# Impact of AR/VR on Holistic Product Development

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**Abstract.** The increasing developments in augmented and virtual reality areas have proven vast merit in streamlining and enhancing the product development process. The near real-like visualisation coupled with the ability to make real-time experimentation opens enormous possibilities in reducing prototyping-related product development costs, creating engaging user experiences, and early detection of failure modes. Visualisation in the virtual environment also makes the product development process more holistic by allowing designers to communicate complex design ideas and create differentiated marketing strategies for target user groups. This paper studies the visualisation of a tabletop workstation in virtual reality to gain insights into user experience, predict technical errors, estimate spatial constraints, and standardise usage patterns. The study indicates that visualisation in a virtual environment holds much promise in reducing cost, the time taken in each build-test-build cycle, and capturing user experiences.

**Keywords:** virtual reality, product design, lean product design, design philosophy, product visualisation, product prototyping.

## 1 Introduction

With concepts such as user-centric design and lean product development gaining importance, designers rely heavily on user studies and evaluation combined with rapid testing of prototypes to see how they function. Also gaining momentum are concepts of creating differentiated user experiences that drive sales and build stronger brand and product resonance in target markets. Therefore, predicting the product's performance as early as possible becomes an advantage. The traditional product testing methods involved physical prototyping, testing for failure modes and technical details and testing with users in controlled environments. This lengthy process required multiple iterations in a build-test-build cycle, adding to the expense of the process for each new design cycle. [1] Identifying critical design flaws through real-time interaction with users in an immersive environment in the early design stages has vastly reduced product development expenses.

This paper studies a workstation in a virtual reality environment using the HTC Vive in a Unity environment. The workstation's performance as a holistic product has been evaluated during the early stages of the design itself, allowing the designers to finetune the products to suit the needs of their target audience best.

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## 2 Challenges in traditional prototyping and user testing

Prototyping and user testing are essential aspects of the product development process, correlating directly with a product's success in the market. However, the major drawbacks are the cost and duration of each build-test-build cycle. Another massive handicap in product testing by traditional methods is the limitations on real-time incorporation and testing of user feedback. This increases the number of iterations and repeatedly creates logistic issues involved in testing with participants.

## 3 Advantages of using augmented/ virtual environment in user testing

Virtual reality is a computer-generated three-dimensional environment that recreates the real world through computer pixels. People can interact with this simulated reality to understand a product better than two-dimensional drawings and ideas communicated through words. Augmented reality, on the other hand, superimposes the computer-generated three-dimensional effect on the real world. Users can experience a product in their environment, made immersive through the virtual image and spatial audio.

Introducing virtual and augmented reality in user testing processes creates various possibilities, such as real-time manipulation during user testing, reducing the number of build-test-build cycles. [2] This has a long-term impact on reducing the product development timeline and cost. The users can experience a product in an immersive and impressive environment that can bridge the communication gap between product owners and target customers. Designers working in interdisciplinary teams while identifying critical failure modes and technical details can sharpen the focus of product development through creative thinking paired with strategic and analytical thinking enabled through visualisation in a virtual environment.

The virtual and augmented reality environment also enhances collaboration across technical, design, sales and marketing teams by allowing them to collaborate irrespective of geographic constraint. This makes the product development process holistic and oriented towards the diverse needs of the users identified by the various teams, making product development genuinely user-centric. [3] The users can also be involved from the early stages of product development ventures, studying their interaction with the product and identifying consumer perceptions, challenges, and delights. [4] Real-time testing enables an intuitive understanding of user behaviour and needs.

User stories and product details can be validated within and between the design teams and the audience through product visualisation enabled in virtual or augmented reality spaces. Another added dimension is storytelling through product visualisation. This tool can immensely benefit the marketing and sales team to effectively deliver targeted user experiences and complex information about products beyond brochures and statistics. [5] This improves product perception and reduces the barriers to conversion, driving sales or gaining investment. [6]

## 4 Introduction to the tabletop workstation

The design tested in the virtual environment was an intelligent tabletop small office/home office solution delivered through a product-service model. It reduces the office footprint to a portable unit personalised for the user-designed for the new era of work. The three most important aspects involved in the successful design of this product were a minimum spatial requirement, adaptability to user needs and interaction with the user. The ease of assembly, disassembly, and product maintenance are other crucial aspects as the product is expected to

move across multiple users. Testing for these aspects, especially the latter two related to product lifecycle, would require more work with prototypes generated by traditional means.
Work-from-home furniture is already crowded with several products with similar offerings. Virtual reality in early consumer perception studies can help create a suite of differentiated experiences that enable differentiation from competitors, besides aiding in creating a relevant and impactful story that captures such experiences and value offerings.

**Fig. 1**. Architecture of a typical wireless sensor node.

## 5 Experimental setup in augmented reality

The CAD model of the workstation was imported in .fbx format to the Unity environment with the product modelled and rendered in Blender. From the package manager, Google Cardboard was employed for the AR experience in Android with Vulkan rendering and multi-threaded rendering disabled for speed optimisation. An app was exported from Unity for running tests on an absolute scale (1:1) and product environment (home setup).
The AR foundation package initiated an AR origin and session to track the user's position in the AR world. An AR plane manager capable of monitoring the horizontal and vertical ground planes based on the camera's image feed was assigned an empty game object. The product was made as an object to instantiate if and only if the plane manager detects a horizontal plane. A translucent plane with contrasting borders gives the user visual feedback about plane detection. The user can also move the model along the ground plane by swiping.
Animations for height adjustment (one of the user interactions with the product) were made in Blender with UV mapping for better surface texture. The animation was imported to Unity's working assets folder, where additional lighting was done in the Unity settings. The entire animation was clipped as a single animation clip and was set to perform animation as a default state. An animation trigger was set to start the animation when the player's position was less than a meter from the object. This was done with a new animation state known as idle, which remains active when the user is out of range. The table's movement happens through gas springs substantiated by spatial audio imported to the unity assets folder as a .wav file triggered at the start of the animation.

**Fig. 2.** The workstation visualised in a home setup using AR

## 6 Experimental setup in virtual reality

For testing in the VR environment, the CAD model of the workstation was imported to Unity in .fbx format and set up in a virtual VR plane.HTC VIVE was to present the VR environment to the user. The Head Mounted Device (HMD) was then integrated with the inbuilt camera's tracking and orientation. A hand gear prefab from Unity interacted with the system with the hand gears. The camera's teleportation was initiated to facilitate the player's movement. The user in the VR environment controlled the teleportation location. The below picture shows the teleportation marks and the ray casting. Tactile feedback was given to the user regarding the selection and teleportation process. Commonly used tabletop items such as laptop computer screens and coffee mugs were imported into the VR environment. All the models were made of rigid bodies using a mesh renderer. Their respective mass densities and approximate drag properties were included. All the tabletop objects were made interactable and throwable by adding separate components.

**Fig. 3**. CAD model of the workstation visualised in VR

## 7 User testing in VR environment

The case study was conducted in two parts, with an initial pilot study of 6 participants,

followed by a study with 23 participants.
The virtual environment consisted of an office with regular furniture and a designed tabletop workstation. The study was conducted with 23 participants to validate the product’s effectiveness and gain insights into the user experience. The participants were introduced to a room environment to familiarise themselves with the VR environment and gain proficiency with the controls. This phase took an average of 6 minutes per participant. The participants were introduced to the office environment, where they were assisted with the VR controls until they felt comfortable. The task was to find a comfortable sitting and standing height for use. The users were asked to check the aesthetics and experience of the features of the workstation. They could place computers, keyboards, mouse, notepads, coffee mugs and printers to arrange their workstation. A heat map was generated from the places the users touched to change the height and adjust the angle of the table. This was used to determine the placement and design of an intuitive user interface. The users were then asked to complete a questionnaire to assess the user experience based on a 7-point Likert scale. [7] The average time for filling out the questionnaire was 18 minutes.


**Fig. 4.** The workstation being tested in an office environment in VR for various metrics.

## 8 Discussion

It was observed that the users took longer to understand the product's functioning and layout in the augmented reality environment when compared to the VR environment. The interaction was more immersive in virtual reality than in the AR model. The participants took an average of 7 minutes to gain proficiency in using the HTC Vive headgear and hand mounts to interact with the objects in the scene. The average time to arrange the items was around 4 minutes. However, the experiments ran longer as the participants took an interest in experiencing the workstation from all sides and giving feedback on the product. From the above experiment,the users took snapshots of the desired position of the various products. It was concluded that the product size should be increased to allow the target product users to use two computer screens. Also, the product's height adjustment was shifted from manual to electric drive to reduce the possibility of errors and the load on the user.


**Fig. 5**. Heatmap of user interaction to move the workstation in upward movement.

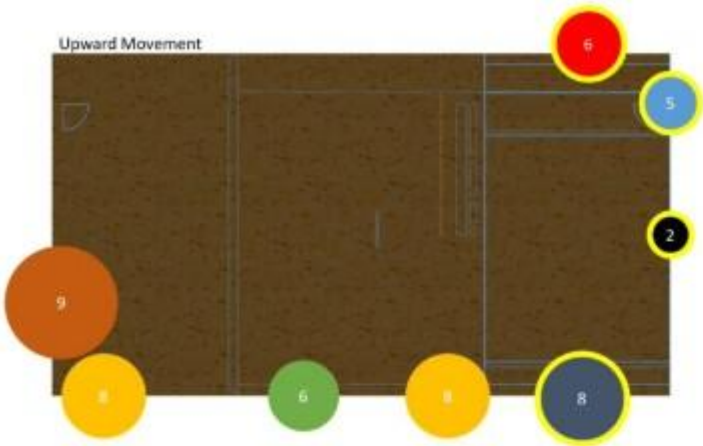


**Fig. 6**.Heatmap of user interaction to move the workstation in downward movement.

The study revealed a few erroneous designs of the tabletop that would have remained unnoticed without the virtual reality experience. For example, the tabletop's rotatable section has a high probability of collision with monitors in its proximity. To avoid this, the design was updated to include a small bump in the tabletop design that would limit the range of setting the monitor/laptop to avoid a collision. Another design element was two stationery holders (pre-designed) on the tabletop. The virtual experience revealed that two holders were optional or desirable. One of the holders needed to be moreusable after placing the objects and was removed. The CPU's ideal placement was also under debate. The experiment allowed user feedback to determinethe ideal placement of the CPU to the side. It was noted that the users needed to give more attention to the movement of the table. The action of the table happens through gas springs. Even though the gas springs were visible in the model, the users needed clarification about the model's movement. The mostvital perceptions were innovativeness and interest. Perceived reliability and comfort were identified as parameters that could be improved. The safety of objects on the workstation was another concern that required attention. Fig. 5 shows the heat map of the first intuitive contact of the hand controller to the product in the virtualenvironment. The numbers represent the number of subjects touched in the region in the upward and downward movements.

## 9 Learnings

The significant learning from the product was the virtual environment's effectiveness in testing products without spending large amounts on prototypes. It identifies errors in design and allows the evaluation of unique user experiences by immersing the users in an environment mimicking reality. Another critical aspect of user testing in the virtual environment is the ability to alter the product in real time according to user preferences without any added cost. The real power of user testing lies in the power of realistic rendering, which is only sometimes achievable in the prototyping phase. This facilitates a highly accurate user experience evaluation and makes the products more intuitive.

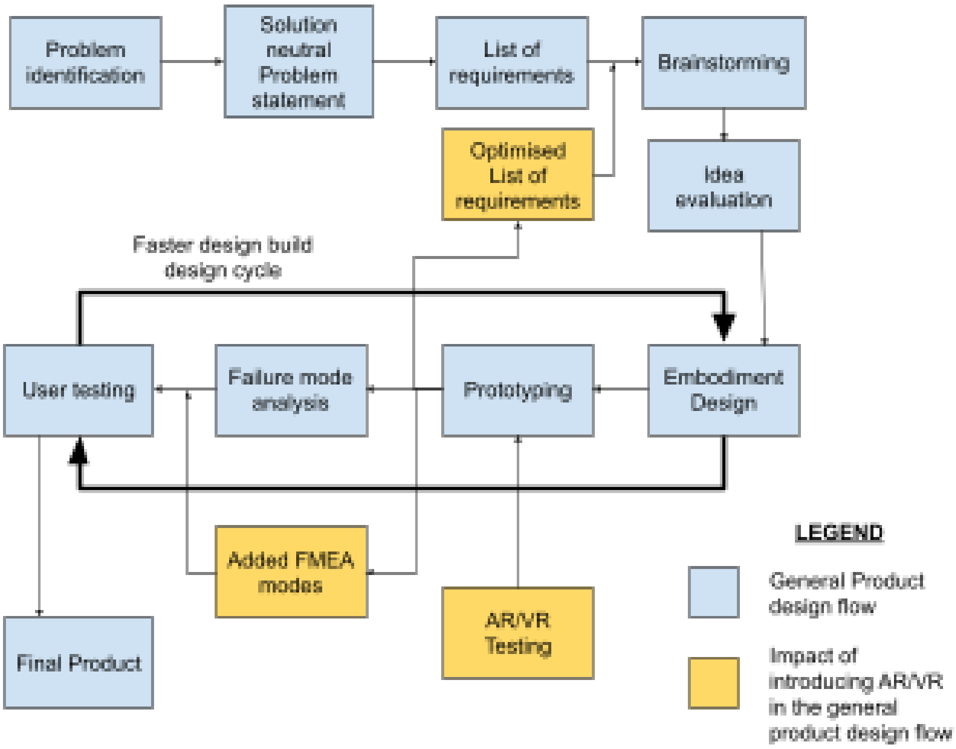


**Fig. 7**. Impact of introducing AR/VR visualisation in the general flow of product design

Besides the impactful possibilities of enhancing user experience, product visualisation in the virtual environment has significant prospects in creating engaging marketing strategies and delivering superior technical performance through finished products. [8] A fully functioning digital prototype developed for the virtual reality environment can help communicate complex ideas through innovative and immersive storytelling that reduces the barriers to purchase by allowing fully informed decision-making. The seamless visualisation can also facilitate the identification of potential technical errors and aid in crucial decision-making during product development.

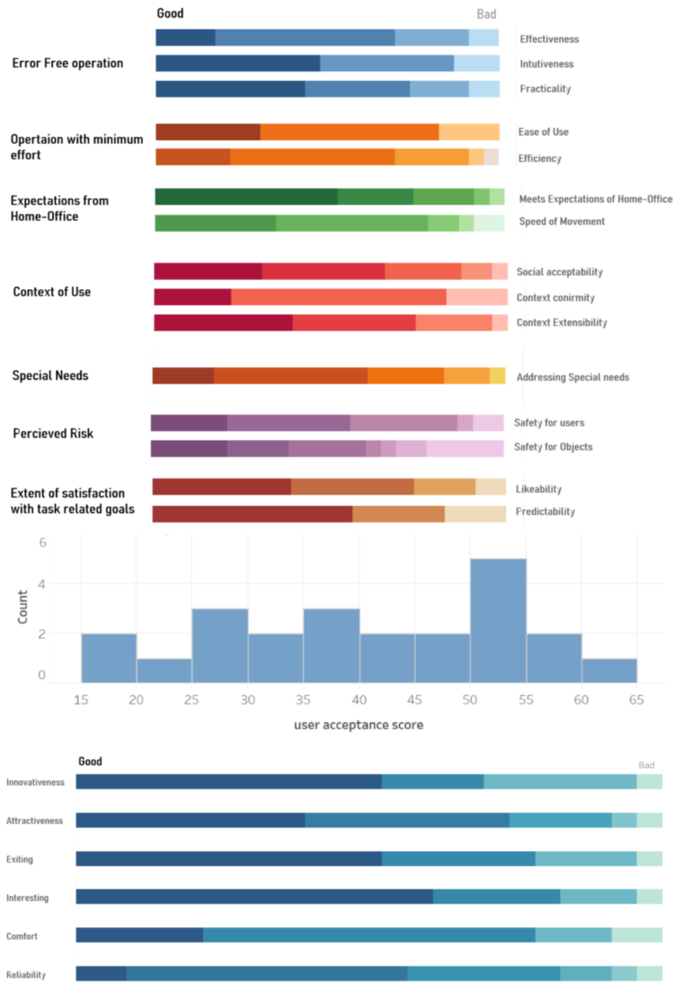


**Fig. 8**. User experience (top), user acceptance (middle) & user perception (bottom) of the workstation derived based on the experimentation in VR environment

# 10 Conclusion

Real-time visualisation is potentially a massive driver in designing user experiences and selecting design trade-offs. Clients can reduce the risk of financing design projects by enjoying the real-time experience of interacting with products and getting a feel for the form, proportions, and relationships with the context. AR and VR technologies also promise to collaborate with designers and cross-functional design teams across geographies, especially relevant in a post-pandemic world. [1]

The design changes made to the product were crucial in the product's overall functioning without any added cost in the different testing cycles. Early and immersive visualisation helped make these vital decisions to increase the product's table size and electric drive. The study also gave a broad view of the weight distribution of the tables. The products arranged by the users sensitised us to the change in taste for the people when it comes to organising items on the worktable.

Valuable insights into user experiences captured in the study open doors to an essential aspect of design as products become increasingly human-centric and companies strive to balance products' functionality with desirable user experiences. This can motivate purchase decisions by allowing users to make a more informed decision by accurately visualising the product's size, design, and functionality in their space. [9]

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## References

[1] Holtorf, J.: "Jabil." Available: https://www.jabil.com/blog/augmented-reality-in-product-design.html.
[2] B2B Marketing: "Six examples of VR and AR." London, (2017).
[3] Şahin, D. & A. T.: "Augmented reality applications in product design process." Global Journal on Humanities and Social Sciences, (2016).
[4] Stumpp, S. M. T. K.: "User Experience Design With Augmented Reality (AR)." Presented at the 14th European Conference on Innovation and Entrepreneurship, Greece, (2019).
[5] Poushneh, A. V.-P. A.: "Discernible impact of augmented reality on retail customer's experience, satisfaction, and willingness to buy." Journal of Retailing and Consumer Services, Vol. 34, pp. 229-234, (2017).
[6] Ozturkcan, S.: "Service innovation: Using augmented reality in the IKEA Place." Journal of Information Technology Teaching Cases, Vol. 1 (2020).
[7] Wechsung, A. B. N. & I.: "Developing Usability Methods for Multimodal Systems: The Use of Subjective and Objective." Presented at the Institute of Research in Informatics of Toulouse, Reykjavik, Iceland, (2008).
[8] Cehovin, B. R. & Cehovin, F.: "The Impact of Augmented Reality." Copenhagen: Copenhagen Business School, (2017).
[9] Hsu, J. K., & Fiore, H.-H. L. Ann Marie.: "Effect of image interactivity technology on consumer responses toward the online retailer." Journal of Interactive Marketing, Vol. 19, pp. 38-53, (2005).