D5.4 Innovation Mapping Report of Creative Industries in Healthcare sector

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Document Summary

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1. Introduction

The term **Creative industries** stand for a wide range of activities including cultural industries and all of the cultural, artistic, scientific and technological productions based on knowledge and skills. The creative industries are a type of activity which includes production and exchange of ideas in the field of culture, art, science, technology, often realized in specific material products, information and services.

UNESCO defines Creative Industries as "*sectors of organised activity whose principal purpose is the production or reproduction, promotion, distribution and/or commercialisation of goods, services and activities of a cultural, artistic or heritage-related nature*."

Creative industries embrace wide sectors. The Department for Digital, Culture, Media and Sport (DCMS) of the UK Government recognizes at least nine different creative sectors:

1) Advertising and marketing
2) Architecture
3) Crafts
4) Design: product, graphic and fashion design
5) film, TV, video, radio and photography
6) IT, software and computer services
7) Publishing
8) Museums, galleries and libraries
9) Music, performing and visual arts

Many of these sub-sectors are predominantly commercial and profit oriented and therefore are crucial to the well-being of other areas of the EU economy.

Europe has a strong interest in the cultural and creative industries, as they are a source of economic growth, as stressed in the report of the European Creative Industries Summit:[1] "*The cultural and creative sectors make up nearly 4.5% of the European economy, thanks to nearly 1.4 million small and medium-sized businesses generating and distributing creative content all over Europe. The cultural and creative sectors have shown great resilience during the crisis – they actually continued to grow – while stimulating creativity and innovation spillovers in other sectors. About 8.5 million people are employed in creative sectors across Europe – and many more if we take into account their impact on other sectors such as tourism and information technology*"

Creative industries are amongst the most innovative industries in the economy. Their business models consist of developing new innovative ideas and to transform them into commercial products for their

[1] European Creative Industries Summit, Brussels 2015, http://ecbnetwork.eu/wp-content/uploads/2015/09/ECIS-2015-Brussels.pdf.

customers. The non-standardized nature of their products is closely related to innovation. The framework of collaboration, flexible networks and temporary and project-based cooperation promote innovation and creative products in Creative industries.

Traditional research and innovation can be measure by the generation of new technological artefacts and patents. Measuring innovation in Creative industries is however a huge challenge due to the difficult of definition and continuous nature of the innovation process. Creative industries are specially characterised by new forms of innovation processes, such as processes and approaches like design thinking, open design and open innovation. Design is not only used in the innovation process to create new products and services but design-thinking methods can be applied in services, systems and organisation to create new business models and organisational innovations.

Innovation in the Creative industry is often also closely related to digitalisation and the emergence of new ICT tools. Interlinking the Creative Industries with digital technologies results in the creation of new jobs, opportunities, services and new products that have a positive impact on the whole economy.

Digitalisation provides new opportunities but also special challenges for Creative industries. It changes the way they integrate creativity, bring new perspectives, features, functionality attributes and foster innovation across sectors. It enables new forms of innovation such as co-creation, user driven innovation or open innovation increasing the heterogeneity of actors in innovation systems. Through digitalisation Creative industries profit from lower production costs, new distribution channels, creation of new business models (such as online music platforms or video on demand) and development of new markets, products or services.

One of the major challenges connected with digitalisation, is the transformation of business models. Digitalization leads to an increasing hybridization of economic models entailing a multiplicity of funding and revenue sources. In the gaming sector for instance currently six economic models (with physical or digital payment, subscription, free-to-play including Paymium, advertising and micropayment) function in parallel.

In terms of the sectoral development of the Creative industries in the last decade, the most dynamic sectors had been software & games, performing arts & artistic creation, design & visual arts as well as archives, libraries, cultural heritage. These sectors experienced an increase in the number of enterprises, employment, turnover as well as value added. The future competitiveness of the cultural and creative sectors will depend upon their capability to embrace and exploit the maximum potential of digitalisation and ICT.

When it comes to Healthcare Industry, innovation can nurture from unexpected pathways. Nowadays Healthcare companies are moving beyond traditional R&D activities to reach a wider ecosystem for insights, ideas, technology, and talent. Healthcare innovation is no longer considered to be solely focused on technology development, but now encompasses business models, new services, different means of engaging with customers and novel organisational practices.

In the last few years, since Design has entered the Healthcare system, deep changes have been happening, causing a race for innovation that is generating competition between healthcare providers. This competition is forcing to improve healthcare for benefit of everyone. On the other hand, Design

can complement the scientific method, helping to translate ideas into real possibilities, and give solutions that other disciplines are not able to.

Healthcare has opened its arms to design-led thinking, with many using the methodology to design improved experiences and solve problems within the complex healthcare landscape. Medical devices are becoming a part of our everyday lives, whether to monitor, diagnose, or predict the likelihood of a disease or illness, or prevent it through healthy habits. Human Centered Design and Design Thinking in the Medical Device Development Process drive a higher return on investment. Design Thinking makes a device easier to use and more efficient. At least as important as the greater efficiency and efficacy, are the intangibles that drive acceptance. People interact better with devices they want to use and feel comfortable using. Design Thinking in medical device development places a priority on the interaction of an individual with the device.

This report aims to bring to light how Creative Industries can promote Healthcare innovation to achieve new horizons and demonstrate the application of the know-how of sectors like Audio visual or Gaming, can push Healthcare to go a step further.

2. Creative Innovation Processes

Innovation in the creative industries involves new ways of doing things and new patterns of human interaction (often originating in non-economic, non-commercial contexts), such as non-traditional methods of involving users in design content and service activities. The evolution of the creative industries reflects an increasingly globalized society, enabled by digital technologies, where Internet has changed the process of value creation and shifted the balance of innovation between firms and consumers/users.

User-driven innovation encompasses understanding of real user needs and systematic involvement of users in the innovation process, which is reflected in new business models. User participation and knowledge transfer from users to firms are everyday practices within the Creative industry domain, especially in those sectors driven by digital technology. In fact, by involving users in innovation and product development processes, organizations increase the probability of successful outcomes, since the co-developers are also future users.

This section focuses on the role of the creative "participative consumer", an increasingly important stakeholder within the Creative industries.

2.1. Open Innovation

Open Innovation is the use of deliberated inflows and outflows of knowledge to accelerate internal innovation in order to expand the market for external use of innovation (Figure 1). This concept falls directly in the gap between business and academy. Conceptually, it is a more distributed, more participatory, more decentralized approach to innovation, based on the observed fact that useful knowledge today is widely distributed, and no company, no matter how capable or how big, could innovate effectively on its own.

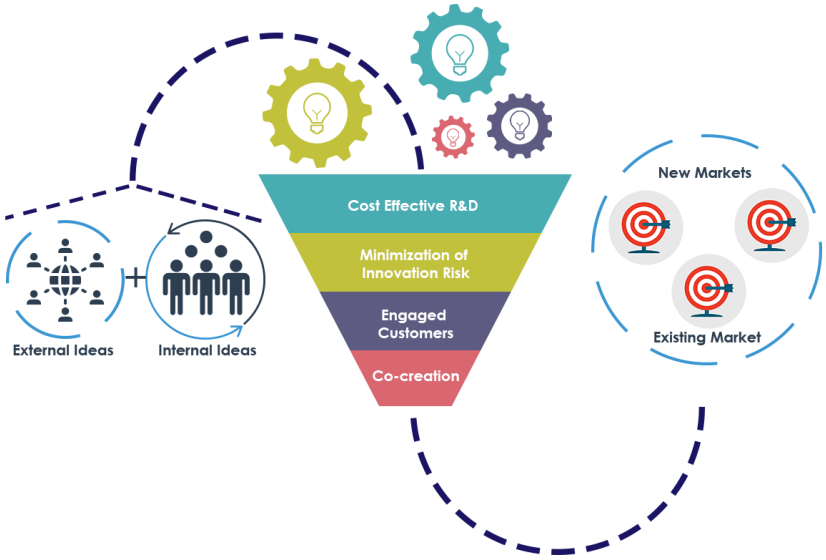

Figure 1. Open Innovation general process

The application fields of open innovation are frequently linked to the manufacturing sector, in particular to technological markets, or indeed to business or financial services. Innovation in the Creative Industries is also increasingly about business models, new channels and diversification. Open innovation creates also new growth opportunities for Creative Industries.

Open Innovation implies new forms of collaboration between different people and organisations involved in health innovation. In particular, new kinds of collaboration between different sets of actors:

- Public sector (health service and/or research organisations) and private sector organisations.
- Health service/research organisations and their employees (practitioners and researchers).
- Health service/research organisations and the people they serve (citizens/patients)

Innovation is increasingly a collaborative endeavor, with organizations looking outside of their current workforce for inspiration, ideas and insight. Nowhere is this more so than in healthcare, where technologies as diverse as robotics and the Internet of Things, big data and machine learning are having as big an impact as bioinformatics and biology.

Health innovation includes innovations to prevent illness and promote health and wellbeing. It might take the form of new products, services, processes, organisations or policies. In fact, it often involves several of these simultaneously. Successfully launching a new technological innovation, for example, might require developing complementary technologies, new business models, new processes, new roles for patients and clinicians, or policy changes.

Collaboration in health innovation is nothing new. What makes Open Innovation approaches distinctive is the way in which they blur traditional roles between actors. For example, public health systems have long collaborated with pharmaceutical companies, but traditionally this has involved companies developing profitable products and the state distributing the results for public benefit. Through product development partnerships however, pharmaceutical companies come to apply their expertise to neglected health challenges. Meanwhile, through clinician innovator programmes, public sector health organisations encourage staff innovation and entrepreneurship.

2.2. Design Thinking

Design thinking is a process of systematic innovation that prioritizes empathy for end users, paying particular attention to their wants and needs, in order to fully understand the problem, developing solutions more effectively and comprehensively and adapted to the end user's needs. This is why the Design Thinking has been increasingly used in the health field.

Design thinking empowers employees and patients to play an active role in solving challenges. By focusing on emotional and functional needs of staff and patients weigh in on their encounters, new processes centered on the needs of key stakeholders are created.

Design Thinking model has five stages: empathize, define, ideate, prototype and finally test (Figure 2).

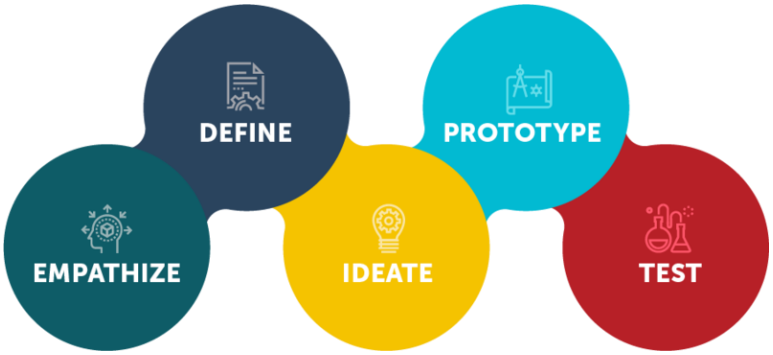

Figure 2. Five-stage Design Thinking process.

1. **Empathize:** In the first step, the focus is on the users view and their behavior in the context of their lives, to engage to users and experience what the users experience.
2. **Define:** In the second step, after synthesize the empathy findings into compelling needs and insights, based on a deep understanding of the user, is time to come up with a problem statement, defining what is needed to be created.
3. **Ideate:** Then, the time to ideate and generate radical design alternatives has come. This step is similar to brainstorming where the goal is both a large quantity of ideas and a diversity among those ideas.
4. **Prototype:** Prototyping means getting ideas and explorations out of the head and into the physical world. The idea is to perceive and interact with the generated ideas and make them real.
5. **Test:** The fifth step includes testing the prototypes and getting feedback about the proposed solutions. This is a chance to refine the solutions to make them better and continue to learn about users.

When it comes to apply this model to Healthcare field, focusing on functional and emotional needs, staff and patients can empathize the emotions they had during the medical experience. For instance, when a hospital wants to create a better emergency department experience, leaders may focus on wait times by streamlining the triage process to shorten wait times. However, for patients this shorter wait time may not make their experience better if they're sitting in a waiting room that is dirty, overcrowded and loud. By implementing a design thinking framework, patients' physical and emotional experiences would be considered in the creation of a solution that is less focused on shorter wait times but addresses the entire wait experience for the patient and their family.

Design Thinking begins with a deep understanding of what the client wants to accomplish. Products should reflect the visual brand language of the client, an expression to the customer of image, feel, thoughts and value. The goal should be to simplify product development by focusing on objectives and desires that are important to the users of the product:

- Approachable
- Intuitive

- Ready to use quickly
- Different levels of controls for different users
- Consistent and repeatable

Another important aspect to be considered is product esthetic. Medical device companies can be well ahead of the competition in technology and lose the battle in the market if they don't delight the consumer. Consumers are used to the slick feel and functionality of smartphones, and they don't tolerate anything less from state-of-the-art medical equipment. Meeting this demand requires a deep understanding of the "user journey". Using ethnographic research, designers observe users in their environment to gain empathy and discover unmet needs and opportunities.

2.2.1. Design Thinking in Patient Care

Until now, patient experience issues were addressed with simple post-visit surveys. Some hospitals are beginning to use Design Thinking methodology with surveys, focus groups and observations to identify patterns and discover problems to come up with solutions that can be implemented right away. These solutions do not have to be perfect, but the observation of how the potential solution in place is working will help to develop more new ideas.

A patient empathy map might help hospitals to understand patient's pain, concerns, fears and go beyond the clinical treatment. Among the benefits Design Thinking application is bringing to healthcare, it is worth to highlight the user experience improvement when interacting with machines (reducing anxiety and fear), the improvement of the doctor-patient communication or the increase of comfort and mobility of patients.

Some of the first applications of Design Thinking in healthcare were carried out by the company GE Healthcare, they not only applied this methodology to the innovation and development of new instruments and medical tools, but also on patient experience.

One of the first applications was transforming a magnetic resonance machine (MRI) and the room where resonances were made, into a spaceship or on a pirate ship (Figure 3). This redesign lead to better patient experience decreasing fear and anxiety attacks of patients specially children.

Figure 3. Redesigned MRI using Design Thinking

Another example of patient experience is the redesign of patient costume, which used to be quite uncomfortable for users, especially for the shyest ones. Thus, using Design Thinking process, patient costume was redesigned in order they could be used both inside and outside the hospital without embarrassment.

2.2.2. Design Thinking in Clinical Experience

Hospitals often originate sensations of anxiety and displeasing among patients and visitors. Impersonal rooms, cold illuminations, chemical odors, long waiting times. Design thinking may bring forth innovative ways of helping patients and visitors feel comfortable and make their experience bearable.

Driven by Design Thinking, hospitals can be transformed elevating the patient and visitor experience. The first step in any design-thinking process is to understand the end-user's experience by looking inside and outside the system for ideas about how to improve the medical service and how their patients felt when they entered the hospital. For example, scheduling from the just-in-time practices or clever architectural and interior ideas can also contributed to reducing patients' fears and annoyances.

Herein some principles of design thinking in the facility's redesign of the clinical experience:

- **Start with patient-first thinking**: The first step in a design-thinking process is understanding the end-user's experience. Patient experience must be on the mind of the designers.
- **Borrow best practices from outside industries**: Next, hospital leaders looked inside and outside the healthcare industry for ideas on how to improve its customer service.
- **Put ideas into action**: These small-scale experiments, which may be somewhat informal, supported the gradual adoption of new ideas.
- **Make physical structures reflect the goal**: Architectural and interior design changes also intended to remedy patients' fears.
- **Learn from failure**. Every lesson learned can contribute to the next solution.

2.3. Human Centered Design

Human Centered Design (HCD) is defined by International Standards Organization (ISO) as:

"*Human-centered design is an approach to interactive systems development that aims to make systems usable and useful by focusing on the users, their needs and requirements, and by applying human factors/ergonomics, usability knowledge, and techniques. This approach enhances effectiveness and efficiency, improves human well-being, user satisfaction, accessibility and sustainability; and counteracts possible adverse effects of use on human health, safety and performance*."

Human-centered design was originated in the 1980s and continued to evolve through the 1990s. It began as human-computer interaction to help product developers. Specifically, to help computer and software development companies in designing interfaces. And also understand the interaction

between the user, the software, and the hardware. The advent of new interactive technology including tablets, smartphones, tracking devices, depth cameras, wearable devices, augmented reality goggles, and so on, has raised new opportunities for studying and applying this innovation process to the healthcare domain.

Human-centered design prioritizes empathy for the end-user. The main difference between Design Thinking and Human Centered Design is that the first one is a method to develop solutions which nail the actual problem which the user has, which are not mainly user Interface related. Whereas Human Centered Design focus area in the Human Computer Interaction. Both processes have similar steps but HCD is clearly focused on User Interfaces. The key step in both innovation processes is empathize with the end user, so both processes can nurture from the same identified problems and challenges. The goal in the design of user-centered software is to create systems that are modeled after the characteristics and tasks of the users. Applying disruptive solutions throughout the design life cycle can lead to systems that are easy to learn, increase user productivity and satisfaction, increase user acceptance, decrease user errors, and decrease user training time.

Although additional advanced degree programs in clinical informatics and data science programming are emerging, few incorporate the essentials of human-centered design, digital health technology, implementation science, and healthcare operations along with outcomes research.

Electronic Health Records (EHR) are a good example where HCD would be useful. EHR are sometimes poorly designed from the user and operational point of view. They unintentionally serve as a data repository for clinical, administrative, and financial information. One of the most important issues in the design of usable applications is to learn about the people who will be using the application. This information is needed because different types of users require different types of interfaces.

Healthcare organizations are also users of health IT and have a different set of duties, goals, and stakeholders they must satisfy. Internal stakeholders include clinicians and operations staff that ensures everyday functions. External stakeholders are patients followed by payers, etc.

Through observation, systems will develop a keener understanding of what people want and need. It involves a variety of methods, including assessing the intended users, observing and analyzing tasks and requirements, developing and testing prototypes, evaluating design alternatives, analyzing and resolving usability problems, and testing the features and interfaces with users in an iterative manner.

Microsoft is one of the best examples of benefiting User Centered Design. For a long time, it was a technology-driven organization. Now, the corporation has changed its strategy to be user-centered. They have adopted an authentic design development process that focuses on users.

3. Audio Visual Technologies

The Audio-visual (AV) sector has a great economic potential and an important cultural and social impact for the development of European economy.

The AV industry has been undergoing a massive shift from Analog to Digital technology over the last decades. This shift was brought about to meet the demand of new digital challenges in this field. Audio Visual communication technologies includes sound, video, lighting, display and projection systems. These are widely used in many businesses such as education, government, the military, healthcare, retail environments, houses of worship, sports and entertainment, hospitality, restaurants, and museums. In fact, today, it would be difficult to find a space where AV solutions are not present. The AV Industry is in constant evolution where technology is constantly growing and becoming more effective for its purpose.

Audio Visual communications are becoming a fundamental component in modern medical technology. AV technologies are elementary integrated parts of medical devices. Solutions for the medical industry offer a broad range of innovative benefits. Communication between doctors and patients, physicians and hospital staff, other healthcare facilities, doctors and EMS workers, and medical students and instructors have been greatly enhanced.

The medical industry is increasingly interested on AV solutions which can offer several innovative benefits to both physicians and patients. Technology has always been an essential component of the Healthcare industry, which is why modern hospitals and clinics continue to insist on using the last innovative commercial AV equipment for patient care. This section summarizes the most AV technology trends that are inspiring new Healthcare AV designs.

3.1. 4K and Ultra High Definition (UHD) Video

Healthcare industry is the perfect environment to take advantage of 4k and UHD video technology. 4K and UHD Video are needed for two applications: extra-large video displays, and for fine resolution critical inspection viewing, such as what would be required in medical surgery procedures where extremely high-resolution images are essential. The more accurately the images are detected and displayed, the more accurate the diagnosis. This has led to an evolution from computer tomography (CT) to high-resolution computed tomography (HRCT). The narrower the zones are defined and the more accurate the images taken at the individual levels, the more data which is collected for the final 3D model.

For example, the trend of minimally-invasive surgery which leads in shorter recovery times and fewer complications, means that surgeons often need to rely on laparoscopic cameras to perform procedures. To make clinical decisions during surgery, surgeons need to have confidence in the images they are seeing. 4K resolution (3840 x 2160) offers better depth and perspective and richer detail than standard HD.

4K is approximately four times the resolution of a typical full HD resolution as shown on the figure 4. The advantages of 4K image clarity are beyond question for applications such as diagnostics, preventative medicine, or virtual surgery. Generating videos with 4K resolution requires a significant amount of processing power. Thanks to advancements in semiconductor technology, this processing

power is becoming more accessible to medical device manufactures, in platforms that provide excellent performance and flexibility.

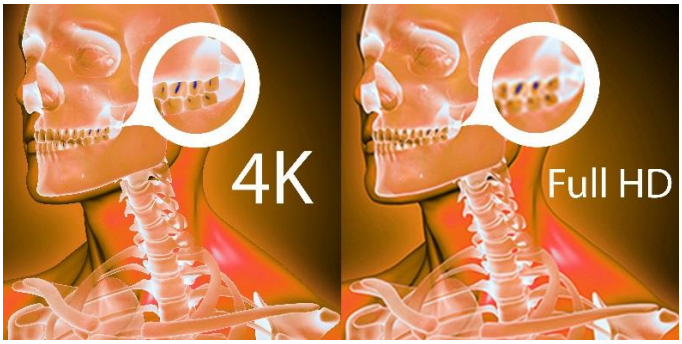

Figure 4. 4K and full HD resolution comparison

3.2. Laser and LED based illuminating systems

Illuminating systems span a broad range of life science applications in areas like photocytometry, microscopy, and spectroscopy applications, in general medical diagnostics, single disease detection and for gene sequencing, cell sorting, or when looking at the molecular level to blood, tissue samples, or body fluids.

The LED and laser spaces are undergoing a converging process. LED optical brightness and efficiency are constantly improving, generating more photons in a given area and higher power densities serving more applications better and with improved repeatability. Lasers, which were traditionally large, expensive, and complicated, are migrating in the opposite direction. They have smaller footprints, less overhead and complication, and are becoming easier to integrate for use in the life sciences segment.

LED based illuminating systems have become indispensable in medical technology and dentistry. But the requirements placed on these lighting products are very high: Minimized size, high, application specific color rendering index, efficient temperature management, usability and excellent disinfection opportunities are all extremely important.

Another laser and LED based illuminating systems are lampless projectors which utilize these light sources instead of traditional lamps of video projectors. LED works in tandem with a fluorescent element and a laser within the projector's light engine to provide the light source and render the images. The main advantage of this technology is that instead of the 2,000-hour lamp life expectancy that you would get from a traditional projector lamp, the LEDs are predicted to last approximately 10,000 hours plus without replacement! This obviously provides better cost savings over time.

3.3. Wireless technology

Wireless medical devices are not new, but they are about to have a much larger impact because of the way that forward-looking hospitals are linking them together to create truly connected environments.

This increasing number of wireless medical devices in hospitals has led to the vision of the connected hospital, a fully integrated hospital where wireless technologies allow caregivers and patients to roam throughout the hospital while providing accurate and timely monitoring.

By incorporating wireless technologies into medical products, many products that were once tethered to patients, positioned next to hospital beds and located at a nurses' station are now transportable. This has allowed two major healthcare improvements. First, it has increased patient mobility, both at the hospital and at home. The development of less invasive monitoring and treatment methods for common diseases has also improved patient mobility. Innovations have allowed at-home patient monitoring, minimising patient trips to the hospital and saving valuable hospital space.

The second improvement is that healthcare professionals now have real-time access to patient data throughout hospitals. Caregivers can monitor their patients and retrieve patient data on handheld devices at the patient's bedside. Timely access to patient data allows doctors to make immediate critical care decisions and perform administrative tasks such as gathering patient notes and writing prescriptions.

Wireless transmissions allow audio and video signals to be sent via wireless data networks (or between two devices using wireless data network communication protocols). Inevitably, implementing these new technologies brings upon challenges which include deploying a strong, secure infrastructure with robust reporting and monitoring features.

3.4. Digital Signage and Video Walls

Digital signage of all sizes is becoming more affordable with every year. This means that video walls as a whole are more accessible. The screens prices are decreasing while resolution and features are getting better than ever.

One of the biggest benefits of video walls is their versatility. Although it is not a new technology, with the emergence of interactivity, the desire to have video walls that interact with users has increased. From donor recognition in the lobby to surgical schedules posted at nurse's stations to wayfinding the cafeteria. The applications for this digital display technology in hospitals and medical offices abound.

3.5. Virtual and Augmented Reality

Among of the most exciting developments in the world of AV technology, virtual reality (VR) and augmented reality (AR) have gained a lot of traction in the past decade. They prove especially beneficial in the design industry. In the future, expect the demand for VR and AR to increase in numerous industries, including entertainment, retail, advertising, health care, travel, and museums.

Augmented reality (AR) and virtual reality (VR) medical devices have immense disruptive potential, with the capacity to change how the healthcare industry delivers patient care and provider training. These technologies are helping to take medicine outside clinical spaces and will present a wide range of opportunities for innovators as professionals continue to adapt.

AR technology layers over the real world, providing digital visuals, sounds or other stimuli that give insights from gathered data or add enhanced detail to reality. From contact lenses that give visual cues to diabetics when glucose levels fluctuate dangerously to smartwatches that use near-field

communication to remind patients to take prescription medicine when it's nearby, there are already technologies in development that help patients take control of their health using AR.

VR experiences can serve as adjunctive care with other treatment regimens, like programs that provide visuals for amputees or stroke patients in physical therapy. VR can also provide an alternative to some pharmaceutical interventions for psychiatric care, especially in the treatment of phobias, anxiety or even some personality disorders.

There are some potential advantages with the use AR/VR compared most known volume rendering techniques in diagnostic imaging, which are listed below.

1. Volume rendering technique takes a lot more computer processing as it creates an artificial light source within the image to generate shadows for imaging. As it involves more computer processing, it has a higher possibility for interpretation errors related to processing.
2. The depth perception achieved from 3D imaging used with AR or VR may provide improved visualization and additional characteristic detail such as microcalcification (a tiny abnormal deposit of calcium salts) and its patterns such as compact clusters or a linear or branching pattern to determine the risk of cancer. Thus, AR/VR imaging may decrease the amount of manual thresholding by providing more details about complex structures.
3. AR/VR environment may facilitate enhanced or additional digital content on radiology processing tools. An example could be, the use of different colors to represent different parts of a complex structure; use of different shapes like a cube or sphere (remember AR/VR provides 3D imaging) to represent similar anatomies.
4. A radiologist, surgeon, and patient can improve their communication and collaboration with computer-generated graphics with this additional information. AR/VR enabled imaging may provide additional arrow or note(s) in imaging for communication at ease between aforesaid. It may also improve overall patient care procedures.
5. As AR/VR provide 3D imaging and there is a possibility to deep dive with the capability of rotating, zooming and flying into a three-dimensional image with HMDs, there is a very high probability that we can detect tumor cells from the early stage which may remain unidentified with the current technologies and techniques.

AR and VR devices are changing the paradigm shift of patient care and provider training. For these technologies, there will be no shortage of opportunities for innovators who want to enter the market.

3.6. Architecture Adapting to AV Technology

In the past, the AV industry has adapted to suit the architecture of spaces. Now, as companies strive to fully integrate their intelligent audiovisual systems, architecture is often adapting to the needs of technology. When these two industries work together, the AV technology can blend in with its surroundings instead of looking "tacked on" and obtrusive. Ideally, the integration will offer flexibility for the future, so that the space can adapt to evolving technology.

4. Gaming in Healthcare

Gamification is the application of game elements and digital game design techniques to everyday problems, including business dilemmas and social challenges. As game technology matures and becomes more user-friendly, the application of games has also broadened in scope, and technologies developed are now being used for serious games, visualization, training, medical and military simulation applications.

Gaming is making an important dent in Healthcare innovation. Gamification involves applying game design techniques, game mechanics, and/or game style to non-game applications to solve problems, engage audiences and to make otherwise mundane tasks more fun and engaging. Gamification is increasingly being applied to many industries, including digital health, to create fun and engaging experiences, converting users into players.

Gaming in Healthcare IT industry has become one of the biggest trends. With the advancement in digital technology, gaming in healthcare industry aims to bridge a gap between entertainment, medicine, technology and education. By mixing self-monitoring and entertainment, Gaming is yielding the type of traction and adoption that will ultimately lead to sustainable patient behavior modifications and improved health outcomes. Gamification is changing the healthcare landscape on many fronts.

4.1. Smart Games in Healthcare

After being used by the military and airline industry for some time, now the time for healthcare industry has come to use simulations and gaming methods. This section brunches the actual main uses of gaming for innovative healthcare companies.

4.1.1. Apps for smartphones and tablets

Health Apps are growing at an exponential rate. These apps are designed to monitor every aspect of an individual's health profile, from nutrition, to activity, to sleep and more. These are some of the key areas that current apps are addressing:

- **Nutrition, weight management, and obesity:** Apps that manage nutrition and weight are quickly becoming important tools in improving health-related behaviors. Among chronic conditions, obesity is one of the most concerns of actual society and it is ideal for game-based applications that can track health metrics in an engaging manner, and provide challenges and rewards.
- **Disease prevention, self-management, and adherence:** Adherence to schedules these days seems like a strong effort to many patients. This can be especially problematic if a slip in schedule affects to their health, as is the case for chronic diseases like diabetes, that requires constant testing and monitoring. Gaming based apps for monitoring and self-managing are employing a fun and rewarding strategy for children specially to ensure they stay on track with their treatment.

- **Cognitive, mental, emotional, and behavioral health**: There are many cognitive and emotional areas that can also be helped by gaming. Already existing apps can help relieving anxiety trough deep breathing exercises and ocean sounds.

4.1.2. Professional Development and training

The application of digital games for training medical professionals is on the rise. Games and simulations are more and more utilized to train healthcare professionals in methods for diagnosis, medical procedures and patient monitoring.

Technological innovations, such as virtual reality simulations and e-learning applications, have led to consistent improvement in learning outcomes, and already play a role in surgical residency training programmes. Games are useful for specific educational purposes and relevant for developing skills to medical personnel.

4.1.3. Data Analytics, Machine Learning and Artificial Intelligence

Applying new technologies and algorithms such as machine learning, patient and healthcare data information can be compiled and analyzed. Machine learning is mature enough to star accurately predicting medical event and reducing medical errors and subsequent healthcare costs. The opportunities for this technology to improve and accelerate clinical, workflow, and financial outcomes are limitless, from chronic disease prediction to reduce hospitals readmissions.

The promise on Artificial Intelligence (AI) to improve outcomes in matters of life and death is still very intriguing. While there is still much to overcome to achieve AI-dependent health care, most notably data privacy concerns and fears of mismanaged care due to machine error and lack of human oversight, there is sufficient potential that governments, tech companies, and healthcare providers are willing to invest and test out AI-powered tools and solutions.

In the very complex world of healthcare, AI tools can support human providers to provide faster service, diagnose issues and analyze data to identify trends or genetic information that would predispose someone to a particular disease. When saving minutes can mean saving lives, AI and machine learning can be transformative not only for healthcare but for every single patient.

AI-assisted robotic surgery

Robots can analyze data from pre-op medical records to guide a surgeon's instrument during surgery, which can lead to a 21% reduction in a patient's hospital stay. Robot-assisted surgery is considered "minimally invasive" so patients won't need to heal from large incisions resulting in shortest recovery times and less complications. Via artificial intelligence, robots can use data from past operations to inform new surgical techniques.

One study that involved 379 orthopedic patients found that AI-assisted robotic procedure resulted in five times fewer complications compared to surgeons operating alone. A robot was used on an eye surgery for the first time, and the most advanced surgical robot, the Da Vinci allows doctors to perform complex procedures with greater control than conventional approaches. Heart surgeons are assisted Heartlander, a miniature robot, that enters a small incision on the chest to perform mapping and therapy over the surface of the heart.

Virtual nursing assistants

From interacting with patients to directing patients to the most effective care setting, virtual nursing assistants could save the healthcare industry money and time. Since virtual nurses are available 24/7, they can answer questions, monitor patients and provide quick answers. Most applications of virtual nursing assistants today allow for more regular communication between patients and care providers between office visits to prevent hospital readmission or unnecessary hospital visits. Care Angel's virtual nurse assistant can even provide wellness checks through voice and AI.

Aid clinical judgment or diagnosis

Diagnosis AI assisted is still undoubtedly in its infancy, but there have been some exciting use cases. A Stanford University study tested an AI algorithm to detect skin cancers against dermatologists, and it performed at the level of the humans. A Danish AI software company tested its deep-learning program by having a computer eavesdrop while human dispatchers took emergency calls. The algorithm analyzed what a person says, the tone of voice and background noise and detected cardiac arrests with a 93% success rate compared to 73% for humans. Baidu Research recently announced that the results of early tests on its deep learning algorithm indicate that it can outperform humans when identifying breast cancer metastasis. Prime minister Theresa May announced an AI revolution would help the National Health Service (NHS), the UK's healthcare system, predict those in an early stage of cancer to ultimately prevent thousands of cancer-related deaths by 2033. The algorithms will examine medical records, habits and genetic information pooled from health charities, the NHS and AI.

Workflow and administrative tasks

Another way AI can impact healthcare is to automate administrative tasks. It is expected that this could mean billions in savings for the healthcare industry as machines can help doctors, nurses and other providers save time on tasks. Technology such as voice-to-text transcriptions could help order tests, prescribe medications and write chart notes. One example of using AI to support admin tasks is a partnership between the Cleveland Clinic and IBM that uses IBM’s Watson to mine big data and help physicians provide a personalized and more efficient treatment experience. One way Watson supports physicians is being able to analyze thousands of medical papers using natural language processing to inform treatment plans.

Image analysis

Actually, image analysis is very time consuming for human providers. MIT research team has developed a machine-learning algorithm that can analyze 3D scans up to 1,000 times faster than what is possible today. This near real-time assessment can provide critical input for surgeons who are operating. It is also hoped that AI can help to improve the next generation of radiology tools that don’t rely on tissue samples. Additionally, AI image analysis could support remote areas that don’t have easy access to healthcare providers and even make telemedicine more effective as patients can use their camera phones to send in pics of rashes, cuts or bruises to determine what care is necessary.

4.1.4. Simulations using Augmented Reality (AR) and Virtual Reality (VR)

Gaming know-how in Augmented reality and Virtual Reality technologies is making possible key innovations that can dramatically improve treatment for patients and more and more healthcare systems are willing to test them.

VR-based medical simulations are already in use across the medical learning community to include surgical procedures, emergency medical care, collaborative hospital incident command scenarios, and psychological issues such as PTSD, pain management, and insomnia.

In contrast to VR, the AR technology uses real live inputs to affect the user's senses through sound, video, graphics, or avatars. This technology is transforming the medical sector from providing real-time data and assistance during complicated surgical procedures, to supporting aftercare and administration. This is only the beginning of the potential benefits to health and well-being.

Both technologies have the potential to create new applications that support the training of medical professionals and the delivery of health services and improve the health outcomes of NHS users. However, they also risk displacing workers in the health sector, including public servants in the NHS.

The UK digital health system is already home to pioneering innovations in the AR and VR space. The most well-known example is the first operation to remove cancerous tissue using a VR camera, which was performed in the UK at the Royal London hospital. This allowed numerous medical students to watch the operation 'live' instead of a few students straining to catch a glimpse over a surgeon's shoulders. However, there are also a host of other examples, within the NHS and globally, of AR and VR helping improve the health outcomes of patients.

The Blue Room, an immersive VR technology, which has been developed by Newcastle University's Institute of Neuroscience, helps those with autism overcome phobias through re-creating real-world scenarios through VR (Figure 5). The technology is now being offered in the NHS.

Figure 5. Blue Room example of personalised scene created for dog fear

AR and VR technologies could also help the NHS and other health service providers make service delivery more cost-effective, particularly when training future medical professionals. For instance, they

can be used in simulation training to reduce the number of educators and trainers required, and increase the number of students who can participate in these training sessions.

In addition to helping medical professionals, there is growing evidence that suggests that these technologies empower users to monitor their health and incentivise leading a healthy lifestyle. Some mobile apps aim to combine elements of gaming and entertainment with motivation for cardio-vascular exercise like an app called *Zombies, Run!* which uses AR to simulate a race for survival from zombies. Meanwhile, in the Netherlands, an AR project – AED4EU – has been launched to help people find public defibrillators.

AR and VR have also shown promise in helping patients manage their post-stroke rehabilitation, eating disorders and obesity, and chronic pain.

4.1.5. Examples

Ayogo (https://ayogo.com/)

Ayogo company has designed an app called Empower to help these patients which have chronic conditions and must be proactive about maintaining and improving their health and overall wellness. The app helps them to develop new behavioral habits specific to their condition.

Mango Health (https://www.mangohealth.com/)

With this tool patients can actually earn monetary rewards simply for taking their medication. Remembering to take one's prescription isn't always easy when you're dealing with school, work, errands, phone calls, appointments and emails. To address this, Mango Health's app issues reminder alerts. Patients earn points every time they take their medication.

Reflexion Health (http://reflexionhealth.com/)

Reflexion Health developed a virtual instruction platform to "reimagine the physical therapy experience". In the comfort of their own home, patients can watch an animated instructor model a particular exercise on their t.v. or computer screen. Physicians can see if their patient is following through with the exercises by following their progress.

Cohero Health (https://www.coherohealth.com/)

This company developed the app called Asthma Hero to help young asthma patients to stay on schedule with their medication. The app connects to a blue tooth sensor that attaches to the inhaler with a strap. This unit communicates with the mobile app to keep track of when the medication was administered and whether or not it was taken properly. Patients or their parents can specify: the number of times the inhaler needs to be used or the number of puffs that need to be taken

Reminder notices are then issued based on these settings. Asthma Hero lets the patient choose and name their own hero character and rewards points for adherence to the treatment schedule.

Information is also stored on a cloud server. The physician is therefore able to stay informed about relevant details associated with the patient's compliance and usage of the medication.

Pact (http://static.gym-pact.com/)

Pact is an app funded by the founder of Guitar Hero. Users literally make pacts with themselves to consistently exercise and eat healthy. And they can get paid real dollars to do so. The powerful driving force of this preventative healthcare game is that they can actually lose money when they fall off track. Players specify how much money they agree to be deducted from their credit card or Paypal account for every day that is missed. This money will then go into a collective pool that issues payouts to those who do reach their goals.

Akili (https://www.akiliinteractive.com/)

Akili has designed an assessment game called Evo which mainly purpose is detecting Alzheimer's disease. The game design for Evo tests players on how well they cope with cognitive interference (distractions) which is important for functioning in real life, especially when it comes to self-care and safety. During the game, the player encounters the ipad or iphone device in order to steer an alien down a river.

Syandus (https://www.syandus.com/)

One of their applications offers simulation learning technology for patients with COPD (Chronic Obstructive Pulmonary Disease), a progress disorder where breathing becomes increasingly difficult. The dynamic visuals give a peak into specific areas of the body. And users are able to actually see what types of physiological changes happen when they make certain choices (e.g. drug therapy, smoking etc.) or expose themselves to various environmental factors. This innovative educational technology not only benefits actual patients but students of the life sciences (e.g. medical school) as well.

DIDGET Blood Glucose Meter

Bayer's Didget blood glucose meter, which connects to a Nintendo DS gaming platform, is intended for kids between 4 to 14. It helps manage their diabetes by rewarding them for consistent blood glucose testing. As points accumulate, new game levels and options unlock. There are leader boards with kids who collected the most points, web games and an online community as well.

4.2. Evolution of Gaming in Healthcare

Gamification to affect healthy outcomes already exists, but healthcare organizations have just begun to scratch the surface. They must stay abreast of technological advances to ensure that they're relevant to their customer base. Herein some recent and future developments of gaming technology that have the potential to be applied in Healthcare are:

- **Micro-Learning and Gaming**. Data collected from a variety of sources can be used to provide just-in-time training at the point of need. Instead of large training systems or cumbersome curriculum, gamified learning can be tailored and served up for each learner.
- **Transmedia and Storytelling**. The future of learning is fundamentally a story that weaves in characters, storytelling, genres, and a variety of delivery platforms. Imagine learning about the dangers of unsafe sex through a story-driven narrative that requires you to make the right decisions to keep characters healthy.
- **Gesture and Sensor Recognition**. A number of tech companies are developing gesture sensor recognition systems. For instance, they are looking to develop a dictionary of gestures which can be used to replace buttons and knobs currently used. A Japanese sensor technology company, Alps Electric, is taking this sensor technology one step further, by creating a cross between an arcade game and an appointment with a healthcare specialist. This face recognition sensors will help to monitor patients and can help to decides when to call a doctor or a nurse.

In the rapidly changing healthcare landscape, organizations aiming to stay competitive need to shift focus. The name of the game is customer engagement—knowing what healthcare consumers want, how they think, what motivates their behavior, and how best to communicate with them in a meaningful way.

Technological advances will continue to drive and evolve gamification and how it's used in healthcare. From apps to leaderboards to simulations, gaming is one certain channel that wise insurance companies will employ to reach, gain, and retain customers—and achieve healthier populations.