

Manual techniques- part of the presentation of physical models

16. Brainstorming, initial idea and sketches- manual techniques

Graphic techniques drawings, 3D as collage – digital media

17. Brainstorming and concept manual. Digital media. Techniques drawings digital medial sketches manual, graphic media, 3D views digital media

18. digital- project devolvement / techniques details definition. Manual- concept, brainstorming

19. Digital media in we'd to explain detailed information about project as well as to make more interested such as: rendering layout

Manual techniques in used when we want to brainstorming to find concept

20. for devolving the process to my project- digital media

First steps and conceptual drawing- manual techniques

21. for 3D perspective and layout and graphic- computer

First steps- manual

22. Usually I start doing the concept in 3D as a draft. Therefore, I don't use manual techniques

23. I don't use manual techniques because, cannot draw good. When I have any idea I usually draw on Illustrator

24. I always use digital media to explain the diagrams 3D models

And use manual techniques to draw some sketches and real models

25. When I am developing the concept I use digital media and then manual techniques to see precisely if it's possible the design

26. it's depends on the objectives and tasks. Traditionally sketches and concepts developing's requires manual techniques use real modeling's it's possible to use that even output stage too … tablets …. V-ray so manual techniques are to concept and presentation at the end.

27. As I major in interaction design, so I usually use manual sketches to do story board, concepts devolving. I think manual techniques it a good way to discuss with others

Discuss

In order to obtain the best results which, the researcher got from the questionnaire, the majority of the students follow the traditional way according to the design process and design thinking, but, some of the students preferred to follow their own personal way or create his/her own method to create a special design process which just serves him/her. Some of the student answered depending on his/her experience, the information which he/she got from lessons, or from another source of information in interior design like, design blogs, magazines of interior design web sites. So, we found, when the student does not have the skills, capacity, even time, or to save effort and time, they used the technology directly to create the design through the traditional way, because the majority of the students think that the clients do not ask or care about the sketches and the concept and that the most important thing for clients is the final result. We got some responses saying if we already have the idea of the design in our mind we can directly start with 3D technology, because it is not necessary to lose time and effort making or drawing sketches and then convert all these sketches to digital drawings and start directly. The same reasons which expressed that the students are given permission to avoid one of the most important steps in the design process, could be the reason for spending more time, effort, lose money and the possibility to increase the work load.

It is clear that the students' reliance on this kind of technology is much more than normal, because the majority of the students said it is impossible to produce good work without this technology. Even if we look back just 30 years ago we did not have this kind of technology but we had very competent designers who built themselves up without all this technology.

"Above all, think of life as a prototype. We can conduct experiments, make discoveries, and change our perspectives. We can look for opportunities to turn processes into projects that have tangible outcomes. We can learn how to

take joy in the things we create whether they take the form of a fleeting experience or an heirloom that will last for generations. We can learn that reward comes in creation and re-creation, not just in the consumption of the world around us. Active participation in the process of creation is our right and our privilege. We can learn to measure the success of our ideas not by our bank accounts by their impact on the world." –Tim Brown

So, the students argue that they use and rely a lot on this kind of technology, because today it is impossible to sell your design project if you cannot manage this software.

Point of view of the researcher

The researcher thinks that it is not necessary to learn and use 3D technology in the field of interior design to be a good interior designer or to increase more work, we cannot avoid the role of this kind of technology in improving the interior design field in the two aspects, commercial and educational, and it is a big mistake if we connect the design thinking, process and creativity with technology. All the aspects of a design project can be done without technology and with a bit of creativity.

Recommendations

The researcher recommended interior designers to follow the traditional way of design thinking, process and creativity to improve their skills in this field of study by keeping up to date with all the new technology to help interior designers improve their capacity of understanding the space and controlling it by using these tools.

RQ1. How do you use these programs in your design process? Could you explain?

1. Hard to explain. I use them to gather, I don't finish everything with one.

2. Just in a regular way.

3. Auto cad- to make all drawings. Plans, sections etc. - sketch up- 3D and Photoshop – renders

4. I mainly use is this way. Sketch - start program middle – end project. A little bit before the middle of the programs of the project

5. After brainstorming for precise design

6. I defines a concept making mood boards (design, illustrator, then I do a plan (AutoCAD) and finally the 3D (3ds max sketchup, Photoshop)

7. Everything start with hand sketches anyway. I start use programs when my hands get tired

8. I use these programs to explain my idea with dimensions, with color materials and other specific thing used in design.

9. Illustrator for having brainstorming about design.

10. To be more specific

11. PPT/P.S. Helps me to get clear logic system. 3D max made me know most of details of the space

12. I use these programs and make my scheme look like more enlightening

13. Model an idea, concept and then do render.

14. I medialize the shape of the building a 3DS max or Revit and at the end of the project I render on 3DSMAX.

15. AutoCAD- plans and sections, Photoshop- I image manipulation in design, arrangement of graphics content, 3DSMAX – 3D modeling and rendering

16. colored drawings or sketches Photoshop. Graphic- InDesign or illustrator / techniques- AutoCAD light collection

17. I use these programs to schematize ideas/ choices to show how I image the space and to make visible) understandable what's important for me in the project.

18. Sketch up modeling v-ray. Rendering adobe; post effect and layout.

19. `Sketchup 3D max; rendering AutoCAD technical changes, Photoshop/ layout diagram

20. to showing perspectives and views and layout.

21. Usually in 3D part

22. AutoCAD- for planning and layout. 3D max- for rendering. Photoshop- for editing the render.

23. For basic idea I use Illustrator at the beginning, easy way. Then I combine the technical drawings in AutoCAD and so on.

24. Like sketchup, I use it from idea design to the impression drawing to connect each thought.

25. AutoCAD and rhinoceros- for detail drawings 3ds max and Photoshop – visual.

26. I use these programs to deliver my ideas to clients.

27. Usually use rhino to do the digital model.

Discuss

The second question of the qualitative part of the questionnaire was similar to the first one, but the researcher needed to know a very specific thing from each question in this questionnaire.

Almost all the responses in this question were normal with some exceptions. The students who answered this question expressed their use of multi software to make their design project following a lot of methods, manners and styles. Each one of them is trying to be unique by using their own design processes. All the answers above are stated by the students.

We can observe that many students use graphic design programs to obtain the best final presentation, because of them as said before, the clients do not care about the process and how the design is produced. The most important thing for them (we mean the clients here) is the final design which is applied in full scale.

This means the clients can be convinced favorably of the design. If we made the final step like a high-resolution image which obligates the designer to use these kinds of programs he/she would specialize in and dedicate enough time during the design process.

As we can also observe not one of these students which the researcher carried out the study on in class, uses manual techniques throughout the design process. All of them think it is necessary to create the final step using computer programs to obtain the best result which means they are not convinced that the traditional way or the manual techniques produce a design which has the same result if we made it correctly.

Point of view of the researcher

From the point of view of the researcher the students are all right in using this design process, simply because if we create a beautiful design and we do not sell it, it means we do not know the requirements of the market outside of our design office and this is a big mistake that every designer can make.

A few years ago, when we did not have this technology all the design processes were by hand without any kind of helping from computer technology, A few years more ahead, the researcher believes that we will lose the current design process and follow the evolving 21st century, as we can see and observe in the design process from the presence of technology in our discipline (interior design) and the big impact on this discipline using this kind of technology and how technology has changed the design process and is still changing by allowing designers to make all the design process without any kind of manual techniques needed.

For some students if they already have the imagination how the model or the design will be, they will start by directly using computer programs. There are some good strategies to not lose time doing sketches for these students.

RQ2What if any, specific programs have you found the best to assisting you in the design process?

1. Photoshop, InDesign, sketchup

2. AutoCAD

3. Sketchup with v-ray- super fast

4. AutoCAD and Photoshop 3D, 3Ds max and v-ray- illustrator.

5. Photoshop.

6. I am to learn to pick up anything new, so I started to 3d max mainly.

7. AutoCAD and sketchup

8. Illustrator

9. Rhinoceros

10.3ds max. Because I use it for many years. I like use it to think about the space.

11. Sketchup. It can better be understanding of the space

12. Rhino (for modeling) 3Ds max for rendering

13. 3d studio for rendering. For cad drawings- Revit that allow the modelise in 3d really quickly

14. Autodesk, adobe,

15. Sketchup in quiet and immediate, it permits to see your project in 3d in very few time

16. Illustrator and sketchup; you can quickly create and show something about the project … also improving the way in which you're doing it.

16. There are not a pretty one yet

17. AutoCAD, 3d max, Photoshop, InDesign

18. Sketchup, 3d max, AutoCAD, Dialux

19. No one is the best in anytime

20. 3d max

21. Photoshop

22. Cinema 4d

23. Grasshopper

24. AutoCAD, Photoshop, 3Ds Max V-ray, Illustrator

Discuss

In this question, according to the answers of the students, we can observe each one of the students uses a different program, looking for the best results, every one of them thinks the package which they use is the best one to obtain the best result, some of them just use one program and some use more than one, yet still giving importance to the final result which the client will see and discuss with the designer.

Some of the answers say, if we use these programs this way we can get the best results very quickly or super-fast. It is a good enough reason to produce a new program which combines many tasks to get a better result in less time as one of the students said.

Point of view

Even this question is very similar to the second-to-last question where the researcher needed to know the specific programs. This information obtained can help the programs companies to innovate, develop and get better.

The software companies can innovate some programs with more than just advantages, like mixing the architecture skills with graphics skills and tools. It will facilitate the work of the designer, and at the same time it will reduce the time needed to make some designs, by this meaning saving money for clients and the designer.

RQ3. Tell me about some of your research strategies when you need/ wish to develop a new concept (object)? (Based in 3D technology on interior design?

1. I use Pinterest to gather the inspiration I try to start from 0 level of my imagination of an object, thinking directly.

2. Start with learning, getting aware of the topic (articles, books, etc.) start down your thoughts. Start putting them to scale on AutoCAD. Draw 3D on sketchup.

3. Research history, art project, lot of Pinterest.

4.I never use program when I develop my concept. I do research about the project + sketches+ keywords etc.

5. Online research, Pinterest

6. Web research

7. We have a lot of 3D programs; I hope to combine between them. Virtual reality I think it is a great technology that allow the clients and others to feel they are in the real space. They can feel material and color.

8. Design blogs

9. Step by step. Philosophy. Method, concept, it there are some really good idea. I also like join it to the early steps.

10. Learn more things in different ways.

11. Preliminary research (books) magazines/websites for inspiration. Sketching then modeling/ cad drawing. Rendering

12. Feed often books/ magazines, about architecture, with 3D pictures look on website (enervation, to have some idea about the lighting to use on 3d renders

13. When I'm starting a new project, I don't like spending a lot of time on the internet, because that pushes me towards things that have been done already. I like to develop until certain point, see if it exists and go on.

14. I would search to care studies or do some research about technology in some form on video to learn how to do.

15. First, I would look for some cases study on order to see what was already been done, also to find some similar object that has already been represented through 3D technology.

16. I take reference from databases of professional fields to consult what's done before to concrete my ideas

17. Searching and looking for innovative and special design from the internet.

18. Searching for concept on internet

19. Researching about site / location where we will design as well as people who will use or live in that space. Or brand of the client also construction of the space. Brainstorming, looking for case study, discuss with client, develop a new concept.

20. First step I browse the internet, search in interior design magazine, then I try to develop a draft using 3D.

21. I take inspiration from the web and then try to give a shade in sketchup

22. Look some online video tutorials.

23. 3D technology it's an easy way to show the model. Grasshopper can make some models that are really hard to obtain in normal software.

Discuss

The majority of the students use the internet when they want to develop a new concept in interior design, through some blogs, pictures and articles.

Some of them prefer to start reading some books about the topics and construct a general idea about the design, starting with coming up with all the devolving in this topic, and they show cause to design something new and do not repeat any design for another one, and according to their answers its purpose is to avoid mistakes which another designer has made in their previous designs.

All these strategies are correct for most professors. Normally, not even the professor asks the students how they devolved the idea, but they explain

strategies like this during the course and therefore, the students use it. Some of the students prefer to visit a similar real-life design to observe and take notes about the design. This strategy it will drive the designer to avoid the errors and try to fix it, it is one of the best strategies to build upon.

Point of view

The doctorate candidate, in this question, needs to know if students follow the same strategies or different ones, although he thinks students do not spend enough time developing ideas and creating a new method to make a design.

The candidate thinks, each design in our daily life needs a special method, so we cannot generate some methods in all our designs because it is impossible to find two spaces with the same diminutions, site plan, and target.

If we ask students to create a project, they most probably will look back to some case studies in different situations, trying to avoid the maximum possibility of mistakes of previous designs. The candidates even explained this idea in the second-to-last paragraph. It should be clearer to understand.

The clients normally do not ask the designer how he/she has created the idea of the design. They are unaware of this.

The second part of the questionnaire for the students was closed questions (multiple- choice). The students had to choose one of the written answers or choose the last option which was `other and specify`.

Statics

		Q1	Q5	Q6	Q7
N	Valid	30	30	30	30
	Missing	0	0	0	0

Frequency Table

RQ3. 1. How would you describe yourself (skill-wise) in terms of computer technology?

A. poor

B. Good

C. Advanced

D. Other (Specify)....

Discuss

In terms of the first question it was about the capacity of students exploring or displaying their work by using software. We can observe that the majority of the students have a good to an advanced level in this technology. The obtained results from this question show how important this technology is for students to represent their work and communicate with clients.

Today students, professionals and professors in this field should at least have knowledge and a perception of this kind of technology to be able to express clearly to the average person who does not have this knowledge. They are the bridge between their clients or students to express their ideas in the easiest way possible.

The two students who answered poor knowledge in this technology gave the questionnaire to the researcher and said they knew that they had a very low level in 3D technology, but were well aware of the importance of it and because of this, promised to improve their skills. The researcher did not even ask them but he knew that they had very good skills in drawing by hand.

However, the importance of this technology has persuaded those students to say that they do not feel any less capable than their colleagues.

Referring to the students who answered the third option, 'Other` said to the researcher that they did not know their level due to the fact that they asked the researcher for a definition of poor, good and advanced level. They simply believe that no one can describe this.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Poor	2	6.7	6.7	6.7
	Good	14	46.7	46.7	53.3
	Advanced	11	36.7	36.7	90.0
	Other	3	10.0	10.0	100.0
	Total	30	100.0	100.0	

RQ5. Do you think it is necessary to learn this kind of technology to be a good interior designer?

Yes (specify)….

No (specify)….

Discuss

Obviously, as we can observe, the majority of students think that learning this kind of technology is important to be a good designer or at least to sell or market the design. However, there was a low percentage who said the contrary and said `No`. To conclude we can say that within a few more years´ time this percentage will change to more a supportive way of thinking by using this technology.

Many of the students´ state that they use the 3D technology or the technology in their design process because it helps them to express their ideas

better and to let the clients understand the concept and helps them to find an easier way to communicate with clients. So, all the arguments state that students are driven to value the role of this technology in our discipline, and this role year after year will get more space in our design process and more importance and have more benefits from these tools and software.

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Yes	21	70.0	70.0	70.0
	No	9	30.0	30.0	100.0
	Total	30	100.0	100.0	

RQ6. Do you prefer to draw or make some preliminary sketches for your design first? Or do you prefer to start directly with the programs?

A. Make some preliminary sketches

B. Start directly with the software programs

C. Other (specify)….

Discuss

In question number six the researcher needed to know if the students followed the traditional way in the design process starting with sketching step by step to achieve the final step to represent the work to the client. The responses were normal due to the fact that they are following the correct way to generate a new design however the design is or which discipline is acquired for the design. As we can see from the obtained results the percentage is high, meaning students are able to know when they should use the technology and when they should not. All these obtained results are based on the design education that the students received in their first years in this field of study.

Like creativity in this field, improving our skills as a designer in drawing is very important to express our ideas and convince our clients that we are working on concepts and all our steps are based on our knowledge and experience and the design process and that nothing is achieved by coincidence.

In my point of view, a few years later, the main step of design process will be to create or draw preliminary sketches digitally. Even now there are many designers who have been using a digital tablet to make sketches for years and as a result I think as an interior designer and researcher in the use of new technology in interior design. The use of a paper and pen to create the sketches will disappear little by little like many disciplines as we will explain in the use of 3D printers in interior design and how it has had an impact on many manufacturers like furniture design.

The students who answered they directly start using technology use this strategy when they already have the idea, concept and the evolution of the design process and design thinking according to their comments on the questionnaires. Two students answered (Other) by mixing more than one technique achieves a better result and presents useful and clear sketches.

We were doing a small investigation based on the use of Digital Tablets in interior design because it is one of our new tools in this field and we cannot hide or ignore its role in the design process today, there are many uses for the digital tablet stated in domestic tasks for many things to do using this device, even the digital tablet is not a new invention but it uses the discipline of an interior designer. It is relatively new with great success and in a few years` time its use will increase in the design process more than any other new technology.

4.25. Digital Tablets and the Drawing Process

After some time, the generation of drawings has advanced albeit current view of how portrayals are delivered loans basically towards hand creation. Computerized tablets are making this be tested. Drawings made by hand ordinarily utilize a bit of paper and pen or pencil. Today, the computerized tablet has the stylus intended to substitute the pen and screen in lieu of a bit of paper. Like how the bit of paper decides the creators hand development over the page, so does the computerized tablet. The tablet can be turned, flipped and moved to fit the point of view of the client. The stroke of the stylus on the screen can make straight and bended lines in both two-and three-measurements permitting full inundation in the inventive deduction handle. To best see how the advanced tablet can substitute the planner's sketchbook, Jeff Bezos (2008) offers this knowledge with respect to the inventive improvement of Amazon Kindle's digital book.

Digital Sketching

As interior designers are winding up plainly more commonplace and capable in utilizing advanced tablets, early draws will progressively be created utilizing computerized tablets as they have changed the way experts go about thought era (Brandon and McLain-Kark, 2001). Starting late, specialists have exhibited expanded enthusiasm for the investigation of thought era utilizing advanced outlining 24 strategies in plan studios. To pick up understanding into the topic, one can look to instruction as momentum research reports are found here. The connection between inside outline training and practice is profoundly interlaced, with a strong succession of instruction, experience and examination found in the meaning of the inside plan calling (NCIDQ, 2012). Establishing standards demonstrate the skills an

inside originator probably, characterized by a typical assemblage of information with an unmistakable sign of the connection between inside plan practice and instruction (ASID, 2007; Guerin and Martin, 2004; Harwood, 1989).

Brickly (2012), introduced her encounters on utilizing iPad innovation to expand inside plan understudies comprehension of conventional outline abilities, for example, drawing, tuning in, perception, composing and introduction in establishment studios finding expanded levels of trust in understudy portraying with the utilization of advanced tablets. Furthermore, Meneely (2007 and 2012), investigated the advantages of computerized innovation in classroom drawing utilizing the structure of rationale, brain and media in assessing understudy achievement. Intention concentrates on the center rationalities and procedures configuration understudy's an incentive with the accentuation of psyche being on the attitudes that represent the utilization of innovation in outline instruction. Media then gives investigation of how apparatuses enable plan understudies to accomplish their objectives. It was found that participant thought processes in learning had more to do with taking care of the requests of innovation than supporting their outline forms making comprehension of how members see innovation in early plan stages urgent (Meneely and Danko, 2007). Media investigation shed extra knowledge on how innovation affected their plan forms showing advanced outlining diminished certain mechanical boundaries as it didn't require the actuation of an order to execute a line, members could simply draw. Extra advantages, for example, expanded adaptability of thought era and capacity to adjust thoughts rapidly and effortlessly, were additionally refered to. Nonetheless, a few members felt advanced portraying was 25 more qualified for reasonable drawing improvement and not generation of introduction drawings. With the arrangement of thought process, brain, and media,

Meneely and Danko (2007) find that innovations part in computerized outlining is huge when definitively connected in the thought era handle.

For designers that have been prepared utilizing computerized tablets, early phases of drawing are as liable to be made on screen as in a sketchbook. Drawing yields can be made rapidly and precisely illuminating points of interest that might be indistinct by hand (Plunkett, 2009). With the capacity of PC projects to move early outlines into arrangements, heights and other nitty gritty drawings beginning thought era utilizing this innovation bodes well. Those that once battled with producing hand representations are currently ready to thrive using accessible innovation (Lawson, 2002).

Critical thinking in inside outline has been changed by the individuals who utilize computerized portraying in the plan procedure (Taute, 2005). Investigation of thoughts happens quickly, and inside fashioners can now investigate more ideas with less hazard on account of computerized tablets. Meneely and Danko's (2007) discoveries bolster the utilization of outlining utilizing advanced innovation as it has a tendency to lessen boundaries to imaginative intuition since it doesn't depend on initiating summons, as on a PC. The paperless condition a computerized tablet makes builds adaptability for the client to produce thoughts at whatever point and wherever motivation strikes (Meneely, 2010). The sharp inside fashioner must be set up to catch thoughts quickly guaranteeing thoughts aren't overlooked, and the computerized tablet goes about in that capacity a recording gadget. Hank (2003) states:

The way that we live in the Information Age has been said too often. Yet, the way that drawing is an intense apparatus for this data age has once in a while been said by any stretch of the imagination… What is required are speedier approaches to get those pictures on paper, quicker approaches to get thoughts over, and snappier approaches to utilize drawings to get the outcomes we need and need (p. 9, 11).26

Because of the incorporation and acknowledgment of computerized tablets inside fashioners have adjusted, and for the most part grasped, such devices have expanded their outline abilities.

Remember that creators new to any innovation may succumb to accessible instruments and configuration highlights (Brandon and McLain-Kark, 2001). Era of thoughts can rapidly be adjusted by choice of the device catch that can most rapidly execute a form of the idea. The interruption this conceivably causes to the inventive points of view of the planner may unexpectedly control them far from the center standards of the outline thinking process (Dorta, 2008).

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Make some preliminary sketches.	25	83.3	83.3	83.3
	Start directly with the software programs.	3	10.0	10.0	93.3
	Others.	2	6.7	6.7	100.0
	Total.	30	100.0	100.0	

RQ7. What do you perceive to be benefits of using 3D technology in the design process?

A. Good display for your design

B. Save effort and time

C. Increase sales

D. Other (specify)….

Discuss

The majority of students think the best benefit that they can perceive from using this kind of technology in their design process is, saving effort and time even though the difference of percentage in this response and the first one, is a good display for the design, it is low. If we compare these two responses with other choices such as increasing sales, students are convinced that the technology is no more than tool to help them to represent their work and gives them an easier way to communicate with professors at the moment and clients in the future. They know very well what a good design I and a good design created by a good designer who knows what he/she is doing, so we can say that the students which the researcher did the study on, know the value of this kind of technology appropriately and the use of it.

Four students preferred responding to an increase in sales, which is the third option with a low percentage compared to other responses. Two students responded ´Other´ and then specified that they did not see any impact or benefits using this kind of technology, exactly like the older generation. Even the older generation in design said it is very important to use it to have work and sell products today.

We cannot ignore that this kind of technology helps us to get better results in less time if we are devolving the ideas, concepts and our skills in using it. One important thing is that we cannot ignore that students´ responses depend on the education that each one has received, but in general all the design schools around the world teach their students the capacities of this software to let them imagine how they can fulfill their ideas into real life

		Frequency	Percent	Valid Percent	Cumulative Percent
Valid	Good Display for your design.	11	36.7	36.7	36.7
	Save effort and time.	13	43.3	43.3	80.0
	Increase sales.	4	13.3	13.3	93.3
	Other.	2	6.7	6.7	100.0
	Total.	30	100.0	100.0	

4.25. Discussion

The motivation behind this examination study was to investigate how inside plan professionals use PC innovation amid the outline procedure. Specifically, noteworthy was if and how outline experts are utilizing the PC innovation while creating new thoughts for the customer inside the schematic plan stage. Two principle classifications rose up out of this review, with fundamental topics and sub-subjects giving an exploratory establishment to improve the restricted learning that exists on this topic. This section is broken into three sections including (1) outline of discoveries, (2) examination of discoveries and (3) future zones of research.

4.26. Summary of Findings

Two noteworthy classes molded the discoveries of this review: member inspirations and member encounters. Inside every class, rising subjects and sub-topics were recognized. Member inspirations for utilizing the PC innovation amid the outline procedure uncovered four developing subjects: (1) correspondence, (2) data gathering, (3) business profitability. The correspondence subject had three sub-topics that developed (1) new innovation, (2) physical model and (3) visual introduction. The subject of data social affair incorporates two sub-topics of (1) accumulation of data and (2) thought era.

Inside the classification of participant encounters, there were two subjects that developed. They were (1) effect on work procedures and (2) capability of configuration projects amid configuration handle. The topic, affect on the work forms, had two subthemes that developed: (1) preferences and (2) hindrances.

The classification of participant's inspirations for utilizing the advanced tablet in configuration ventures included four topics: (1) correspondence, (2) data gathering, (3) business profitability. The correspondence topic had three sub-subjects that rose (1) new innovation, (2) physical model and (3) visual introduction. The subject of data social affair incorporates two sub-topics of (1) accumulation of data and (2) thought era.

All participants showed that some type of correspondence – new innovation, physical model and visual portrayal was one of the crucial inspiration for utilizing the PC innovation amid the outline procedure. Participants over and over talked about the capacity to rapidly and effortlessly utilize the PC innovation to demonstrate the customers the procedure of the venture, contractual workers, or staff at whatever point and wherever required.

Most felt that the PC innovation gave quick correspondence that was critical in keeping up contact to encourage choices all through the plan procedure.

The capacity physical model of different venture segments, for example, site components or different completions, was likewise talked about. The capacity to momentarily record inside plan related substance onto the PC innovation was a component all members utilized an awesome arrangement. Expanding venture correspondence between the customer, temporary worker and originator was additionally examined by members, as they favored the simple to utilize physical arrangement did by PC innovation like 3D printer gives. Not at all like most customers, inside originators have an inborn capacity to think and see visual spaces before they are built. Along these lines, it is reasonable that members saw that utilizing the PC innovation to expand their capacity to outwardly impart plans to their customers was a genuine reward of the PC innovation. Truth be told, various members likewise talked about how the visual devices the PC innovation offered empowered them to be more profitable.

Participants talked about in detail parts of the PC innovation that offered both data social event and thought era. While an objective of this exploratory review was to better comprehend inside outline experts' utilization of the PC innovation for thought era, it turned out to be clear after information investigation of the discoveries that the expression "thought era" was characterized diversely by members. The first meaning of thought era, as characterized in the writing survey, was to concentrate on the portraying of plan thoughts. Members saw outlining as a part of thought era, yet extended the definition to incorporate assignments, for example, gathering information, thoughts or materials to finish the venture. It was the view of the members that these assignments helped members produce thoughts that thus tackled outline issues.

Furthermore, information investigation uncovered that lone a couple of members utilized the PC programs for portraying and that a portion of the members utilized the PC innovation for the production of development drawings or particulars.

Inside the classification of member encounters, there were two topics that developed. They were (1) affect on work procedures and (2) capability of PC innovation amid configuration handle. The topic, affect on the work forms, had two subthemes that rose: (1) preferences and (2) detriments. The effect of the PC innovation and its possibilities were noticeably communicated by members of this review. Members more than once expressed their yearning to better see how other inside originators were utilizing the PC innovation with expectations of increasing new information from them.

Various advantages of the PC innovation were rehashed much of the time all through participant interviews giving awesome understanding on the PC innovation convenience in the outline procedure. Among the many favorable circumstances members talked about was speak with customers at whatever point required. Regardless of whether on work site, at a customer meeting or individual responsibility, the capacity to have moment visual correspondence expanded members' multi-entrusting capacities.

The yearning to keep up an aggressive edge in today's worldwide commercial center was talked about by a few participants. They saw that to remain side by side with the changing innovation and inside outline industry, it was best to end up plainly rapidly accessible with the wide choice of instruments and projects PC innovation advertised.

Additionally, expanded advantages to their association's work process, participants additionally said key restrictions to adequately utilizing the PC innovation in configuration forms. The first constraint members expressed

was absence of time to take in all the accessible projects. Many communicated an awesome longing to coordinate the innovation into the plan procedure all the more viably, however that time precluded them from doing as such. The "ease of use" of the projects was their essential concern. This insufficiently outlined segment of the PC innovation was one reason members did not utilize the PC innovation for the production of development drawings and particulars.

There was overpowering endorsement by the members that the PC innovation can be utilized for practically every undertaking required in the outline procedure expected the thought era stage. Albeit a few assignments on the PC innovation were less demanding to finish than others, all members felt the PC innovation could keep on revolutionizing their work process forms. Two members communicated the capacity to incorporate outline ventures with different applications as of now being utilized by engineering and configuration firms. The significance of Integrated Project Delivery and building data displaying is seen to be a need that will be tended to sooner rather than later.

PC advancements are winding up plainly progressively famous inside the engineering and outline industry. Members felt it was especially vital to be fully informed regarding new innovation inspired by a paranoid fear of being deserted. With most members owning sole proprietorships and one working in a structural firm, one would think this conclusion would first originate from bigger firms, as expressed at first in the review restrictions. In any case, this review uncovered that that all members, paying little respect to the firm size and sort, were worried with remaining side by side with advances. Plainly members felt the PC innovation is the future and they should be all the more adequately with mechanical change, or their practice could be abandoned.

4.27. Examination

From multiple points of view, the discoveries of this review bolster discoveries from the current collection of learning. It must be noticed that there are additionally discoveries that repudiate existing exploration as well as speak to research that has not been accounted for. Taking after is an exchange concerning how this review fits into the current assortment of information.

4.28. Member Motivations

4.28. 1. Member Motivation Theme 1: Communication

All members demonstrated some type of correspondence was an essential reason they utilize the PC innovation in the outline procedure. Rising up out of this present review's discoveries were three sub-topics of correspondence, (1) new innovation, (2) physical model and (3) visual introduction with each assuming key parts in the plan procedure. Members all concurred whether correspondence is verbal or non-verbal, it comes to fruition in an assortment of structures and through various media.

Members over and again examined the capacities to rapidly and effortlessly utilize the PC innovation projects, staff or other fundamental venture individuals at whatever point and wherever required. Most felt it was critical to have the capacity to utilize this instrument to keep up consistent contact to keep the venture pushing ahead.

As Brickley's (2012) contemplate with advanced education understudies finds, the capacity to build tuning in and perception abilities utilizing the PC innovation is an instrumental device basic in expanding

relational abilities with customers from various nations, as developed by this review concerning inside plan professionals.

With inside plan projects, for example, 3D studio max certify by the Council for Interior Design Accreditation (CIDA), stringent principles are put forward under which both staff and understudies must agree to guarantee the most elevated amount of inside outline instruction is set. CIDA Standard 6: Communication concentrates on "an assortment of correspondence methods and innovations fitting to a range and reason for gatherings of people" (CIDA, p. II-16).

Thusly, it is necessary that relational abilities are viable in plainly imparting content inside the outline procedure, in both instruction and practice. With inside outline understudies being prepared in CIDA projects to see how to express thoughts plainly and adequately, it is nothing unexpected when another innovative instrument goes ahead the market inside plan experts are a portion of the first to embrace it.

Words are the most widely recognized methods for human connection, loaning themselves to both up close and personal and PC created association among individuals (Johnson, 2010). The American Institute of Architects (2007) Integrated Project Delivery (IPD) strategy obviously bolsters open, coordinate, and legit correspondence among venture members, moreover fortifying the esteem outlines programs give by supporting that same open, synergistic correspondence. With more firms grasping the IPD strategy for venture administration, extend correspondence is progressively advancing. It has been demonstrated by coordinating the IPD structure into the venture procedure, an expansion in positive general venture results comes about.

This organization of venture administration was demonstrated by a few members as an essential methods for venture administration. All members took a shot at tasks that used some type of this venture conveyance

strategy. When all is said in done, there was an agreement of correspondence being a center element of effective venture finish for all gatherings included. The expanded correspondence among all required in a venture is one advantage of Integrated Project Delivery you can't contend (Johnson, 2010).

Undertakings as straightforward as demonstrating the outline as a picture for correspondence purposes, permitted the inside originator to speak with many plan trains as expected to keep the venture correspondence streaming easily, streamlining the stream of data.

Supporting the yearning to keep up clear lines of venture correspondence, inside plan professionals depend on the procedure of configuration intuition to promote their goals. As distinguished in current writing on configuration considering, inside fashioners are handy, propelled people who longing to utilize new apparatuses inventively and instinctively to find elective answers for the current issue (Dohr and Portillo, 2011; Fisher, 2010).

Supporting Tim Brown's meaning of configuration considering, is this current review's discoveries that members' in this review promptly coordinated customers' needs with what is innovative practical and a strong business system. Members enthusiastically incorporated the PC innovation for correspondence purposes, preceding every other errand in the outline procedure, and showed the essential explanation behind the combination is to assist their business rehearses. The procedure of configuration speculation is a one of a kind trademark that epitomizes inside plan experts met for this review.

The normal capacity most inside creators need to think outwardly is another part of configuration believing that identifies with correspondence

utilizing the PC innovation. The reality participants are utilizing the PC advances to increment visual correspondence with their customers is not shocking. Despite the fact that the procedure of plan itself is mind boggling, inside planners are constantly hunting down approaches to upgrade their center aptitudes thinking usefully to take care of different issues within reach (Burdick and Willis, 2011; Lawson, 2006).

Truth be told, the larger part of participants additionally talked about their capacity to be more profitable with the visual devices the PC innovation brings to the table instead of their customary devices. From review pictures and seeking the web, to offering formal introductions, members depended upon the PC innovations as a specialized gadget (or device) to exhibit their intrinsic inventive capacity to customers. By having the capacity to get content on their plans and stream the introduction to customers, participants' discovered customers reacted more successfully than conventional techniques utilized.

This inventive utilization of the PC innovation specifically realizes better approaches to take a gander at issues and seeing new open doors promoting the imaginative outline prepare (Cox, 2005). Furthermore, it additionally expands how the review of numerous thoughts at the same time prompt plan arrangements (Fischer, 2010).

In general, the discoveries in this review are predictable in supporting past research in regards to correspondence inside the plan procedure. Each member communicated various routes in which the ceaselessly utilize the PC innovation to increment new innovation, physical model and additionally visual correspondence with customers and contractual workers. The simplicity of correspondence the PC innovation gave was one of the primary purposes behind beginning to utilize the PC innovation in the plan procedure,

yet it was soon found by all account not the only advantage the PC innovation offers.

4.28.2. Participant Motivation Theme 2: Information Gathering

Additional correspondence, all participants showed they presently utilize the PC innovation for some type of data assembling in the plan procedure. Rising up out of this present review's discoveries were two sub-subjects of (1) accumulation of data, and (2) thought era. Participants all concurred that thought era included drawing, as well as the get-together and archiving of thoughts too.

The outline projects are one of many instruments inside plan professionals' uses to upgrade their innovativeness amid the thought era handle. Be that as it may, after information examination, it turned out to be certain that thought era was not characterized as the demonstration of portraying itself, but rather widened to incorporate the accumulation of data to create thoughts. Members stated they saw portraying as an important part of thought era, yet extended the extension to incorporate such assignments as social affair information, and thoughts or materials to finish any segment of the venture procedure. Just a single member of the review utilized those projects for outlining; a few utilized it for making development drawings or particulars.

The outline programs demonstrated to expanded works and spared time, exertion and cash. Despite the fact that portrayals were not the essential use for PC advances in thought era, the gathering of substance to produce thoughts is as yet a basic piece of outline. Planners can in any case utilize this substance to create thoughts, perceive potential clashes or conceivable

outcomes for thoughts preceding them working out as expected, better encouraging critical thinking (Bilda and Demirkan, 2003). Participants in this review promptly utilized the outline programs for assignments of this nature. While every member had a marginally extraordinary procedure to gather this substance, the final product ledge gave a strong establishment to thought era.

Concerning the inventive procedure, thought era can be seen as "incorporating front-end planning and back-end assessment" making the thought era prepare irreplaceable (Smith, 1998). Members in this review more than once demonstrated that the procedure of data social affair not just occurred in the underlying phases of the outline procedure, yet rather happened comprehensively all through. What's more, the compact, adaptable nature of those projects, it additionally fits advancing inventiveness in outline (Smith, 1998). With respect to members alluded to as the social affair of online data utilizing PC, members frequently utilized the PC innovation to record and research any data appropriate to the venture organize they were in.

By having expanded data access with all data channels, participants enormously used this element to ceaselessly accumulate fundamental data.

In 2011, Geist's review verified that understudies in advanced education profited from expanded data access because of the utilization of innovations in their coursework. Similarly, as Geist's understudies were urged to utilize the PC innovation in any methods agreeable to them to contend an errand, so do the members' in this review. Every member utilized PC advancements in somewhat unique ways, yet all discovered they were getting a comparable final product. Be that as it may, it must be noticed that most members made a request to better see how other inside originators were utilizing advances with expectations of streamlining their procedures.

Generally speaking, the discoveries of this review are reliable with past research in regards to thought era and inventiveness in the plan procedure. Each participant talked about some part of data social affair, regardless of whether gathering data or thought era in their venture procedure as a fundamental piece the outline procedure. Members were changing their work stream to better use the PC advances to assemble data to better encourage a more streamlined plan prepare.

4.29. Participant Experience Theme 1: Impact on Work Processes

Preferences of utilizing the PC advances in work procedures were noticeably communicated by members in this review. Innovation is quickly turning into a typical industry device, as pointed out by Pable (2007). The mechanical wonder is one that is happening quickly and everlastingly changing how inside planners approach their occupation.

At the center of this mechanical change lies the dissemination of advancement hypothesis. This hypothesis expresses the selection of new innovation is not prompt, but rather one that happens after some time including the view of others (Rogers, 1995). Examine members more than once communicated the longing to better see how other inside fashioners were utilizing the plan programs with expectations of gaining from them. Regularly, it was communicated that system would be made empowering inside fashioners to impart encounters to another teacher and utilizing those outline programs when all is said in done to better encourage learning. This craving is a typical component of dispersion of development hypothesis as a segment of innovative selection needs to do with different suppositions and convictions on the current innovation.

Members likewise specified key impediments that affected their utilization of the outline programs in work forms. The most conspicuous restriction that rose up out of this review was impression of absence of time to take in those projects for the outline procedure. For the most part, members in this review all communicated a craving to have more opportunity to take in every one of the components of this sort of innovation to better coordinate into work forms. Nelson (2010), alerts that it is normal for specialists to become involved with taking in another innovation, and dismiss the imaginative procedure. Members in this review all knew about the time requirements taking in another innovation carried with it and were exceptionally cognizant not to have it take away from their work forms. Because of this, most let taking in the new innovation tumble to the sidelines for the outline procedure, in spite of the fact that dissatisfaction was as yet communicated. Members needed to have sufficient energy to better take in the new innovation all the more proficiently as they saw generally it would keep on furthering their work forms. Kalay's (2006), think about finds the critical part new innovation plays on professional work process should be precisely adjusted, as the connection between the two is not generally gainful. Members of this review were apparently mindful of this weakness and incorporated the innovation of those outline programs with alert all through their work forms. Specialized troubles, for example, getting the customary plan way and PC to synchronize totally, because of either obsolete innovation or client blunder, were examined by restricted members. It was found that these occurrences were to a great degree constrained in nature.

Johnston (2010) states, that while innovation assumes a key part in the plan procedure mechanizing manual undertakings, it can likewise enhance accuracy. Generally, this announcement seems to be accurate for members of this review as said in past areas. Be that as it may, certain segments of the outline programs; all utilized PC innovation, constrained members to make

development drawings, determinations and other comparative plans. Most members expressed they would utilize the plan programs for review these sorts of outlines, however not for the making of. It is here that this review negates other research with respect to utilizing innovation in the plan procedure.

Generally speaking, the discoveries of this review bolster and negate past research discoveries with respect to the utilization of PC innovation for work forms. Albeit most members talked about critical points of interest to utilizing the outline programs for these reasons, various constraints rose confining experts' work forms. Dissemination of development hypothesis completely underpins the appropriation and incorporation of the outline programs into professional work process.

4.29.1. Participant Experience Theme 2: Perceived Potential of the Design programs

McLain-Kark (2002) states, utilizing innovation in the plan procedure is an apparatus for spanning customers and planners together, decidedly affecting the outline procedure. Their review on the crossing over of innovation in the plan procedure gives confirmation of how innovation can be utilized as a part without bounds through advancing innovation. Participants in this review all communicated their future aims and wishes for the combination of the plan programs into work forms in the right way. Affirming this, specific participants communicated the capacity to incorporate outline ventures with different projects as of now being utilized by engineering and configuration firms, for example, AutoCAD. This approval additionally upheld the significance of Integrated Project Delivery techniques affecting the outline business.

Participants saw configuration projects are winding up plainly progressively well-known inside the engineering and outline industry, and all members felt it was critical to remain current with this new innovation because of a paranoid fear of being deserted. Shockingly, a large portion of the members were from Politecnico di Milano, with just three working in an engineering firm. One would think this assessment would first originate from bigger firms, as expressed at first in the review confinements. Nonetheless, it was found that all participants, paying little mind to the firm size and sort, were worried with remaining side by side with innovations. By and large, members felt the plan projects are the future and they should have been ready or would in the blink of an eye be deserted. Along these lines the business is going always showing signs of change how originators approach the venture procedure (Brandon and McLain-Kark, 2001).

By and large, the discoveries of this review bolster members saw potential for the plan programs in the outline procedure. All participants examined with awesome fervor the future potential outcomes the PC innovation could have on their work rehearses. Despite the fact that most members are not as of now utilizing the outline projects to what they see as the most extreme potential, they do express that in time they will be.

4.30. Outline

Participant inspiration and experience components inside plan experts communicated in this review make a reasonable connection between this present review's discoveries and that of Meneely and Danko's (2007) structure characterizing rationale, brain, and media in assessing understudy accomplishment in learning using innovation. Every aspect of this system particularly concentrates on a particular subject that rose up out of this

exploratory review reflecting inside plan professionals' utilization of configuration projects in work forms. As per Meneely and Danko (2007), rationale concentrates on the center methods of insight and procedures configuration understudy's esteem, with the accentuation of psyche being on the attitudes that represent the utilization of innovation in outline instruction. Media then gives investigation of how instruments enable outline understudies to accomplish their objectives (see Figure).

MOTIVE

What core philosophies and fundamental process do design student value?	
CLARIFIES	PURPOSE
SITUATION KNOWLEDGE	To clear up the setting that innovation will serve.
PLAN DOMAIN	To build up the criteria overseeing our choice
DOMAIN PRECEDENTS	
CULTURAL TENETS SETTING	And utilization of a specific innovation or apparatus
CONTETUAL CRITERIA	To give the benchmark to surveying and supporting the utilization of innovation
JUSTIFICATIONS FOR USING INNOVATION ERRAND NATURE OF THE ERRAND TO BE FINISHED PURPOSE, OBJECTIVES, AND PROCEDURES	

MIND

HOW DO MINDSETS GOVERN THE USE OF TECHNOLOGY IN DESIGN EDUCATION?	
CLARIFIES	PURPOSE
DISPOSITIONAL KNOWLEDGE	To monitor and regulate our actions with self-awareness
Self-Awareness	To link prior knowledge with new

Knowledge

Personal Beliefs/Outlooks	To identify and test assumptions.
Habits and Preferences	
Personal goals and desires metacognition	
Tacit Assumptions	
Outcome Expectations	
Self-Observations	
Self-Evaluation	

MEDIA

How do tolos empower design students to achieve their goals?

CLARIFIES	PURPOSE
TECHNICAL KNOWLEDGE	To understand the capabilities and limits of digital and media
TOOLS/TECHNOLOGY	To assess the applicability of a specific tool or technique to a particular context.
CAPABILITIES/LIMITS OF THE TOOL	
FUNCTIONS AND OPERATIONS	
COMMANDS TECHNIQUE	
NEW WAYS OF WORKING	
METHOS AND PROCEDURES	
APPLICATION TO DESIGN PROCESS	

Figure. Motive, Mind and Media Framework (Meneely & Danko, 2007, p. 71).

Identifying with Meneely and Danko's system, the intention, or center rationalities and central procedures, behind specialists' utilization of configuration projects were found to build correspondence all through all parts of the outline procedure.

All participants emphatically trusted the primary setting for utilizing the outline projects were to help in expanded correspondence in all aspects of the venture procedure. The way of how the outline programs streamlined venture correspondence was an element all members extraordinarily craved. By having versatile, moment techniques for correspondence members could contact customers, staff or contractual workers as expected to keep up venture stream.

The ability of the outline projects to drive the association and sharing of data in each of these classifications inspired each of the members to consistently utilize the PC innovation in their everyday work exercises.

Additionally, thought process is the component of the brain, which offers a superior seeing how professionals' attitudes drive their utilization of innovation. A mindfulness of how the plan projects can build the capacity to multi-assignment and acquire data wherever and at whatever point required was communicated by all members. Over and again, the capacity of the plan projects to finish assignments or get data in a hurry was talked about by participants. Components, for example, this were significantly coveted, making intention in members to buy the gadget. The last segment of this structure concentrates on media, which investigates how the utilization of mechanical devices engages the client to meet venture objectives.

This part demonstrated the most grounded association between Meneely and Dankos (2007) think about and the exploratory data assembled from this review. The abilities of the plan programs gave various alternatives to outline experts to work inside the plan procedure; however, confinements of utilizing the plans programs for certain business efficiency objects were talked about. Members found that specific errands are best finished by the utilization of a portable workstation or desktop PC, yet never neglected to push the advantages those plan programs gave. All participants incredibly

esteemed the adaptability configuration programs offered better helping them meet their venture objectives.

Generally speaking, the discoveries of this exploratory review offered help for Meneely and Danko's (2007) work that gave an underlying establishment to the investigation of inside outline experts' utilization of the plan programs in their work forms as their work with understudies was comparative in nature. The finding of this enlightening now gives extra data encouraging the assemblage of information on this topic.

4.31. Conclusions

The discoveries of this review offer a foundational comprehension of inside originators' recognitions concerning the utilization of the outline projects and how they use them in their working environment. A few subjects rose up out of this exploratory review conveying to light the numerous likenesses among member inspirations and view of utilizing the outline programs amid the plan procedure.

This review shows that all members were exceptionally energetic to join the outline programs into their work forms because of those projects' capacity to upgrade the customer to-planner correspondence and also data gathering. Members were furthermore roused to proceed with the combination of the plan programs into the outline procedure inside the limitations of their assets: time, mechanical proficiencies and accounts. Impediments to the extra appropriation of those projects were baffling to members; be that as it may they likewise perceived these as unmistakable tradeoffs of innovation incorporation.

All members felt the plan programs have monstrous potential for use in the outline procedure to keep on enhancing correspondence, thought era, and work process. With advantages of the plan programs far exceeding the specialized constraints, every member more than once expressed their yearning to promote their insight into the outline programs and develop it into all parts of their life. The members trusted that the calling was quickly developing, incorporating configuration programs wherever conceivable. All expressed they wanted to remain current with innovation to stay aggressive in today's market and trusted it was basic to keep on working towards coordinating new projects into their practice. This resonating explanation is one that is demonstrated over and over by scientists, who in various zones have found that most callings must remain current with innovation, or they will soon wind up noticeably outdated.

A number of the discoveries in this review are both straightforwardly and in a roundabout way upheld in segments of writing. While none of the discoveries in this review unmistakably discredit any current research conclusions, one specific finding in regards to business efficiency to some degree appears differently in relation to past research conclusions. This analyst is persuade this is because of the point by point kind of innovation being considered, plan programs, when the current writing alluded to the reception of innovation all in all. Be that as it may, since this is an exploratory review, this finding ought not astonish.

Before leading this review, it was accepted that members would likely talk about such subjects as how they utilize the outline programs in the plan procedure and after that all the more particularly for thought era. These point zones get far reaching consideration in existing writing; subsequently it appeared to be sensible that inside outline experts may likewise utilize them

routinely by and by. This presumption demonstrated valid generally. This current review's members uncovered that inside outline experts characterized thought era more extensively than that of the era of introductory drawings and representations, to incorporate that of data assembling and research. The larger part of members communicated they at present don't utilize the plan programs for portraying purposes nor to create drawings, however do utilize the outline programs for the social event, survey and sharing of outlines.

It is felt that the discoveries of this exploratory review cause give extraordinary knowledge to how inside plan experts right now use the outline programs in the plan procedure alongside for thought era. Members shed light on a moderately obscure range of research, which is quickly changing, because of quick paced mechanical advances. Despite the fact that there is much yet to be learned on this topic, it is trusted a strong establishment for future research was given on a theme that is regularly evolving.

4.32. Future Research

This review was exploratory in nature. The specimen was little, restricted to one geographic territory and included just those inside architects as of now utilizing a plan programs in their work forms. Consequently, there are a few open doors for future research.

• Expand the review to incorporate across the nation members, offering more noteworthy knowledge on how configuration projects are utilized as a part of work procedures. Broadening this review across the country would offer a more noteworthy member pool and ideally acquire inside and out data in regards to how inside plan experts utilize configuration programs. Since all review members lived and worked inside a limited

geographic region, the discoveries can't be thought to be generalizable. Accordingly, comparative research growing the member base to different areas may help figure out which discoveries may be steady over a more extensive geographic and statistic range, and which discoveries may be predictable.

- Create center gatherings with creators at present utilizing the outline programs in their work procedure. It was specified by study members that they needed an approach to have the capacity to trade additional data about how they utilize the plan programs, so by making center gathering this would permit thoughts to be traded and research to be directed. By watching this communication and trade of data impartially, extra inspirations and subjects may become known of why and how originators utilize the plan's PC innovation.

- Interview inside creators that don't right now utilize the plan's projects to better comprehend why they presently can't seem to incorporate it into their work forms. Since this review was restricted to just current rehearsing inside creators who utilize an outline's projects by and by or through another person, this bit of the populace was prohibited. With beginning study respondents communicating different purposes behind not yet utilizing a plan programs, it was shown that the reasons are endless, however yet all feet they ought to move towards coordinating this innovation into their work procedure. Analysts could then find extra inspirations and recognitions behind the utilization, or scarcity in that department, plan programs.

- Further research could better characterize private and business inside originators to better comprehend if there is an inclination of

configuration projects reception and utilize contingent upon the region of practice. Since this review had a small participant pool, just three participants were essentially private designers with all others were amongst draftsmen and architects. Furthermore, a specimen separating the different practice regions inside business inside outline, for example, corporate, friendliness, government, and so on could be directed, so as to figure out what, assuming any, topics rise.

Top to bottom reviews could be led on the motivational subjects found in this review to increase further knowledge on how the outline projects are utilized precisely for each of the topics. While this review gives a general comprehension of inside originators thought processes and view of utilizing the outline programs for configuration purposes, much stays obscure about the colossal detail to which it is utilized. For instance, the larger subject of correspondence could be concentrated more top to bottom where members were seen in their everyday schedules to better comprehend the degree of which the outline projects are utilized.

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Capítulo V

EL IMPACTO DE LA IMPRESIÓN 3D EN EL DISEÑO DE INTERIORES

Impresión en tres dimensiones (3D)

5.1. Introducción

La tecnología 3D rompe los límites de los mundos reales y virtuales. Sin embargo, las aplicaciones de esta tecnología han sido en gran medida confinadas a prototipos industriales, como en el uso del diseño asistido por computadora y la fabricación asistida por computadora (CAD-CAM) para fabricar modelos virtuales. Hoy en día, las impresoras 3D están cada vez más disponibles, en parte impulsadas por la tendencia hacia las tecnologías *OpenSource* (Kostakis et al., 2015, Rayna et al., 2015, West y Kuk, 2015), aumentando dramáticamente el acceso a las tecnologías 3D democratizando la cadena de producción de diseño, moldeo y fabricación (Rayna y Striukova, 2015).

En este proceso, las técnicas de modelado 3D se han situado como importantes competencias básicas, y las innovaciones desarrolladas a través de las aplicaciones generalizada de las tecnologías 3D han conducido a avances en la ciencia médica y la automatización de maquinaria (Bassettet al., 2015; Hackett y Proctor, 2016; Katsioloudis et al., 2014; Kostakis y Papachristou, 2014; Zhang et al., 2015).

En respuesta a esta tendencia, los programas de educación técnica y vocacional que anteriormente se centraban en enseñar tecnologías básicas han comenzado a introducir programas de modelado 3D. Los programas de modelado 3D se enfocan en el desarrollo de habilidades, usando un modelo de enseñanza que pone el mismo énfasis en la teoría y la práctica. El concepto de CDIO (Concebir, Diseñar, Implementar, Operar) abarca el establecimiento de conocimientos básicos, la transferencia de conocimiento, la aplicación de

los conocimientos adquiridos y la resolución de problemas (Jianfeng et al., 2013), combinando los conocimientos teóricos y la formación profesional para satisfacer las exigencias de la enseñanza técnica y profesional. Además, promueve habilidades relacionadas con la observación, diseño y el procesamiento de información necesarios para el modelado 3D. Sin embargo, las diferencias entre los estudiantes a un nivel individual afectan a los resultados del aprendizaje, y la formación en modelado 3D depende en gran medida de la habilidad innata del estudiante. Estudios anteriores han indicado que los estudiantes de modelado 3D necesitan ver los ángulos para construir espacios abstractos cognitivos (Carroll, 1993; Kurtulus, 2013; McGee, 1979), destacando la importancia de la capacidad espacial.

5.2. Revisión de literatura

La popularización del diseño asistido por ordenador / fabricación asistida por ordenador (CAD-CAM), los controles numéricos de computadora (CNC) y los brazos robóticos han reducido significativamente los costes de producción y la producción ha mejorado (Pedersen et al., 2015, Xiao et al., 2015).

A medida que las nuevas tecnologías de fabricación maduran, las tecnologías para la modelización rápida y la personalización han comenzado a recibir mayor atención (Berman, 2012).

En los últimos años, la popularización del movimiento de código abierto (Kostakis et al., 2015, Kostakis y Papachristou, 2014; Kuk, 2015) ha impulsado la difusión de técnicas para el prototipado rápido (RP), también conocido como impresión 3D, para satisfacer las demandas de la manufactura industrial. El prototipado rápido implica el moldeo capa por capa, en contraposición a la fabricación substractiva tradicional (Baumers et al., 2015). En los últimos años, se han desarrollado varios métodos de RP, incluyendo el

Fused Filament Fabrication, modelado de deposición por fusión, la litografía estereoscópica, la sintetización láser selectiva y la tecnología PolyJetTM (Berman, 2012; Kumar y Kumar, 2015; Oropallo y Piegl, 2016; Yap y Yeong, 2015).

La creciente popularización de la tecnología de impresión 3D ha tenido un impacto gradual en el hardware y software industrial, impulsando cambios en la formación educativa y en las operaciones comerciales (Berman, 2012; Bassett et al., 2015; Chua y Leong, 2015; Rayna y Striukova, 2015; Oropallo y Piegl, 2016). En la ciencia médica, por ejemplo, la impresión 3D ha dejado atrás el alto coste de la personalización para permitiendo a los médicos diseñar y utilizar *stents* médicos personalizados (Adams et al., 2015; Zhang et al., 2015).

Ya en 1997, los investigadores presentaban materiales multimedia para presentar el material RP de forma más cohesiva e interactiva (Chua et al., 1997). A lo largo de los años, los enfoques multimedia adquirieron un importante papel en la mejora del proceso de educación para la tecnología de prototipado rápido (Lim et al., 2004; Chua et al., 2010). Además, los conceptos de Ciencia, Tecnología, Ingeniería y Matemáticas (STEM) y Educación Profesional y Técnica han impulsado la integración de la tecnología de impresión 3D en la educación (Bharti et al., 2015, Schelly et al., 2015). Se ha producido material didáctico sobre la tecnología de impresión 3D (Telegenov et al., 2015) facilitando el aprendizaje en campos que van desde la ciencia médica, la ingeniería hasta la ciencia para el arte (AbouHashem et al., 2015, Casas y Estop, 2015, Farooqi y Sengupta, 2015). Kostakis y Papachristou (2014) desarrollaron una fresadora de impresión 3D basada en Proyecto*Reprap*, *Lego*, para demostrar el concepto de "diseño global y fabricación local ". Al año siguiente, Kostakis et al. (2015) introdujeron impresoras 3D en las escuelas secundarias para ayudar a los estudiantes a

desarrollar prácticas de diseño colaborativo y creativo. El amplio y profundo impacto de la tecnología de impresión 3D en la industria y la educación han impulsado la necesidad de ayudar a los estudiantes a desarrollar capacidades independientes de modelado en 3D.

Las tecnologías de impresión 3D han atraído cada vez más la atención últimos años, sobre todo porque permiten que cualquier persona sea diseñadora y fabricante. Paquetes de software como Meshmixer Schmidt R, SinghK (2010) y *Autodesk 123D Autodesk* (2010) *Autodesk 123D* proporcionan a los usuarios finales interfaces de modelado 3D intuitivas para la impresión 3D, permitiendo que casi todos puedan utilizar directamente las impresoras 3D de escritorio. Sin embargo, propiedades tales como la densidad, la masa y el momento de inercia a menudo se ignoran cuando se crean objetos 3D para la impresión. El modelado de objetos considerando tales propiedades es difícil porque están influenciadas por las geometrías externas de los objetos. En este estudio se busca optimizar la estructura en voladizo (o eje delgado) de los objetos. Esta estructura es un componente comúnmente impreso de numerosos modelos 3D, pero su fuerza no siempre puede ser garantizada. Por lo tanto, la optimización de las estructuras en voladizo de los objetos es un tema muy importante.

5.2.1. Habilidad espacial

La capacidad espacial se define como la capacidad de "manipular, girar, torcer o invertir mentalmente un estímulo presentado pictóricamente y es un aspecto de las inteligencias múltiples" (Carroll, 1993; Gardner, 2011; McGee, 1979).

La capacidad espacial puede ser subdividida, además, en elementos de cognición espacial incluyendo "visualización espacial, orientación espacial,

relación espacial o velocidad rotación, rotación mental, velocidad de cierre, flexibilidad de cierre, velocidad perceptual y memoria visual" (Carroll, 1993; Linn and Petersen, 1985; Lohman, 1979; McGee, 1979).

La capacidad espacial está estrechamente relacionada con la industria de impresión en 3D de hoy en día y el desarrollo de aplicación de materiales de enseñanza y la enseñanza (por ejemplo, videos, animaciones multimedia y aplicaciones) para mejorar la capacidad espacial ha surgido paulatinamente como un foco de investigación (Morán et al., 2008, Hung et al, 2012; Price et al., 2014; Sánchez y Wiley, 2014; Passig et al., 2016). Katsioloudis et al. (2014)

Es decir, no podemos separar la relación entre la capacidad especial y la impresión 3D, porque simplemente la impresión 3D hoy en día se considera como una herramienta de representación, lo que se correlaciona entre ambas. Por otro lado, en esta propuesta de trabajo buscamos la ampliación de esta relación a través de introducir un nuevo método de trabajo consistente en incrementar la compresión de la habilidad especial en el campo de diseño de interiores y la arquitectura, lo que resultará un buen entendimiento de esa relación.

Los diseñadores están comenzando a adoptar las posibilidades ilimitadas que la impresión 3D puede ofrecer, creando principalmente objetos sólidos basados en diseños digitalmente trazados. En otras palabras, la impresión 3D permite a un diseñador dibujar cualquier objeto, que luego será hecho una realidad tangible por un ordenador. Formas que serían imposibles de llevar a la práctica utilizando métodos tradicionales son ahora factibles.
Estados Unidos, Singapur y los Países Bajos parecen ser los líderes en el mundo de la impresión 3D, llegando a diseñar por ejemplo una casa totalmente impresa en nylon en construcción en Ámsterdam.

Es poco probable que imprimamos nuestras propias casas en un futuro próximo; no obstante, podremos ser capaces de imprimir elementos significativos de las mismas. Será posible producir los objetos "imposibles" sin obstáculos como la gravedad, las fuerzas, etc. por lo que se podrán realizar opciones totalmente personalizadas bajo demanda.

La impresión 3D en la industria de la construcción tiene importantes beneficios, entre los que cabe destacar la eliminación de materiales desperdiciados debido a la producción a demanda y la eliminación de los costes de transporte, ya que los diseños podrán imprimirse localmente. Esto tiene beneficios tanto financieros como ambientales. Además, esta tecnología se está desarrollando a gran velocidad, por lo que la impresión 3D de artículos llegará a ser más rápida y menos costosa que la producción en masa de artículos utilizando moldes.

La impresión 3D ha sido ampliamente utilizada hasta ahora para crear muestras de productos y presentaciones para los clientes antes de la ejecución de diseños de arquitectura.

Las impresoras 3D ya están disponibles para uso personal y doméstico, con minoristas como Amazon vendiéndolas *on-line*. Sin embargo, es demasiado pronto para entender cómo va a influir esta tecnología en nuestras vidas cotidianas. Podemos asumir, no obstante, que esta tecnología ayudará a crear nuevas industrias y nuevos empleos. Creo que en el futuro más y más a menudo vamos a ver ejemplos de diseño innovador donde elementos únicos serán imitados a una escala y detalle perfectos.

A pesar de que las limitaciones de la impresión en 3D se deben actualmente a la falta de materiales que se pueden manipular (por ahora se trata de plástico, resina y metal), esta tecnología se desarrollar a un ritmo acelerado. Singapur ha hecho de la impresión 3D una prioridad importante y cuenta con numerosos centros dedicados a la tecnología. Están tratando de construir un edificio en 3D impreso de gran altura, piso por piso. En una escala más pequeña, un buen ejemplo puede ser el mobiliario binario de Cohda, famoso por sus mesas en forma de "líquido fluido".

Fig. 25. Algunos ejemplos de prototipos realizados por la técnica impresión 3D en el laboratorio de la facultad de diseño en Politécnico di Milano, durante la estancia del autor. Imagen del autor 2016.

El desempeño de la impresión 3D hoy en día en el sector del diseño de interiores es limitado, pero está creciendo a un ritmo muy rápido para mantenerse al día, al igual que en otras disciplinas como la medicina, la fabricación de prótesis, y los prototipos de muebles como el del ejemplo anterior y muchos más. Aún con toda esa innovación, esta técnica no ha cubierto todas las necesidades del diseño de interiores de tal forma que su uso

esté extendido, llegando a ser una técnica fundamental para este campo. Hoy en día, sin embargo, casi todos los estudios de diseño de interiores están experimentando con la introducción del servicio de impresión 3D para facilitar a diseñadores y clientes la comprensión de los espacios mediante la fabricación de modelos físicos de los muebles y algunos detalles de la decoración y la experimentación de los prototipos antes de su producción a nivel comercial.

Fig. 26. Prototipo de un edificio de la Plaza Roja de Mosco realizado en Politécnico di Milano, demuestra la capacidad de la impresión 3D para imprimir modelos físicos con detalles muy precisos. Imagen del autor 2016.

El papel de la tecnología en el diseño de interiores resulta tan importante que llegará a ser un elemento imprescindible en el proceso del diseño, y la impresión en 3D llegará a ser, al igual que lo han sido otras técnicas, imprescindible para representar nuestros diseños en la vida real a través de modelos físicos.

5.2.2. Uso de impresoras 3D en espacios irreales

En el emirato de Dubái quedó demostrada la potencia de la impresión 3D para convertir los espacios irreales en espacios reales y manejables, mostrando las numerosas ventajas de utilizar está técnica en la producción de productos de diseño de interiores a nivel profesional, llegando a un gran nivel de perfección con un coste bajo al construir una casa a escala real con materiales adaptados y sostenibles. Queda así en discusión el actual alto coste de la impresión 3D y la dificultad que se plantea habitualmente para conseguir materiales como los que utilizan estas impresoras.

El uso de la impresión en 3D en la arquitectura sigue siendo anecdótico ya que la logística aún está en creación, pero una nueva prueba de concepto acaba de ser presentada en este ámbito. Este espacio de 250 metros cuadrados (2.700 pies cuadrados), es lo que el Museo del Futuro de Dubái proyecta instaurar como "el primer edificio de oficinas impreso en 3D del mundo". China, por su parte, dio a conocer el primer edificio de oficinas y mansiones impresas en 3D del mundo a principios de 2015.

El propósito de este nuevo edificio, anunciado por primera vez en junio de 2015, es mostrar el compromiso de los Emiratos Árabes Unidos con la innovación y sus perspectivas de futuro y promover su papel como uno de los líderes mundiales en la impresión arquitectónica 3D.

Fig. 27. Este ejemplo demuestra la potencia de la impresión 3D en el campo de la arquitectura y el diseño de interiores. Imagen tomada de https://www.cnet.com/news/dubai-unveils-worlds-first-3d-printed-office-building/

Se empleó una impresora 3D para imprimir el edificio en una mezcla especial de cemento, capa por capa. En total, se tardó un total de 17 días en imprimir el edificio con un coste aproximado de 140,000 dólares, después de lo cual se añadieron los detalles de diseño interior y exterior.

Un técnico especialista se encargó de monitorizar la impresora 3D. Otras siete personas se ocuparon de la instalación de los componentes del edificio en el lugar, y otros diez electricistas y técnicos se ocuparon de los elementos de ingeniería. Todo ello permitió un ahorro del cincuenta por ciento en los costes laborales habituales en un edificio de estas características.

La oficina de planta abierta albergará temporalmente la *Dubai Future Foundation.* Además de proporcionar un espacio de trabajo, también podría ser utilizada en el futuro para albergar exposiciones, talleres y otros eventos.

5.3. Trabajo de campo

Durante la estancia del autor de la tesis en el Politécnico di Milano, surgió la idea de proponer un nuevo método de usar la impresión 3D que facilite el trabajo del diseñador en representar su diseño en modelo físico y presentar de esta manera una comprensión completa del diseño al cliente, lo cual permitirá evitar todos los imprevistos técnicos que pueden surgir en el cliente sobre la planificación del espacio interior. Fue así como el autor comenzó a desarrollar esta idea, haciendo pruebas e imprimiendo ejemplos como el anterior, experimentando la funcionalidad de este nuevo método y explorando sobre las ventajas que puede proporcionar a los diseñadores de interiores. También fue importante analizar cómo puede aumentar la percepción del concepto diseñado en el cliente. La idea en sí no es tan novedosa, ya en los últimos años han visto la luz diversos métodos para utilizar las impresoras 3D en dos vertientes, o bien imprimiendo objetos, como en los ejemplos siguientes.

Esta propuesta de trabajo tiene como objetivo facilitar el trabajo del arquitecto y del diseñador de interiores en la representación de los modelos físicos al consumidor, y también brindar al cliente una vista real al espacio diseñado y ofrecerle la oportunidad de comprobar, observar y tocar los elementos del diseño como modelos físicos.

Nuestra propuesta hace hincapié en el uso la impresión 3D en el diseño de interiores para presentar la impresión 3D como nueva herramienta en el proceso del diseño, que ayude a los diseñadores a representar un modelo físico en un tiempo de realización reducido para el cliente. El modelo físico del diseño es tan importante como el modelo virtual (fotos realistas 'renderizadas') para representar el diseño en la actualidad, lo que significa

que el modelo físico del diseño vuelve a jugar un papel fundamental en la representación de los diseños, presentándose como un modelo innovador y eficiente frente a la representación virtual.

5.3.1. Propuesta de un nuevo método para el uso de la impresión 3D

Fused Deposition Modeling, es el nombre original de la técnica de 'Modelado por Deposición Fundida`'. Esta técnica fue patentada por S. Scott Crump en los años 80 del siglo pasado, y es la más extendida en la impresión de objetos en 3D, además de ser la más asequible. El manejo de esa tecnología es muy sencillo, lo cual permite que muchas personas que manejan algunos programas 3D puedan utilizarla y aprovechar sus ventajas, ya sea a un nivel doméstico o a un nivel comercial.

5.3.2. Diseñar el modelo requerido

El proceso comienza por diseñar nuestro objeto en modelo 3D y prepararlo antes de trasladarlo a la impresora 3D. El modelo 3D se puede realizar a través de muchos programas de diseño, aunque aquí mencionamos los mejores programas o *software*s para trabajar con impresoras, de los que destacamos por su eficiencia *Cura, Cartware, 123D Cutch, 3D flash, TinkerCad, 3DTin , Sculptris, ViewSTL, Netfabb Basic, Repetier y FreeCAD*. Todos estos programas trabajan con la función de Diseño 3D, CAD, *Y Slicer* y *STL Viewer*.
Después de tener el objeto hecho en modelo 3D, se guarda en formato .STL, lo que permite a la impresora 3D leerlo. Luego, a través de un *software* de corte, posicionamos el objeto sobre la cama de impresión, para garantizar que el objeto se pueda imprimir en la base de la impresora.

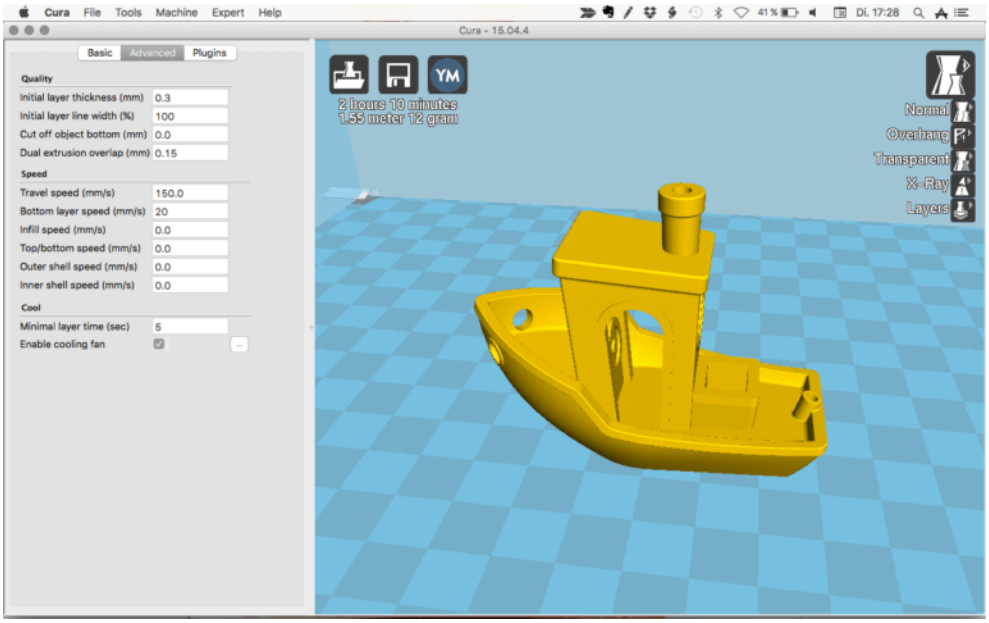

Fig. 28. Modelo en 3D listo para imprimir en el programa Cura. Imagen tomada de https://all3dp.com/es/mejores-programas-software-gratis-impresora-3d/

5.3.3. Preparación del prototipo

Después de llevar a cabo todos los pasos para preparar el objeto, ahora comenzamos el trabajo con la impresora 3D, eligiendo el material adecuado para el objeto; ya sea plástico, madera o metal, y ajustamos la configuración de la impresora según el objeto para obtener el mejor resultado posible. En este momento el filamento se calienta para extrudir a través de la boquilla. La cabeza se ajusta a una pista en movimiento y empieza a extrudir la capa de la base del objeto en un movimiento vertical u horizontal, en este tiempo la boquilla construye algunas capas para soportar el objeto y mantenerlo en forma. La cabeza de la impresora 3D lleva un ventilador para enfriarse las capas y mantener el objeto. Hay que elegir la forma adecuada de imprimir teniendo en cuenta el relleno de objeto, el tamaño y la complejidad.

Después de tener el objeto impreso, hace falta comprobarlo y observar si se ha dado cualquier fallo durante la impresión. Algunos de estos posibles

fallos pueden ser reparados para garantizar la obtención del mejor resultado, limpiando las impurezas de la impresión y de los materiales de soporte, y asegurando que el objeto simula el modelo virtual. Tenemos además la posibilidad de pintarlo para obtener el aspecto original que aparece en el modelo diseñado.

Para sacar partido del uso de la técnica de impresión 3D es imprescindible desarrollar un nuevo uso específico en el diseño de interiores, más amplio y con más usos. Es por ello que el autor propone una nueva aplicación de esta técnica en el diseño de interiores para implementar lo que actualmente los diseñadores de interiores están realizando de manera manual, lo cual es costoso en términos de tiempo y coste.

La propuesta del autor tiene como objetivo facilitar el trabajo a los estudiosos del diseño en general en la construcción de prototipos para sus productos y ahorrar tiempo, esfuerzo y capital. La propuesta conlleva presentar un nuevo método de utilización de la impresión 3D en los estudios para presentar los diseños a sus clientes de una manera fácil de realizar, entender y/o modificar.

Las impresoras de 3D tienen como inconveniente que solo utilizan un material para imprimir, y además necesitan mucho tiempo para imprimir los objetos en escala de prototipos. La experiencia personal del autor asegura además que hace falta controlar todo el proceso de impresión, ya que se puede producir un fallo en cualquier momento de forma totalmente imprevista. Para evitar todos estos errores proponemos en este estudio un nuevo método para la impresión 3D aprovechando esta técnica al máximo, dentro de la concepción tecnológica actual del diseño de interiores.

La propuesta contiene un proceso completo sobre el uso de la impresión 3D en los estudios del diseño de interiores en la fase preliminar de presentación del diseño al cliente, pero en lugar de presentar un modelo físico proponemos un modelo virtual, que después podamos manejar y

materializar. El modelo físico suele presentar el diseño en la vida real en escala reducid y la idea de esta propuesta se ha construido sobre el concepto de imprimir varios modelos de muebles usados en el diseño e imprimir el *layout*, y posteriormente ordenar los muebles según el plano del diseño y teniendo en cuenta la escala de los muebles y el conjunto del diseño.

En otras palabras, el autor ha seguido el proceso habitual en los diseños para no complicar el procedimiento al usuario, aunque únicamente en las fases preliminares del proceso descritas anteriormente.

El autor se atrevió a introducir cambios importantes en las fases posteriores del modelo tradicional de diseño, que a su juicio y teniendo en cuenta la irrupción de las técnicas de realidad virtual y aumentada, resultan totalmente necesarias para brindar una reflexión y servir de referente a futuras investigaciones, así como una gran posibilidad para explorar nuevos horizontes en la investigación de carácter tecnológica y futurista en el campo del diseño de interiores.

Fig. 29. Un modelo físico de una casa totalmente amueblada, demuestra la distribución de los muebles y la relación entre los espacios y los muebles en escala pequeña. Tomada de http://www.home-designing.com/2014/07/4-bedroom-apartment-house-floor-plans

El resultado final del proceso de esta propuesta es similar a la imagen anterior, y permite aumentar la percepción de los espacios y representar la relación entre el espacio y el mueble a través de la planificación del espacio, ayudando así al cliente a percibir el espacio de un modo óptimo y facilitando la comunicación entre el diseñador y el cliente.

A través del nuevo método presentamos una manera más fácil de entender el espacio, mostrando la relación adecuada entre el espacio y el mueble mediante los modelos físicos, como hemos podido ver en el ejemplo. La propuesta incluye la impresión de varios modelos de muebles: sillas, mesas, camas, entre otros. En definitiva, esta técnica es capaz de construir el diseño completo, con todos sus detalles, y muy similar al original (tipo fotografía realista) que se puede obtener a través de los programas de diseño.

Ahora con la innovación en esa tecnología es posible imprimir varios prototipos en diferentes materiales que simulen los materiales originales, con sus diferentes texturas, lo que permite al cliente ver su diseño en la última fase y de primera mano, sin un ordenador y pudiendo ver, tocar y observar el diseño como si fuese en su escala real.

Esta propuesta permitiría asimismo al cliente hacer cambios en la distribución de muebles en sus propias manos y ver cómo queda y el resultado final, sin ningún tipo de esfuerzo extra para el diseñador o arquitecto. Es decir, está técnica permite al consumidor hacer una nueva planificación de muebles con la supervisión del diseñador y sin que el diseñador o el arquitecto toque el modelo físico del diseño.

Fig. 30. Un prototipo de una silla realizada en los laboratorios de impresión 3D en Politecnico di Milano, durante la estancia del autor, demuestra la capacidad de esa técnica de producir ejemplos que simulan los muebles originales al detalle. Imagen del autor.

Para llevar a cabo los prototipos de la propuesta no es necesario disponer de un tipo específico de impresoras 3D, la idea está diseñada y desarrollada para cualquier tipo de impresora, siendo de gran utilidad para

todos los estudios de arquitectura y diseño de interiores no especificar un tipo exacto de impresoras 3D, ya que esta propuesta tiene por objeto facilitar el trabajo de diseñadores y arquitectos sea cual sea la calidad de su impresora y recursos. De igual manera, no utilizar solo un tipo de impresora también nos ayudará también a multiplicar las utilidades de este estudio y garantizar la realización este proceso con un coste reducido.

El desarrollo de la presente propuesta implicó del mismo modo una serie de dificultades; la propuesta fue realizada en muy poco tiempo y con un soporte limitado por la falta de tiempo, material y experiencia requerida para llevar a cabo estudios de este tipo; otro factor que dificultó desarrollar más la propuesta radica en la escasez de material de investigación y la falta de los recursos económicos, lo cual limitó los resultados esperados de la propuesta.

Fig. 31. Un prototipo de una silla relazada en los laboratorios de impresión 3D en Politecnico di Milano, durante la estancia del autor, demuestra la capacidad de esa técnica de producir ejemplos que simulan los muebles originales y la perfección. Imagen del autor.

El siguiente ejemplo de máquinas trabaja con otro sistema diferente para construir el prototipo desde la base hasta el final. Este sistema

denominado “de control numérico” o “control decimal numérico”, es un sistema de automatización que funciona con códigos y órdenes especiales, que hacen trabajar a la máquina de la misma forma que emplea un escultor. Este tipo de máquina trabaja desde un bloque al que, siguiendo las órdenes introducidas en la impresora, se le van restando capas hasta obtener la forma final del objeto.

Trabajar con este tipo de máquinas se considera un trabajo ineficaz si consideramos el tiempo necesario para llevar a cabo un objeto y el material mediante el cual la máquina empieza a llevar a cabo la forma requerida; otro inconveniente de trabajar con esta forma para obtener prototipos 3D es el polvo que resulta de imprimir el objeto y las dificultades que éste implica al técnico, además de la contaminación resultante.

Con la innovación de las impresoras 3D y la masificación de sus usos en diferentes sectores se ha reducido bastante el uso de este sistema para la obtención de modelos 3D, lo cual llevará en un futuro a la desaparición de este sistema en el diseño y la creación de los prototipos 3D.

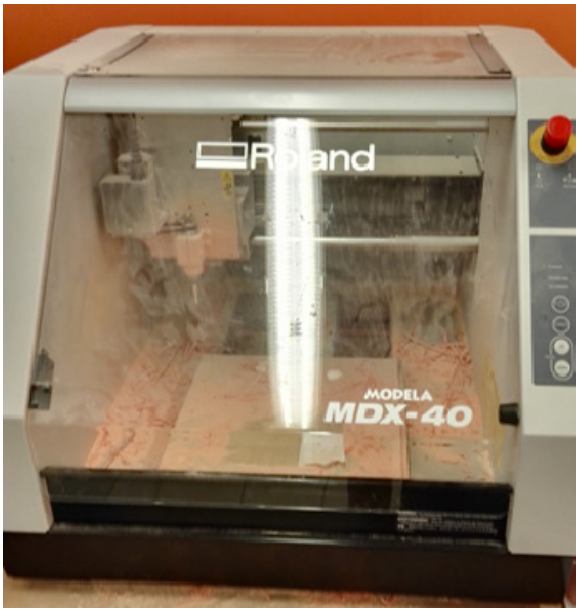

Fig. 32. El control numérico o control decimal numérico (CNC Machine). Imagen del autor.

El control numérico fue un gran invento que en sus inicios supuso un gran giro en la producción de objetos 3D, diseñados perfectamente y con una eficiencia consistente, lo cual hizo que bastantes profesionales del sector confíen en este sistema hasta la actualidad. No obstante, y considerando las particularidades de nuestra propuesta, muchos investigadores y profesionales del diseño y de la arquitectura están convencidos que este sistema ya no resulta viable para el desarrollo de prototipos 3D y que debe ser sustituido de manera inmediata por las impresoras 3D. La siguiente imagen muestra el ejemplo del sistema de control numérico empleado por el autor para la implementación de su propuesta, aunque su uso en términos generales se ha reducido drásticamente en comparación con las impresoras 3D.

Se han empleado dos tipos diferentes de impresoras 3D para producir prototipos de diferentes productos y sacar los modelos del ordenador a la vida real en diferentes escalas, llegando a imprimir en escala 1/1. Son muchas las ventajas que este tipo de impresión presentan, como la perfección del resultado final y el terminado, con poco esfuerzo. Este tipo de impresoras tienen, no obstante, algunos inconvenientes, como el hecho de que trabajan sólo con un material, lo que se traduce en una sola textura en el resultado final.

Fig. 33. Dos tipos de impresoras 3D en los laboratorios del Politecnico di Milano.2016. Imagen del autor.

Tras llevar a cabo esta propuesta, que introduce un nuevo uso de la técnica de impresión 3D en el campo del diseño de interiores, facilitando la representación física del diseño, no debemos perder de vista la utilidad que tiene en el campo del diseño de muebles, al permitir la obtención de un prototipo en poco tiempo y de forma muy cercana a la realidad.

5.4. A modo de conclusión

Esta propuesta presentó una nueva forma de usar la impresión 3D en el ámbito del diseño de interiores, y si bien esta propuesta sigue siendo solo un prototipo que aún necesita mejorar y desarrollarse mucho para lograr su objetivo principal, nos permitió descubrir nuevos usos de la tecnología de impresión 3D en el campo del diseño de interiores y de la producción.

Por otro lado, el nuevo uso de la tecnología de impresión 3D en el diseño de interiores y producción abre nuevos caminos de investigaciones en el campo de producir piezas a escala real, lo que nos lleva a continuar con la visión de construir casas y oficinas incluyendo los muebles en alta calidad y requiriendo de poco tiempo, lo que nos ayuda a reducir el coste de construcción.

Por último, otra ventaja de este estudio es que facilita a los diseñadores usar las impresoras de 3D en la producción de sus prototipos de fabricación, especialmente después de saber que todo el material usado por estas impresoras es material reciclado, lo que significa reducir la contaminación producida por el uso de materiales no reciclados en las otras maneras de representación de prototipos.

5.5. Futuras investigaciones

Las próximas investigaciones que se lleven a cabo tanto por el autor de esta propuesta como por otros investigadores en el campo de la impresión 3D y su uso en el diseño de interiores, deberán tomar en consideración varios aspectos que pueden mejorar la calidad de una investigación o estudio similar:

1. Dedicar más tiempo a la fase de recuperación de material y ampliar la investigación en sus diferentes aspectos, lo que minimizará errores en la fase de producción.
2. Usar diferentes tipos de impresoras 3D, y no centrar la propuesta en unos tipos específicos para no limitar el uso del nuevo método.
3. Intentar conseguir recursos económicos que permitan al investigador ampliar su investigación y desarrollarlo óptimamente para conseguir el material adecuado para la puesta en marcha del plan de trabajo propuesto.
4. Formar un equipo de investigación con formación relacionada con el tema principal del proyecto y con experiencia en dicho campo.
5. Elegir con cuidado un laboratorio con toda la instalación y el equipamiento necesarios para llevar a cabo la propuesta y para que los resultados resulten acordes con las expectativas perseguidas.

Por último, y aunque no podamos considerarla una urgencia, la necesidad de formar investigadores y profesionales altamente cualificados para un uso eficiente, ambicioso y creativo de las nuevas tecnologías resultará crucial para avanzar en las próximas investigaciones, y brindar tanto a profesionales como a clientes experiencias más innovadoras en el mundo del diseño, especialmente el diseño de interiores.

5.6. Opiniones sobre la impresión 3D

Participante número uno, Andrea Ratti.

In my opinion 3D printing could affect the possibility to transfer this technology in the result through this technology, also in living spaces or interior spaces, but I cannot imagine all the interior space of some house done by a 3D printer, because the quality or the standardization to obtain the use of this through this technology doesn't allow to obtain the same shape or textures.

So, I think it could be interesting to obtain some path of interior, and help to drive to item technology in getting more usable friendly, industrialization, realizing the way of using some technology or some materials.

El profesor Ratti, durante la entrevista realizada con el autor de la tesis, cree que la impresión 3D tiene futuro muy prometedor en el campo del diseño de interiores, ya que esa tecnología puede ayudar a producir muchos productos de nuestra vida diaria, pero por otro lado opina que esa tecnología está muy limitada debido a la imposibilidad de producir la misma textura y la misma forma esperaba como resultado final.

Por tanto, la tecnología de impresión 3D, puede ayudar en el sector del diseño de interiores al producir prototipos y en producir productos amigables e inventar nuevos usos de esa técnica.

Participante número dos, Stefania Varvaro.

3D printers it's really useful, and it could be useful if we used it to print a physical model instead of doing that by hand, as it is time saving, and having this as an idea at the begging of the project is really useful.

La profesora Bárbaro en su respuesta a la pregunta sobre el desempeño de la impresión 3D el en sector del diseño de interiores, afirma que es una técnica muy útil para este campo de trabajo e investigación, al producir un modelo físico de los diseños, lo que ayuda a los estudios de diseño de interiores a ahorrar tiempo, lo cual se traduce en una reducción de costes y esfuerzos durante el proceso de producción. Es decir, esta tecnología permite obtener un prototipo inicial en un tiempo reducido.

Participante número tres, Marita Caninia.

Do you think the 3D printer will be useful to print out a mini scale of furniture, and to use it like a physical model to show to the clients how this furniture will look inside the space, and to give the clients more possibilities to think and in sometimes change the space planning?

Well, we think it's just save a bit of time and it gives the clients the possibility to imagine, but not only through 3D technology; there are many ways to do this, it could be more useful for furniture manufacturing and designer to print out the samples, which would allow the clients to see the design with the real shape but small scale, because as you know the initial idea for 3D printer is to make 3D physical models and explore and communicate as a prototype.

On the other hand, if we print models out every time we receive clients, it will be a problem for the energy consumption and pollution, many plastics would be through away, and we are working to reduces all these things to save the plant.

Even if this material is recycled? Yes, and don't forget the cost of all this, we think that this technology has to be further developed, but we think also that it's a good tool; it depends on how you use it.

Respondiendo a la pregunta dirigida por el autor de la tesis, la profesora Caninia cree que la impresión 3D puede ayudar de una manera u otra en la fabricación de muebles o de modelos físicos que sirvan de apoyo al

trabajo del diseñador, al poder ver el cliente el diseño en forma real, pero en una escala mini, que al fin y al cabo es la idea principal de la impresión 3D.

Por otro lado, si imprimimos los prototipos cada vez que recibimos clientes, esta estrategia pueda causar contaminación y aumentar el consumo de energía y aumentar el coste de la impresión. Esto llevaría a que mientras intentamos reducir los materiales perjudiciales para el medio ambiente, en realidad los estaríamos aumentando. Es por esto que se debe desarrollar más esta técnica y explorar una manera más innovadora de imprimir los modelos 3D.

Participante número cuatro, Alessandro Biamonti.

It can be said it's a professional product, but it has cost a lot. At the same time, we have to keep in mind that every day there is new technology.
All the responds about 3D printers and augmented reality came from a short debate with the researcher about this kind of technology.

El profesor Biamonti invita a usar todas las nuevas tecnologías en el sector del diseño de interiores, ya que permiten innovar en este campo de trabajo e investigación, permitiendo a los diseñadores de interiores llevar a cabo su tarea de forma más profesional y rápida.

Participante número cinco, Bogdan Stojanovic.

It saves a lot of time to architects creating models; especially the final models, now it has more uses in other fields more than interior design or architecture.

De acuerdo con el profesor Bogdan Stojanovic, este tipo de técnicas funcionan bien, en el sentido de que permiten ahorrar tiempo, ahorrando

costes en el diseño. No obstante, esta técnica sigue siendo más útil en otros campos.

Participante número seis, Oxsana Nauso

I think it's very useful; actually, we use it at my work very often.
For mockups it's very useful, especially for product design to make samples for the clients before starting to produce it a high level, we mean here a manufacturing.

We start with Rhinoceros and once we have all the models we start printing out all the physical models through 3D printer.

In interior design, it's complicate to represent the space, but for the furniture it's useful, actually we used this kind of technology to make the prototype to present our new work in the international events like Salone di Mobile di Milano.

La profesora Oxsana Nauso opina que esta tecnología es muy útil, y que de hecho la utilizan. Afirma que su utilidad está reflejada especialmente en la creación de muestras de productos antes de comenzar una fabricación a gran escala. También señala el uso de este tipo de productos en ferias de muebles y exhibiciones.

Participante número siete, Barbara Camocini.

I think it's much more expensive than the virtual 3D, and it takes more time; we can do the same task with 3D technology, it's nothing more than 3D moldings, so I think it's the same level of 3D model.

En el caso de la profesora Camocini , ve conveniente el uso de la impresión 3D en el diseño de interiores, ya que opina que esta técnica no aporta nada nuevo respecto a la visión del 3D virtual. Señala además que la impresión 3D es más cara.

Participante número ocho, Giulia Ceppi.

It's another opportunity. It's something interesting to use it in our field like interior designers and architects, as we could use it to save money, effort and time, because as we know it's cheaper to make the sample through 3D printers and it takes lees time and effort.

On the other hand, we can use it like a new tool in our design process.
At the same time, I think it's more useful to make models and it allows the clients to touch it and explore and in this way, we can avoid many mistakes in the high production, but as a designer you have to keep the control, otherwise it will be a risk for your work.

El profesor Ceppi cree que la impresión 3D puede ser una nueva oportunidad en la disciplina del diseño de interiores y la arquitectura, y hace su trabajo principal, que es reducir el coste de hacer modelos físicos y el tiempo necesario para hacerlos.

Por otro lado, podemos considerar esta técnica como un nuevo paso en el proceso del diseño hoy en día, y además permite a los clientes interactuar con los modelos, con la posibilidad de tocarlos y explorarlos.
Por último, nos permite evitar los errores durante el proceso de fabricación, y sobre todo en la alta producción, bajo la supervisión del diseñador para tener un control total en todo el procedo de producción.

Participante número nueve, Galluzzo Laura.

I think yes, we can work a lot on this technology in general, because at the moment 3D technology it's really focused in the design of product more than in interior design, so it could be interesting to understand which is the relationship

between new technologies, and especially 3D printing and the new spaces or the future spaces though interior design.

I am not an expert in this technology but I belief that the space can change a lot with this technology. In terms of space, the new technologies can change the interior space, not only if they produce the space even in the production in interior design.

Desde el punto de vista de Galluzzo, el uso de la técnica de impresión 3D en el diseño de interiores está muy limitad. Los investigadores y los profesionales de esta tecnología están enfocando más sus investigaciones y trabajos en el diseño de producciones, así que podría resultar una herramienta muy interesante y útil para percibir bien el espacio y entender mejor las relaciones entre los muebles.

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Listado de imágenes

FINAL CONCLUSIONS

Final Conclusions

Firstly, we will begin the conclusions of this doctoral thesis by introducing a brief summary about the processing, proposals, and results obtained during the development of the research.

This study is intended to involve and explore the impact of the new technology on interior design nowadays. This thesis contends three main discussed topics which all revolve around the new technology in the discipline of interior design, following different strategies to get the objectives of each chapter. Starting with how the technology changes the scenography and helped many directors, scenographers, and technicians to invent the virtual scenography which conducted many tasks of the scenography by using the technology and changing the way of pre- production, production, and postproduction stages, and at the end of this chapter present a new proposal which introduces the use of augmented reality in representing the final step or phase in the design process and specially in interior design which is the main topic of the research.

To present a perfect vision about the influence of new technology on the design process, in this chapter we intend to present the evaluation of this relationship between the new technology and design process through making profound interviews with professors, professional, students of interior design and architecture, trying to get the maximum of information from those interviews to help all the users of interior design to take advantage of the obtained data, and discuss it from the point of view of an interior designer which is the author of the thesis, to go more profoundly into this impact we asked thirty, first year interior design master students from the Politecnico di Milano, by distributing one model of a semi-structured questionnaire during

the class, which took twenty minutes for the students to respond all the questions.

Later, with all the obstacles which faced the development of the third proposal presented by the researcher as the field of research in this chapter which is the last part of the research, and like all the chapters the main subject is related to the new technology and the field of study of interior design, we treat another proposal which presents a method of new use of 3D printing in the phase of representing the final result of the design process.

Going from the general to the particular aims of this study which achieved the majority of them with a very high percentage of satisfaction, the study has objectives to involve the discipline of interior design, new techniques and methods which permit students and designers to represent their work in perfect conditions which gives the clients a better understanding and at the same time helps the designer to save time, effort, and money. All these aspects benefit the interest of the designer and clients, and assist to improve design thinking and the design process.

One of the goals of this study is to open new pathways to help whether designer or clients improve the way of understanding the space and the techniques of retail spaces. A part from improving the way of understanding, this research has a purpose to increase the use of augmented reality in the field of interior design for all participants whether students or professionals which consequently has had a huge increment of the concept of interior space. As we know the big use of augmented reality in different disciplines and tools, our daily life has had a huge impact from this and nowadays we simply cannot dispense these tools.

As simple as possible finds a new way to use this kind of technology in the fields like architecture and interior design which considerate the new

technology in the majority of the disciplines using it, but with very limited use in architecture and interior for this we are seeking to enhance the use of the technology of augmented reality and 3D printing to achieve desired objectives of this study. Many intents have been completed to attain that, starting by presenting a new proposal of the use of augmented reality on interior design and its impact on itself, passing through the impact of 3D technology on interior design during the design process, later to finish the research a new method was presented with the use of 3D printing on interior design and the topic was discussed, how we can get more advantages from this technology as an interior designer and employment in our design process.

Chapter number one

Using this model rendered representation of 360º designs, users can locate the furniture and decorations created virtually without any physical limitation, with the help of the smart glasses (in our test, the glasses Facebook oculus). In addition, this system allows the user to measure the dimensions of the space, the objects and even to manipulate the furniture freely. Through these glasses, the user experiences an intuitive and natural experience and virtual interaction with the design.

The increased content and sensory information of decorative material-furniture-furnishing devices can be simulated with special stereoscopic equipment, such as an internal AR3D prototype in a arid system to improve the understanding and participation of customers in a custom and interactive interior design project.

This type of experience leads to the limit of the concept of ' instantaneous radio aids ', a global lighting system capable of providing users with an experience of interior design in a realistic and immersive. This model

makes it easier for the user to develop a more participatory attitude throughout the process, coming into contact with the design and participating in the decision making in conjunction with the designer.

In this way, the designer and client can agree on all aspects of the project in advance, saving time and money in the future. RV and RA are already making a huge impact on interior design architecture and interior spaces, and have been for years. The recent incorporation of technology will only serve to accelerate the adoption rate, and it is soon likely to seem strange not to receive a virtual walk from a building or a room, or to see how a new couch is going to fit in before it ever comes into the house.

However, this model presents some drawbacks in terms of real-world information. Mobility in an augmented reality environment is one of the most critical and complicated factors in this type of virtual systems. What's more, the current depth sensors present some limitations on long-range depth detection, which directly influences the ability to gather all the necessary information from the space or room in question. The author considers it important the need for future research on virtual environments and augmented reality systems in interior design to evaluate the possibility of improving the user experience by perfecting the sensor-system interaction.

Interviews with specialists and interior design professionals reveal that, although most of them believe that this type of experience is physical and mentally demanding work, they generally qualify the experience as ' pleasant, original and curious '. The author considers that this fact is due to the little familiarization of those interviewed with this type of virtual environments in their interaction with the system through sensors.

In this same line, the author urges that in the next tests and experiences in

environments of augmented reality, it takes into consideration the importance that the participants or users receive training sessions for their familiarization and approach to this type of environments.

However, thanks to the highly realistic representation in the test performed, it can be confirmed that most of the participants showed high levels of involvement and concentration in the task, which invites the interior designer-and the user-to look optimistically into the future, and exploit the full potential and innovative possibilities of combining one of the most important escenografic tools-the color key or chroma key-with an environment Virtual RA.

For its part, the author considers it extremely important that future research on arid systems in interior design is focused on the development of the limited and primitive databases that contain virtual information on furniture, appliances, decorative elements or lighting for users in this type of RA environments. All of this will have a positive impact on reducing the costs of implementing interior design projects using augmented reality techniques and improving the experience of users in real time.

Chapter number two

The purpose behind this examination study was to research how inside diagram experts utilize PC development in the midst of the arrangement method. Particularly essential was if and how layout masters are using the PC advancement while making new contemplations for the client inside the schematic arrangement organizing. All members in this survey saw various focal points concerning the use of PC development in the arrangement workplace and in the midst of the diagram strategy. Two critical classes

shaped the disclosures of this audit: part motivations and part experiences. Inside each arrangement, creating themes and sub-subjects were perceived. The grouping of part's motivations for using the PC advancement in setup doubts included four points: (1) correspondence, (2) information gathering, (3) business effectiveness. The correspondence subject had three sub-points that created (1) new development, (2) physical model and (3) visual presentation. The subject of information get-together joins two sub-themes of (1) collection of information, and (2) thought period. Inside the class of part experiences, there were two themes that rose. They were (1) influence on work strategies and (2) ability of setup ventures in the midst of a design plan. The point, influence on the work frames, had two subthemes that created: (1) great conditions and (2) difficulties. Coincidental comments, not clear in subjects, included such comments as the issue of being inventively tried while using the PC advancement and individual slants of PC development capacities with respect to work use. The bigger piece individuals saw was that overhauled correspondence was the impelling component for using a PC advancement for their inside blueprint business.

Correspondence was a champion among the most broadly perceived points determined that related to interior designer's motivations for using PC advancement in their work, worked out. Each one of the ten individuals inspected different characteristics of correspondence in the midst of individual gatherings. To enhance correspondence, members communicated the most progressive use of PC advancement was visual depiction with clients, authoritative laborers and staff. Generally, they saw the PC development gave an incite procedure for keeping up visual contact with the thought gathering. Continuing with the correspondence cycle, individuals analyzed the evident estimation of sending staff to the last hurdle which finished by giving brisk thought or client information. The extended thought

reinforced, through minute correspondence streamlined the thought correspondence handled and extended thought profitability.

The last subtheme inside correspondence was the limit of the planner to use the PC advancement for visual correspondence and presentation purposes. For example, individuals communicated the PC advancement is ideal in extending their ability to evidently pass on their thought gathering to the client or partner. A couple of individuals said that their clients respond better to using this kind of visual correspondence than more standard systems in advance used. The PC advancement apparently improved visual correspondence if consolidated with another yield device: a projector or TV. Likewise, as the planner easily investigated through drawings and

documents client changes could be instantly joined as substance was discussed.

The predominant piece individuals met saw information collecting as any errand that incorporates data gathering, considerations or materials to complete the process of starting layout suggestion or to make musings. Part talks showed that amassing of information using PC development going before the errand started was an important usage of the PC advancement in the arrangement technique. A significant part of the time, individuals communicated that get-together and documenting on the web information better energized their endeavors. The ability to rapidly get to information members anticipated that would coordinate business, was something all makers a significant part of the time discussed. A couple of individuals discussed the benefits of investigating material particulars or having the ability to reference past clients' experiences while being away at a site, in a client meeting or travelling on business.

In addition, using PC development for collecting information, individuals, moreover uncovered using the arrangement programs for making musings. Part meets revealed the layout undertakings were being used for the period of musings, yet individuals delivered those considerations by using on the web instruments and activities to create endless supply, of depicting. Two members at present used the automated tablet for drawing purposes; in spite of the way that individuals not at this moment using the propelled tablets depicting capacities conveyed a future longing to learn. Online resources as locales, makers, magazines, and thought and thought time programs all were inspected by individuals as vital devices to thought period.

All members saw the PC development as preference for the layout pro while completing clients′ doubts. Regardless, they felt the full capacities of the PC development are yet to be made sense of. The lion's offer of members unequivocally agreed that PC advancement will, within the near future, go up against higher demand in the layout business focus. They in such manner acknowledged, with specific ventures, that the PC development will be also planned into step by step practices of an inside originator.

The revelations of this survey offer a foundational understanding of inside originators' acknowledgments concerning the use of the framework activities and how they utilize them in their workplace. A couple of subjects ascended out of this exploratory survey passing on the various similarities among part motivations and perspective of using the layout programs in the midst of the arrangement methodology.

This survey demonstrates that all individuals were particularly vivacious to join the framework programs into their work shapes in light of those activities' ability to redesign the client to-organizer correspondence and furthermore information gathering. Moreover, individuals were energized to continue with the mix of the data gathering programs into the layout technique inside the constraints of their advantages: time, mechanical proficiencies and records.

Hindrances to the additional allotment of those ventures were perplexing to individuals; in any case, they in such manner saw these as unmistakable tradeoffs of development joining.

All individuals felt the data gathering programs have huge potential for use in the diagram technique to continue improving correspondence, thought period, and work preparation. With points of interest of the arrangement programs far surpassing the specific requirements, each part more than once communicated their longing to advance their understanding into the blueprint programs and form it into all parts of their life. The individuals assumed that the calling was rapidly creating, fusing design programs wherever possible. All communicated they needed to stay current with the advancement to remain forceful in today's market and believed it was essential to continue working towards planning new tasks into their practice. This resounding clarification is one that is shown again and again by researchers, who in different zones have found that most purposes for living must stay ebb and flow with advancement, or they will soon end up recognizably obsolete.

Some of the disclosures in this survey are both direct and roundaboutly maintained in fragments of composing. While none of the disclosures in this survey unmistakably dishonor any ebb and flow look into

conclusions, one particular finding with respect to business proficiency to some degree shows up diversely in connection to past research conclusions. This examiner is convinced this is a result of the point by point sort of advancement being considered, Data gathering programs, when the present composition suggested the gathering of development with everything taken into account. In any case, since this is an exploratory survey, this discovering should not be dumbfound.

Before driving this audit, it was acknowledged that individuals would likely discuss such subjects as how they use the diagram programs in the arrangement technique and after that more especially for thought period. These point zones get broad thought in existing written work; in this way, it had all the earmarks of being sensible that inside blueprint specialists may in such manner use them routinely before long. This assumption was exhibited substantially by and large. This ebb and flow survey's individuals revealed that inside layout specialists described thought time more widely than that of the period of early on drawings and portrayals, to consolidate that of information gathering and research. The bigger piece individuals imparted was that at present they don't use the data gathering programs for depicting purposes nor to make drawings, however they do use the layout programs for the get-together, study and sharing of blueprints. It is felt that the disclosures of this exploratory survey cause give exceptional learning to how Interior designers at this moment utilize the diagram programs in the data gathering method in hand for thought time. Individuals shed light on a cloud scope of research respectably, which is rapidly changing, due to speedy paced mechanical advances. In spite of the way that there is much yet to be learned on this point, it is believed a solid foundation for future research was given on a topic that is consistently advancing.

Chapter number three

This proposal presented a new way to use 3d printing in the field of interior design, and while this proposal remains only a prototype that still needs to be improved and developed much to achieve its main goal, it allowed us to discover new uses of 3d printing technology in the field of interior design and production.

On the other hand, the new use of 3d printing technology in interior design and production opens new research paths in the field of producing real-scale pieces, which leads us to continue with the vision of building house and offices including the furniture in high quality and short time and which helps us to reduce the cost of construction.

Finally, another advantage of this study is that it makes it easier for designers to use 3d printers to produce their manufacturing prototypes, especially after knowing that all the material used by these printers is recycled material, which means reducing the pollution produced by the use of non-recycled materials in the other ways of rendering prototypes.

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ANEXOS

Anexos

Anexo nº 1

Questionnaire for professors and professionals

RQ1: How do interior design practitioners' use 3D technology when generating new ideas for clients in the schematic design phase?
RQ2: How is the impact of 3D technology on interior design in showing the final design?
RQ3: Do you think that 3D technology allows interior designer to save time, effort, and money? (Motivate the answer)
RQ4: How could be the discipline of the interior design without this kind of technology?
RQ5: Do you think it is necessary to learn this kind of technology to be a good interior designer? (Motivate the answer)
RQ1: How many 3D modelling software do you use? Which?
RQ2: Do you think having some knowledge in this kind of technology help to get more work?
RQ3: Do you think if you have some knowledge in this kind of technology you will get more work?
RQ4: Do you prefer to draw or make some preliminary sketches for your design first? Or you prefer to start directly with the programs?
RQ5: What value do you think students place on the 3D technology as a representation of quality of their design?
RQ6: How do you think students view computer technology's role in their design thinking and their design products?
RQ7: How would describe yourself (skill-wise) in terms of computer technology?

RQ8: How do you use these programs in your design process? Could you explain?

Anexo nº 2

Questionnaire semi- stretched for students

Questions to ask in a semi-structured interview

1. How would describe yourself (skill-wise) in terms of computer technology?

A. poor

B. Good

C. Advanced

D. Other (Specify)....

2. What computer software programs do you use in your design process?

3. In an ideal design process, which activities/phase would you use digital media and what aspects would you use manual techniques?

4. How do you use these programs in your design process? Could you explain?

5. Do you think it is necessary to learn this kind of technology to be a good interior designer?

Yes (specify)….

No (specify)….

6. Do you prefer to draw or make some preliminary sketches for your design first? Or you prefer to start directly with the programs?

A. Make some preliminary sketches

B. Start directly with the software programs

C. Other (specify)….

7. What do you perceive to be benefits of using 3D technology in the design process?

A. Good display for your design

B. Save effort and time

C. Increase sales D. Other (specify)….

8. What, if any specific programs have you found the best in assisting you in the design process?

9. Tell me about some of your research strategies when you need/ wish to develop a new concept (object)? (Based in 3D technology on interior design)