Design Research Papers[1]

Design Principles for Mixed Reality Retail Product Configuration Interfaces

Mixed reality (MR) technology provides consumers with innovative means of purchasing in retail environments, and the integration of MR with product customisation enables potential benefits for personalised shopping and the uniqueness of experiences. This study proposes designing a Mixed Reality Product Configurator (MRPC) for head-mounted displays, aiming to provide systematic MR configuration interface design principles for commercial applications. The empirical study collected feedback on the MRPC from 64 participants through a mimic retail environment experiment using a mixed methods approach by conducting interviews and questionnaires. The design principle identifies thirteen design elements: parametricity, informativeness, comfort, comparability, contextual, intuitiveness, beyond reality value, interactivity, predictability, conciseness, accuracy, visual aesthetics and environmental compatibility. These principles represent five dimensions that need to be focused on for commercial MR customisation system design: functionality, user experience, visual aesthetics, affective engagement, and user comfort.

Keywords: mixed reality, consumer experience, user interface, retail, research through design

Introduction

Retail innovation technologies provide retailers with a competitive advantage in creating diverse product displays and customer experiences (Inman and Nikolova 2017). Mixed reality (MR) technology improves the customer experience by bringing shopping

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experience enjoyment to the consumer (Dehghani, Lee, and Mashatan 2020; Meegahapola and Perera 2017), increasing customer engagement (Jessen et al. 2020; Wang 2020), shopping satisfaction (Grewal et al. 2020), and brand sentiment (McLean and Wilson 2019). To fully harness MR's potential in retail, retailers should create a seamless customer experience where user interface (UI) and user experience (UX) play crucial roles in enhancing satisfaction.

Mixed reality has various definitions in different contexts (Speicher, Hall, and Nebeling 2019). In this study, mixed reality refers to immersive augmented reality (iAR), which uses wearable head-mounted displays (HMDs) to overlay virtual content in the real world. This technology aligns with natural shopping behaviours, allowing users to explore products hands-free without AR smart devices or VR controllers. While the high cost of MR HMDs is a deterrent to consumers, it presents an opportunity for retailers to re-engage customers in physical stores to drive revenue and retention.

However, using MR technology in brick-and-mortar stores is a significant ongoing challenge, such as the limitations of the physical environment for MR headset implementation (Jain and Werth 2019). MR has some apprehensions and drawbacks regarding bystander privacy (Corbett et al. 2024), social awkwardness, HMD discomfort, and injury concerns (Thomas and Holmquist 2021). More specifically, the fatigue and pain from heavy equipment, eye strain, and privacy and comfort of using the equipment affect the duration of use (Jain et al. 2021; Thomas and Holmquist 2021). Encouraging consumers to spend more time browsing merchandise and extending the online dwell time of users can be conducive to business growth (Kao et al. 2021). Addressing these challenges through ergonomic UI design (Koreng and Krömker 2021) and commercial layouts tailored to retail spaces are essential to improving user comfort and reducing inefficiencies.

Configurators, also known as parametric configurators or customer innovation toolkits, are a mass customisation interface for customers to design and develop their products (Thomke and Hippel 2002). It is based on customers' ability to design their products (Hippel 1988). Customisation provides the environment that involves consumers to engage in the design process and provides the satisfaction of purchase. The configurators allow for trial-and-error experimentation and feedback on the simulation results. Consumers can iterate on their preferences until they achieve an optimal design (von Hippel and Katz 2002). Configurators are more attractive to highly knowledgeable consumers, who may consider increasing their knowledge and information inflow (Stremersch et al. 2003). Consumers are prepared to pay a substantial premium for configured products, especially if they positively perceive the configuration process (Franke and Piller 2004). While customisation enhances product utility by better satisfying individual needs, its effectiveness diminishes if the process is perceived as overly complex (Stremersch et al. 2003). Despite the potential of MR in retail, there is a lack of design recommendations to aid UI designers in conceptualising 3D configurators, particularly those without direct access to MR HMDs. This gap increases the need for iterative user testing and prolonged communication cycles between UI designers and software engineers, slowing the design and implementation process.

Consumer preferences further highlight MR's potential, such as jewellery customisation (Jin, Dalton, and Fagan 2023). Fine jewellery, as a high-value product, aligns well with current retail industry strategies when considering return on investment (ROI) (Egaji et al. 2019; Rantala, Colley, and Häkkilä 2018). Despite the rise of e-commerce, brick-and-mortar stores remain pivotal in high-value markets, as consumers often perceive in-person purchases as more reliable and trustworthy (McKinsey &

Company 2014). MR technology can revitalise physical stores by enriching both utilitarian and hedonic values and strengthening consumer confidence and satisfaction (Alzayat and Lee 2021). However, design methods for brick-and-mortar shops using MR mass customisation interfaces have not been explored.

To address this, the study employs a research-through-design (RtD) and mixed methods approach. It creates a generalisable and heuristic MR commercial UI principle for brick-and-mortar store adoption by developing a commercial MR product configurator, using jewellery retail as a pilot industry. This study contributes to MR UI and UX design and human-computer interaction in commerce. Existing MR mass customisation has less discussion, with systems developed for prosthetic customisation in healthcare (Górski et al. 2023) and luxury bag customisation using VR (Altarteer et al. 2013). There is a notable gap in the literature regarding MR configurator design for commercial environments, which require distinct considerations compared to healthcare, education, or construction applications (Höllerer et al. 2001; Silva et al. 2024). Existing MR retail studies primarily explore second-hand record stores (Xi et al. 2024) and a grocery shopping assistant system (Jain et al. 2021), which are unable to predict adoption in mid-high-value markets and lack contextualisation. This study expands MR experience applicability in brick-and-mortar retail stores, extends its implementation to mid-to-high-end products, forecasts consumer acceptance, and provides MR configurator UI design principles, enhancing confidence in MR's market potential. Finally, the MR UI design principles are presented as a set of graphic card toolkits intended to support UI designers in their design processes.

The paper is structured as follows: Section two explains the hypothesis development related to consumer technology acceptance. Section three describes the methodology, followed by the results, discussion, conclusion, and limitations.

Theoretical Framework

While the technology acceptance model (TAM) is commonly used to capture the cognitive, affective, and attitude responses towards new technology, such as MR technology (Davis 1989). Building on TAM, we explain the hypothesis design of the extended survey (Figure 1).

[Insert Figure 1 here]

Figure 1 MR mass customisation retail acceptance hypothesis model

Perceived User Interface Design

MR UI is a medium that helps customers experience virtual content and provides users the ability to navigate products and sensory experiences. Previous studies have found that interface style has a positive effect on perceived enjoyment (Wojciechowski and Cellary 2013). Perceived user interface design (PUID) has a positive impact on perceived usefulness (PU) and ease of use (PEU) (Cho, Cheng, and Lai 2009). This study proposes that consumers positively perceive that interface design could contribute to positive enjoyment attitudes and thus contribute to positive attitudes towards use (ATU). Therefore, the hypotheses are:

H1. PUID has a direct significant positive influence on ATU.

H2. PUID has a direct significant positive influence on PEU and PU.

Perceived Usefulness and Perceived Ease of Use

Consumer mindsets such as perceptions, associations, attitudes, attachments, and activities are key drivers of brand performance, price premium, price elasticity, market share, and expansion success (Keller and Lehmann 2003). Perceived usefulness and ease of use aim to evaluate the improvement of adopting MR to purchase and onboarding difficulties. PU and PEU positively affect shopper engagement, and engagement has a positive influence on ATU (Recalde, Jai, and Jones 2024). When users perceive that using a technology requires low effort, they are more willing to adopt it and perceive the system as more useful (Huang and Liao 2015; Kim and Forsythe 2008; Venkatesh and Davis 1996). The purpose of MR retail is to increase consumer purchase intention (PI) and facilitate decision-making. Therefore, this study believes that PU and PEU could lead to changes in consumer attitudes towards the use of an MRPC. When consumers perceive an MRPC as useful and easy to use for purchasing, they may increase their intention to use it.

H3. PU and PEU have a direct significant positive influence on ATU.

H4. PU and PEU have a direct significant positive influence on PI.

Attitude Towards Using

When confronted with the launch of innovative technologies, shoppers are expected to embrace, learn, and master technology to engage in experiences and to create experiences. Accordingly, the degree of commitment to learning, customer dynamics, and customer engagement drives consumer behaviour and intention to adopt innovative technology in retail environments (Foroudi et al. 2018). TAM theory indicated a significant association between ATU and user behaviour (Davis 1989). Consumers' attitudes towards using AR significantly impact their purchase intentions or behaviour intent to use (BIU) for technology applications (Jiang, Wang, and Yuen 2021). PUID is predicted to influence ATU and is therefore used as a control variable.

H5. ATU has a significant positive influence on PI, BIU, controlling PUID.

Behavioural Intent to Use and Purchase Intent

TAM model stated that PEU positively influences PU (Davis 1989), and PU has a positive impact on consumers' BIU on mobile AR (Oyman, Bal, and Ozer 2022). PU is a significant factor influencing decision-making and judgement in consumer purchase behaviour and the innovative technology used. Decision-making and judgement are influenced by two paths that are rational processes primarily concerned with making consistent choices, while the other process results from intuition or is based on rapidly occurring emotional responses (Kahneman 2003; Slovic et al. 2005). Therefore, the design incorporates utility functionality and hedonistic elements of stimulus emotions to balance UX. Users' prior experience also affects their PEU on MR and impacts customers' judgment in using a new technology (Obermeier et al. 2021). In light of the above statement that consumer perceptions play an important role in determining technology usage behaviour and purchasing behaviour, it is crucial for retailers to assess potential shifts in consumer behaviour before implementing MR on a mass scale. Therefore, the following hypotheses are proposed:

H6. PEU has a significant positive influence on PU and BIU, controlling for PUID.

H7. PU has a significant positive influence on BIU, controlling PEU and ATU.

H8. PI and BIU have a significant positive influence on each other, controlling PU and PEU.

Methodology

Research Questions

The research question that will be addressed is: How to design mixed reality product customisation user interfaces for use in brick-and-mortar retail environments? To address the question, the theoretical framework follows the guide from the Design Science Research Methodology (DSRM) in six stages of the nominal process sequence to help design the information system (Peffers et al. 2007). The research procedure for designing the MRPC application involved identifying the problem, defining the solution through market research (Jin, Dalton, and Fagan 2023), and inviting stakeholders to participate in the design development and iterative process (Jin 2025). This study conducts hands-on user experience to evaluate design, predict consumer behaviours, and propose design recommendations.

System Design and Development

To implement the Mixed Reality Product Configurator (MRPC), the software used Unity 2019.4.1.8f1, Visual Studio 2019 Community Edition, Mixed Reality Toolkit 2.6.1 (MRTK), and hardware used Microsoft HoloLens 2.

Product Configuration Parameters and Commercial Function Design

The MRPC involves customisation, assembly, and learning to make platforms. The fundamental requirements are extracted from the existing e-commerce and online configurator platforms and refined, and new experiential features are built. Customisation parameters: Materials (n=4), Gemstones (shape and colour) (n=10), Engraving (n1≤4/n2=2), Size (n=12), Shape (ring mount textures and adding extra stones) (n1=4/n2≤2), Gift packaging (n=4). Figure 2 shows screen captures of the functions of MRPC. Table 1 illustrates the MRPC design features.

[Insert Figure 2 here]

Figure 2 a) Compare packaging; b) Compare customisation products; c) Virtual fitting; d) Changing material with visual aid; e) Stone parameter platform; f) Hand menu

[Insert Table 1 here]

Table 1 Function design, characteristics and requirements

Ergonomic Design of Mixed Reality User Interface

The UIs contain four panels demonstrating the above features. Before creating the 3D interface in Unity, MR rapid paper prototype iterations help to identify the system usability issues and user requirements for interface design and product design (Jin and Fagan 2024). The ergonomic MR UI design is derived through three rounds of paper prototyping iterations (Figure 3).

[Insert Figure 3 here]

Figure 3 MRPC UI design dimensions, angles, and distances

A distance of 630-800 mm from the user interface to the horizontal line of sight. To fulfil the needs of the majority of users, the measurement is based on the average height of an adult male (Europe), which is 183 cm, with an arm span of 1600 mm, a single-side of 800mm (Le Corbusier 2000). Considering the 4:3 optical field of view of HoloLens 2 and viewing a screen below 500 mm is prone to near-vision fatigue (Rempel et al. 2007). The ergonomic eye-to-screen distance is 500-990 mm, whereas the average is between 630 mm and 740 mm (Jaschinski 2002; Jaschinski-Kruza 1991). Hence, a comfortable range for use modes that accommodate tangible and remote rays is 630-800 mm. To gain a wider field of view, the multi-interface design for HoloLens 2 is recommended to be 800 mm from eye to interface.

The overall length of the interfaces is less than 1600 mm and less than 800 mm unilaterally, with eyes as the centre point. Based on the average arm span (used 183 cm height), this is compatible with users being able to reach the interface with one outstretched arm (Neufert 1970). The MRPC has an overall length of 1026 mm, which is an adaptable dimension. Although larger display users perform better at completing spatial tasks (Tan et al. 2003), the longer the length, the more space it needs to occupy. Therefore, the interface length can be reasonably trimmed down if space is limited.

The interface position of height should be at the horizontal line of sight of users. The interface position of width is within 90° of the user's horizontal line of sight on each side. Ergonomic studies recommend that the screen be 5°-25° lower than the horizontal line of sight (HLS) when viewing the screen with the naked eye, considering eye comfort, neck comfort, and user preference (Allie, Purvis, and Kokot 2005). The optimum vertical line of sight angles are +25° to -30° (Kress 2020). A physiological aspect of proposing force to the cervical spine from flexion, neck load is 10-12 lbs on HLS (0°), and lower neck flexion to 15° is 27 lbs, and the more head angle, the more cervical spine pressure (Tanaka, Patel, and Murthy 2020). Therefore, considering the additional weight of the HMD that the user's cervical spine needs to sustain, the vertical field of view (FOV) of interfaces is set to HLS (0°), the interface length within angles of +25° to -30°. Limited literature discusses the angle setting in multiple screens in horizontal FOV. Other studies suggest that the human immediate field of view is within 60° on each side of the HLS, and the natural neck rotation angle is within 90° (Denker 2016). In light of these theories, the interface angles of 35°, 40°, and 45° were tested, and a 40° angle was set as horizontal FOV.

Reserve one side space for retail assistants. In a standard retail environment, consumers may require in-store retail assistant service during use. The agent could stand in the reserved position to minimise interference with the user during the service.

Research Design

This study utilised a mixed methods approach, including semi-structured interviews and questionnaires. Using multiple tools strengthens conceptual connections, reduces researcher bias in interpreting qualitative results, and develops more comprehensive findings, increasing confidence in the results (Berg 2009).

Interview Design

The semi-structured interview questions include: 1) Please describe three advantages and disadvantages of using this application towards its UI design, experience, functionality, and comfort. 2) Based on the mockup environment, what would make you consider using this app in real retail shops (most important and least important)? 3) Do you have anything else you would like to experience to improve this system?

Questionnaire Design

The questionnaire design includes six dimensions: perceived usefulness (5 items), perceived ease of use (4 items), perceived user interface design (4 items), attitude towards using (2 items), behavioural intent to use (MR technology) (3 items), and purchase intent (to purchase merchandise) (4 items). The sample question per construct, for example, PU: “If I want to buy jewellery, I could accomplish just what I might need with the MR Jewellery Configurator app in a mixed reality headset”. PEU: “Using the MR Jewellery Configurator app is clear and understandable”. PUID: “The layout of the MR Jewellery Configurator app is user-friendly”. ATU: “In my opinion, using the MR Jewellery Configurator app with mixed reality headsets in a brick-and-mortar retail store is a good idea”. BIU: “I will use the mixed reality headset to purchase products in the future”. PI: “Based on my experience of this experiment, shopping with MR inside a real retail store would make me more likely to purchase a product” (see also Appendix A). To ensure item validity, the questions were adapted from previously validated instruments in the literature and modified to fit the context of this study, maintaining their original structure to enhance conceptual validity. All items were measured using a 5-point Likert scale: 1: strongly disagree, 3: neutral, 5: strongly agree. In addition, demographic questions were incorporated into the questionnaire.

Data Collection and Demographics

The research was conducted in a laboratory environment at a university in the United Kingdom for 14 consecutive days from March to April 2024. Participants were recruited through posters, emails, snowballing, and social media. The subject demographics consisted of 64 samples, including 26 females and 38 males, nationalities from 11 countries. The age bands are 18-25 with 23 subjects, 26-35 with 36 subjects, and 36-55 with 5 subjects. The age mean approximation is 27.46. Of 64 subjects, 2 participants have prior experience. Participants received a £5 voucher as compensation. The study was approved by the University's Ethics Committee, and participants signed a consent form prior to the experiment.

[Insert Figure 4 here]

Figure 4 External recordings of participants' behaviour in comparing virtual and physical products (left). Participants' perspective in HMD (right).

Participants who interact with the MRPC without time restrictions and tasks to mock up a natural retail setting (Venkatesh et al. 2017) (Figure 4). All of them completed the MRPC experience within 15 minutes. After the experience was completed, a questionnaire of approximately 7 minutes and an interview of approximately 30-40 minutes were conducted.

Data Processing and Analysis

The questionnaires were processed for consistency and imported into IBM SPSS software for statistical analysis. Reliability and validity are terms of the quality of this study that were used to evaluate the validity of the proposed TAM model to measure consumer acceptance of MR technology. All subscales showed good or higher alpha values (α=0.69-0.86), suggesting the measurement items have good reliability or internal consistency (see Appendix A). The exploratory factor analysis (EFA) was performed, and Kaiser-Meyer-Olkin (KMO) factor analysis and Bartlett's test were performed for validity validation (Dziuban and Shirkey 1974). The KMO value was 0.850, which supports sampling adequacy, and reflects the validity well laterally, and Bartlett's test of sphericity $p < 0.001$. The cumulative variance explained was 72.769%, indicating that the six factors extracted explained most of the variance in the question items. The degree of commonality of each question item was above 0.5, indicating that the factors well explained the items. The absolute value of the standardised loading coefficients at each measurement relationship is greater than 0.6 and shows significance, implying a good measurement relationship. The confirmatory factor analysis (CFA) was conducted, with standardised factor loading coefficients between 0.624 to 0.869, indicating a strong measurement relationship. Construct reliability values for all six factors ranged from 0.720 to 0.866, supporting composite reliability and convergent validity. The questionnaire data were analysed using least squares linear regression, hierarchical linear regression, and Pearson correlation.

The interview data were imported into NVivo software for thematic analysis. Through random sampling, 24 subjects out of 64 were used for thematic analysis, and six samples were randomly reserved from the remaining samples for the saturation test (Guest, Bunce, and Johnson 2006). Studies suggest that every six participants are supposed to test for theoretical saturation, and that the sample size should be a multiple of six (Creswell 2013; Guest, Bunce, and Johnson 2006). The data collection and coding were conducted by a single researcher, and took measurement of data triangulation, where interview transcripts, internal video, external video, and questionnaires were collectively used for evaluating the MRPC experience. The findings are derived directly from the raw data to avoid researcher bias, and a codebook has been retested to ensure the coder's own consistency over time. The coding procedures included four steps: 1) Transcribing all the qualitative data, per participant generated from 9-24 pages of transcripts. 2) The data were analysed by structured three-hierarchy coding, including concepts, subcategories, and themes (Glaser and Strauss 1999). 3) Constant comparisons were made with the content to find similarities and differences in the data and inductive themes. 4) The reserved samples were not found to generate new concepts, and codes were repeated, and themes were considered saturated (Glaser and Strauss 1999).

Results

Qualitative Results: Mixed Reality Product Configurator Design Evaluation

There are 101 initial concepts, 12 subcategories, and 3 theme categories generated for MRPC. The three thematic categories were advantages, improvements, and new design features.

MRPC Advantages. The themes include four aspects, which are fulfilling functional demands (46.58%), experience optimisation (26.03%), UI comfort (20.55%), and providing affective value (6.85%). MRPC comfort was commonly cited as not requiring improvement, with the main complaint being the heavy weight of the device after prolonged use (4.10%). Affective value is experienced from social escape, product satisfaction, and interactivity, each at 1.37%, and positive sentiment (5.40%). Experience optimisation shows advantages such as novelty and multisensory immersive, each at 4.11%, fun (2.74%), and convenience (1.37%). Self-sufficiency (4.11%) and freedom of fitting (5.48%) are additional advantages that MRPC delivers because of mass customisation.

A user indicated that the MRPC enables self-sufficiency in the shopping process:

> "I don't have to go and talk to sales as often, even if it has a feature for this kind of advice, even I can get away with not having to ask the sales for too much advice." (P22)

One user described the convenience of operating customisation themselves, which leads to more satisfaction with products:

> "And compared to you letting the sales express your ideas, talk to the sales to operate, certainly is not as good as you directly is to use this app with this thing to customise your own [...] you don't know what he will eventually present to you if he presented you are not satisfied with, to repeatedly change may not be very convenient." (P46)

Another advantage is that the user perceived it as offering the convenience of freedom of fitting products in stores:

> "For example, this jewellery with this dress, what is the look, because I definitely want to match jewellery with the clothes, I think it's also the physical shop is very difficult to give me, because I can't change 20 sets of clothes in a row in someone's shop to try this jewellery." (P3)

MRPC Improvement. This mainly reports on UI design aesthetics (54.1%), downsides of the hardware (24.59%), and functional improvements to the system (8.2%), user experience that needs to be optimised in conjunction with the physical shop experience (6.56%), and physiological comfort, including fatigue and vertigo, should be improved (6.56%). UI design aesthetics mostly come from the app style, and graphics should align with a brand. Therefore, it is suggested that UI designers add brand elements to match the app design. The functional features could be improved by: material – it is suggested to improve the realism of textures closer to actual products, such as features of gloss and colour differences. In terms of size, it is suggested to have a function of product automatic detection and adsorption to user body and offering size recommendations. Pin button – partial users report that it causes vertigo, improves the transparency of UI during movement, or eliminates this feature. Sound aids – Audio could be provided for product information. The special effect recommendation function is combined with the special effect cartoon avatar. One user mentioned that the dim ambient light caused eye fatigue, and two users reported vertigo.

MRPC New Design Features. Users suggest that the in-store experience, the environment, and the MRPC app are inseparable and form a holistic service experience (22.22%). Moreover, users derived extended opinions (11.11%) about familiarity, learning costs, and a sense of tangibility. A participant stated that the MR interaction format is unfamiliar to the public, due to its different sense of tangibility from graphic interfaces:

> "Its (MR) interaction and 2D (online) is definitely not the same. Another is that visual is not the same. One is you click the mouse, and this, you are directly reaching out or this way-pinch [...]. It is a plane, and then your mouse moves because this is a habit. But if you say into VR (MR), their feeling of interaction will be stronger, but the second point is that they are not familiar with it, and for the aiming of this thing may be the technology is not there yet." (P14)

Participants suggested some additional new requirements for use (66.67%): *Assembly parameters (14.81%)* – add parameter bars to assembly platforms to help users change parameters such as edge radius, thickness, etc. *Outfit scene (11.11%)* – when a user tries on a product, be able to try on other products simultaneously (such as apparel, footwear). *Recommendation (7.41%)* – it is suggested to offer a complete package of outfit matching and usage scenario suggestions based on the user's product choice. *Size fitting (7.41%)* – it should be able to measure finger size. *Automatic* *information recognition (3.7%)* – add the function of identifying physical products and providing information. *Automatic window folding (3.7%)* – the interface should shrink automatically or with a tap when some windows are not in use. *Drawing scan* (3.7%) – scanning of hand drawings, uploading, and parameter modifications to provide a fully bespoke product. *Payment (3.7%)* – there is a need for a quick and fun MR payment experience, such as app-independent payments or a combination of apps and a till.

Qualitative coding concepts and subcategory characteristics are further inductively processed into universal characteristics to generate replicable design principles. These design principles can be used in developing similar MRPC systems and function as a checklist for evaluation. They outline the essential design features needed for a general commercial configurator and address five attribute aspects of user requirements that must be considered during the design process, including function demand (FD) (69.2%), experience demand (ED) (53.9%), visual demand (VD) (38.5%), affective demand (AD) (23.1%), comfort demand (CD) (7.7%) (**Error! Reference source not found.**). These design principles will be further elaborated in the discussion.

[Insert Table 2 here]

Table 2 Design principles source of code

Quantitative Results: User Acceptance of Mixed Reality Product Configurator

Most of the independent and dependent variables of hypotheses are correlated with each other in Pearson correlation, while H2b is not valid. H3b and H4b ($p>0.05$) remain hypotheses that have statistically significant relationships ($p<0.05$) (Appendix B). Figure 5 summarises the hierarchical regression coefficients for the hypotheses. The calculated effect size $f^2 = 0.135$ ($\alpha=0.05$, power=0.9) is close to medium, which suggests a moderate influence, significant predictive power, and practical significance.

[Insert Figure 5 here]

Figure 5 Mixed reality mass customisation retail acceptance model

The quantitative result indicates that the more well-designed the UI on the application, the more positive the attitude towards its use (H1). UI design consists of three aspects: visual user-friendliness of the layout (PUID1), clarity of navigation (PUID2), and clarity of the UI hierarchical structure (PUID3). Ease of use of technology correlates with user attitudes towards use but barely impacts attitudes towards use. Usefulness, on the other hand, affects changes in user attitudes and purchase intention (H3, H4). Using the MRPC app to complete a customised product purchase enabled users to have a sense of usefulness, which includes the fulfilment of purchase demands (PU1), increased purchase efficiency (PU2), enhanced decision-making ability (PU3), and the satisfaction of expectations from the customised functionality (PU4). The more positive the attitude towards using the MRPC app, the more it will increase the behaviour of the consumer to use it and increase the consumer purchase intent (H5). When users perceive using this MRPC in the shop as easy, it will positively influence their affective and behaviour (H6). Coupled with the results of H4, ease of use will not cause an uplift in intention to buy, but it will cause consumers to perceive in-store use of the HMD and system as useful for purchasing behaviours and will be reflected in an increase in system access behaviours. Prospective consumers who judge MR purchases as easy to use and useful tend to browse and purchase using an HMD (H7). Equally, users who intend to use the MR configurator augment the tendency to purchase products (H8).

The findings of user acceptance show that approximately 78.1% (n=64) of users showed optimism about using MR to purchase in the future, and 60.9% are likely to commit to practical engagement when operating in the MR retail marketplace in the future. 71.9% of consumers intend to use MR and the MRPC app to complete purchase missions. 59.4% believe that this innovative retail approach is practical and that its usefulness directly positively contributes to boosting consumer purchase intent. Moreover, while ease of use of technology has a positive impact on user usage behaviour (β=0.498), usefulness has a relatively more significant impact on consumers both in terms of attitude (β=0.792) and behaviour (β=0.613, 0.509). In other words, technological obstacles to use (β=0.211) are less critical compared to consumer cognition of the purchase task from a utilitarian viewpoint (β=0.613), since usefulness is almost 3.4 times more influential on purchase intent than ease of use. 62.5% of users found the MRPC easy to use, and 6.3% found it challenging. Users' behaviour of browsing with MR in a physical shop drives their purchase intent (β=0.673), and purchase intent also drives users to experience the MR HMDs (β=0.806).

Discussion

The study interprets the reasons for customers' intent to use MR for purchase (see MRPC Advantages). From a pragmatic perspective, the MRPC app still needs to enhance its practicality by optimising the app based on refining the existing MRPC and adding new design features (see Qualitative Results). Notably, the study found that technical ease of use is not a primary factor influencing users in making purchase decisions with these types of commercial, purchase-oriented apps. This could limit the explanation of fully experience-oriented apps. Increasing the frequency of users' MR adoption behaviours can be considered a means to augment consumer purchase motivation. UI design demonstrates its potential value in driving positive attitudes to facilitate user retention. Similar to prior studies, improving practical application features is a key factor in customers' decisions to use the MR (Zimmermann et al. 2023). A study also highlights the importance of hedonic and pragmatic motivations in MR-based retail (Alzayat and Lee 2021). In contrast to previous studies, this study found statistically significant differences in in-store purchase intention (Zimmermann et al. 2023) and statistically significant differences in UI design and attitude towards use. Considering their study lacked planning in terms of UI design, this study emphasises the importance of the designer's role in enhancing the competitiveness of MR retail.

The replication of quantitative results with the qualitative findings validates the validity and reliability of the interpretation of the qualitative data. Thirteen design principles are interpreted below by inducting the findings.

(1) **Parametricity.** The system offers customisation through various parameterisation options. The design should carefully consider the number of parameters available, the method of presenting these options (such as parameter bars or buttons), and the inclusion of detailed information and clear instructions for each parameter.

(2) **Informativeness.** The system should be a comprehensive and informative display (Höllerer et al. 2001). The UI design should ensure a clear layout and logical structure and highlight information (such as pricing and labelling). It should provide instant, customisable design effects and detailed 3D product presentations. Important information should be available in audio aids to improve accessibility. Features of physical product identification and personalised recommendations can help deliver a utility and responsive experience for consumers.

(3) **Comfort.** The system design should integrate software and hardware comfort. Software considerations include interface height, width, and distance to users to reduce neck, arm, lumbar, and eye fatigue. To minimise vertigo caused by system mobility, designers should use dynamic UIs cautiously, incorporating

UI’s transparency or teleportation function to minimise the interface from swaying within the user’s sightline.

(4) **Comparability.** The system should provide a function of comparing self-designed products to aid decision-making. Limit the quantities of comparison to reduce the difficulty in decision-making.

(5) **Contextual.** The system enhances value by contextualising usage scenarios, such as matching products with items from other categories and demonstrating product use context. Additionally, the UI style should align with brand identity and in-store interior style for consistent contextual integration. The system enhances value by contextualising usage scenarios, such as matching products with items from other categories and demonstrating product use context. Additionally, the UI style should align with brand identity and in-store interior style for consistent contextual integration.

(6) **Intuitiveness.** The system should present information in a way that is easy to visualise, minimising the user’s need to imagine (Nielsen 1994). Using colour and highlighting can effectively differentiate functional areas and clarify where users are within the hierarchy. High-priority interfaces should be placed within the user’s primary field of view, while less essential elements should be positioned in the periphery. Customised products should be prominently displayed in the central field of vision to ensure consumers easily notice them.

(7) **Beyond reality value.** The system should offer users experiences beyond what is possible in reality by incorporating emotional value through special effects, gamification elements, and immersive multisensory experiences. Provide self-sufficiency, freedom of fitting, mobility, 3D customisation, virtual fitting, contextualised recommendation and convenience of experience options for those

who avoid social interaction through configurator customisation and try-on and contextualised recommendation features. By offering a range of adjustable parameters, the system helps to reduce resource waste for retail shops, such as displaying more products in less space and minimising user returns due to dissatisfaction.

(8) **Interactivity.** The system should add appropriate interactions and compensate for tactile deficits, but not over-attract attention. Increase fun by combining additional features (namely, virtual customer service, system recommendations, and video) with gamification elements.

(9) **Predictability.** The UI design arrangement and progression relationships should be consistent with the regularity of general practice (Ko, Chang, and Ji 2013). It can be aided by sound to allow the customers to anticipate upcoming actions through a real-time UI response.

(10) **Conciseness.** Keep the system design and functionality pure and simple, and do not provide excessive features (Nielsen 1994). Always remind yourself of the ultimate intention of the system and try to avoid adding too many features to distract users. Collapse or minimise interfaces that are not currently needed and allow users to get the maximum effect with the least effort.

(11) **Accuracy.** The effect of the product should closely match the texture of physical products, reducing colour and texture differences (Koreng and Krömker 2021). Designers should constantly compare the product with the actual object and test it in the environment where it is expected to be used to minimise the deviation caused by environmental factors.

(12) **Visual aesthetics.** The UI design uses rounded corners to keep the user's sight focused on the centre of interfaces and buttons. Enhance the sense of interface

transparency, reduce user attention consumption, and make the key information more prominent (Nielsen 1994). Add brand style characteristics to express brand images.

(13) **Environmental compatibility.** UI design should address the physical environment's impact on user accessibility and virtual product display. Integrating UI design with the shop's interior design can help avoid disconnecting the virtual experience from reality, enhancing overall UX. For example, the UI size is compatible with the space footprint. Some users may require an independent space to avoid discomfort from bystanders.

This *Mixed Reality Product Configurator Design Principles Toolkit* is a set of graphic cards, a repeatable and generic framework that combines heuristics and design solutions (Figure 6). It attempts to aid UI designers and MR developers in developing commercial MC systems. It can be used in various scenarios: the usability testing (user test) stage involves consumers to evaluate the system's usability and experience value. Used as a qualitative tool to conduct workshop activities with stakeholders (retailers, UI/UX designers, interior designers, consumers) after completion of development to co-evaluate the application outcome. As a quantitative tool – a questionnaire survey framework to scale their system in thirteen dimensions and is used repetitively throughout the design and development workflow.

[Insert Figure 6 here]

Figure 6 Mixed reality product configurator design principles toolkit

The usage of thirteen principles, such as parametricity (**Principle 01**), using the jewellery configuration parameters as an example, describes the parametric range and quantity based on ring parameters. It suggests that product managers and designers follow online product configurator parameters of their retail categories. Comfort

(**Principle 03**), by providing an ergonomic MR UI layout and distance design solution, coupled with environmental design (namely, footprint for this UI size, safety, privacy) (**Principle 13**) to enhance commercial viability. Comparability and beyond reality value (**Principle 04, 07**) refer to system functions and experiences development that other channels do not involve, such as virtual fitting, special effects, and recommendations. Principles 02, 06, 09, 10, 11, and 12 align consistently with established online and AR UI design principles (Ko, Chang, and Ji 2013; Koreng and Krömker 2021; Höllerer et al. 2001; Nielsen 1994). New principles 01, 03, 04, 05, 07, 08, 10, and 13 are tailored to meet the unique requirements of MR commercial physical stores.

Conclusion, Limitations and Future Works

This study provides theoretical contributions to the design of mass customisation applications for physical stores using MR. It proposes an MRPC design approach and toolkit that has not been previously explored in research on commercial MR UI design for physical stores. This study also broadens the understanding of user acceptance of MR applications in medium-to-high-value retail settings. The practical implication of this paper is that MRPC offers retailers an opportunity to enhance in-store services and customer experiences. The proposed functional features also guide software engineers towards user-centred research and development. From a design perspective, this study aids UI/UX designers in transitioning from 2D to 3D interfaces, facilitating the effective implementation of MR systems in physical retail spaces. From a marketing standpoint, it supports product managers in developing consumer-centred design strategies.

This experiment was conducted in the mid-high-value jewellery industry, suggesting that other high-value sectors should adjust parametric design according to their brand product needs. Given the influence of product variety, it is recommended that researchers test on a broader assortment of merchandise, which would be a valuable complement. Due to the relatively small sample size, the quantitative results may be limited in robustness. Future work should be conducted with a larger diverse group.

Disclosure statement

The authors report there are no competing interests to declare.

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References

Ajzen, I. 1991. 'The Theory of Planned Behavior'. *Org. Behav. Hum. Decis. Process.* 50. https://doi.org/10.1016/0749-5978(91)90020-T.

Allie, Paul, Cynthia Purvis, and Doug Kokot. 2005. 'Computer Display Viewing Angles: Is It Time to Shed a Few Degrees?' *Proceedings of the Human Factors and Ergonomics Society Annual Meeting*, ahead of print, 1 September 2005. Sage CA: Los Angeles, CA. https://doi.org/10.1177/154193120504900802.

Altarteer, Samar Awad A, Vassilis Charissis, David Harrison, and Warren Chan. 2013. 'Interactive Virtual Reality Shopping and the Impact in Luxury Brands'. *Virtual, Augmented and Mixed Reality. Systems and Applications* (Berlin, Heidelberg), Lecture Notes in Computer Science, vol. 8022: 221–230. https://doi.org/10.1007/978-3-642-39420-1_24.

Alzayat, Ayman, and Seung Hwan (Mark) Lee. 2021. 'Virtual Products as an Extension of My Body: Exploring Hedonic and Utilitarian Shopping Value in a Virtual Reality Retail Environment'. *Journal of Business Research* 130 (June): 348–363. https://doi.org/10.1016/j.jbusres.2021.03.017.

Berg, Bruce L. 2009. *Qualitative Research Methods for the Social Sciences*. 7th ed. Boston, Mass: Allyn and Bacon.

Cho, Vincent, T. C. Edwin Cheng, and W. M. Jennifer Lai. 2009. 'The Role of Perceived User-Interface Design in Continued Usage Intention of Self-Paced e-Learning Tools'. *Computers & Education* 53 (2): 216–227. https://doi.org/10.1016/j.compedu.2009.01.014.

Corbett, Matthew, Brendan David-John, Jiacheng Shang, Y. Charlie Hu, and Bo Ji. 2024. 'Securing Bystander Privacy in Mixed Reality While Protecting the User Experience'. *IEEE Security & Privacy* 22 (1): 33–42. https://doi.org/10.1109/MSEC.2023.3331649.

Creswell, John W. 2013. *Qualitative Inquiry and Research Design: Choosing Among Five Approaches*. SAGE.

Davis, Fred D. 1989. 'Perceived Usefulness, Perceived Ease of Use, and User Acceptance of Information Technology'. *MIS Quarterly* 13 (3): 319. https://doi.org/10.2307/249008.

Dehghani, Milad, Seung Hwan (Mark) Lee, and Atefeh Mashatan. 2020. 'Touching Holograms with Windows Mixed Reality: Renovating the Consumer Retailing Services'. *Technology in Society* 63 (November): 101394. https://doi.org/10.1016/j.techsoc.2020.101394.

Denker, Christian. 2016. 'Assessing the Spatio-Temporal Fitness of Information Supply and Demand on Ship Bridges'. https://doi.org/10.13140/RG.2.1.3646.7443.

Dziuban, Charles D., and Edwin C. Shirkey. 1974. 'When Is a Correlation Matrix Appropriate for Factor Analysis? Some Decision Rules'. *Psychological Bulletin* (US) 81 (6): 358–361. https://doi.org/10.1037/h0036316.

Egaji, Oche A, Ikram Asghar, Will Warren, Mark Griffiths, and Simon Evans. 2019. 'An Augmented Reality Application for Personalised Diamond Shopping'. *2019 25th International Conference on Automation and Computing (ICAC)*, September 2019, 1–7. https://doi.org/10.23919/IConAC.2019.8895045.

Foroudi, Pantea, Suraksha Gupta, Uthayasankar Sivarajah, and Amanda Broderick. 2018. 'Investigating the Effects of Smart Technology on Customer Dynamics and Customer Experience'. *Computers in Human Behavior* 80: 271–282. https://doi.org/10.1016/j.chb.2017.11.014.

Franke, Nikolaus, and Frank Piller. 2004. 'Value Creation by Toolkits for User Innovation and Design: The Case of the Watch Market'. *Journal of Product Innovation Management* 21 (6): 401–415. https://doi.org/10.1111/j.0737-6782.2004.00094.x.

Glaser, Barney, and Anselm Strauss. 1999. *Discovery of Grounded Theory: Strategies for Qualitative Research*. New York: Routledge. https://doi.org/10.4324/9780203793206.

Górski, F., R. Łabudzki, M. Żukowska, F. Sanfilippo, M. Ottestad, M. Zelenay, D.-I. Băilă, and R. Pacurar. 2023. 'Experimental Evaluation of Extended Reality Technologies in the Development of Individualized Three-Dimensionally Printed Upper Limb Prostheses'. *Applied Sciences (Switzerland)* 13 (14). Scopus. https://doi.org/10.3390/app13148035.

Grewal, Dhruv, Stephanie M. Noble, Anne L. Roggeveen, and Jens Nordfalt. 2020. 'The Future of In-Store Technology'. *Journal of the Academy of Marketing Science* 48 (1): 96–113. https://doi.org/10.1007/s11747-019-00697-z.

Guest, Greg, Arwen Bunce, and Laura Johnson. 2006. 'How Many Interviews Are Enough?: An Experiment with Data Saturation and Variability'. *Field Methods* 18 (1): 59–82. https://doi.org/10.1177/1525822X05279903.

Hippel, Eric von. 1988. *The Sources of Innovation*. Oxford University Press.

Hippel, Eric von, and Ralph Katz. 2002. 'Shifting Innovation to Users via Toolkits'. *Management Science* 48 (7): 821–833. https://doi.org/10.1287/mnsc.48.7.821.2817.

Höllerer, Tobias, Steven Feiner, Drexel Hallaway, Blaine Bell, Marco Lanzagorta, Dennis Brown, Simon Julier, Yohan Baillot, and Lawrence Rosenblum. 2001. 'User Interface Management Techniques for Collaborative Mobile Augmented Reality'. *Computers & Graphics*, Mixed realities - beyond conventions, vol. 25 (5): 799–810. https://doi.org/10.1016/S0097-8493(01)00122-4.

Huang, Tseng-Lung, and Shuling Liao. 2015. 'A Model of Acceptance of Augmented-Reality Interactive Technology: The Moderating Role of Cognitive Innovativeness'. *Electronic Commerce Research* 15 (2): 269–295. https://doi.org/10.1007/s10660-014-9163-2.

Inman, J. Jeffrey, and Hristina Nikolova. 2017. 'Shopper-Facing Retail Technology: A Retailer Adoption Decision Framework Incorporating Shopper Attitudes and Privacy Concerns'. *Journal of Retailing*, The Future of Retailing, vol. 93 (1): 7–28. https://doi.org/10.1016/j.jretai.2016.12.006.

Jain, Shubham, Thomas Schweiss, Simon Bender, and Dirk Werth. 2021. 'Omnichannel Retail Customer Experience with Mixed-Reality Shopping Assistant Systems'. In *Advances in Visual Computing*, edited by George Bebis, Vassilis Athitsos, Tong Yan, Manfred Lau, Frederick Li, Conglei Shi, Xiaoru Yuan, Christos Mousas, and Gerd Bruder, 504–517. Lecture Notes in Computer Science. Cham:

Springer International Publishing. https://doi.org/10.1007/978-3-030-90439-5_40.

Jain, Shubham, and Dirk Werth. 2019. ‘Current State of Mixed Reality Technology for Digital Retail: A Literature Review’. In *HCI in Business, Government and Organizations. eCommerce and Consumer Behavior*, edited by Fiona Fui-Hoon Nah and Keng Siau, 22–37. Lecture Notes in Computer Science. Cham: Springer International Publishing. https://doi.org/10.1007/978-3-030-22335-9_2.

Jaschinski, Wolfgang. 2002. ‘The Proximity-Fixation-Disparity Curve and the Preferred Viewing Distance at a Visual Display as an Indicator of Near Vision Fatigue’. *Optometry and Vision Science* 79 (3): 158. https://journals.lww.com/optvissci/abstract/2002/03000/the_proximity_fixation_disparity_curve_and_the.10.aspx.

Jaschinski-Kruza, Wolfgang. 1991. ‘Eyestrain in VDU Users: Viewing Distance and the Resting Position of Ocular Muscles’. *Human Factors* 33 (1): 69–83. https://doi.org/10.1177/001872089103300106.

Jessen, Alexander, Tim Hilken, Mathew Chylinski, Dominik Mahr, Jonas Heller, Debbie Isobel Keeling, and Ko de Ruyter. 2020. ‘The Playground Effect: How Augmented Reality Drives Creative Customer Engagement’. *Journal of Business Research* 116 (August): 85–98. https://doi.org/10.1016/j.jbusres.2020.05.002.

Jiang, Yi, Xueqin Wang, and Kum Fai Yuen. 2021. ‘Augmented Reality Shopping Application Usage: The Influence of Attitude, Value, and Characteristics of Innovation’. *Journal of Retailing and Consumer Services* 63 (November): 102720. https://doi.org/10.1016/j.jretconser.2021.102720.

Jin, Lingyao. 2025. ‘Adopting Mixed Reality Product Customisation in Brick-and-Mortar Retail: Stakeholder Insights for Commercialisation Challenge’. *Proceedings of the 2025 ACM Designing Interactive Systems Conference* (Funchal, Portugal), DIS ’25, July 2025. https://doi.org/10.1145/3715336.3735750.

Jin, Lingyao, Ruth Dalton, and Des Fagan. 2023. ‘Extended Reality (XR) Survey: A Consumer Technology Acceptance Preference Study on Retail’. In *Proceedings of the 8th Colloquium on European Research in Retailing 2023*, edited by Marta Nieto-Garcia, Diletta Acuti, Jason Sit, and Brusset Xavier, 207–218.

Portsmouth, UK: University of Portsmouth. https://cerr.sciencesconf.org/data/pages/Book_of_Proceedings_2023.pdf.

Jin, Lingyao, and Des Fagan. 2024. ‘MRPaperPro: Mixed Reality Interdisciplinary Design Prototyping Technique’. *Proceedings of the 2024 ACM International Conference on Interactive Media Experiences* (New York, NY, USA), IMX’24, 7 June 2024, 268–275. https://doi.org/10.1145/3639701.3656310.

Kahneman, Daniel. 2003. ‘A Perspective on Judgment and Choice: Mapping Bounded Rationality’. *American Psychologist* (US) 58: 697–720. https://doi.org/10.1037/0003-066X.58.9.697.

Kao, Ling-Jing, Chih-Chou Chiu, Hung-Jui Wang, and Chang Yu Ko. 2021. ‘Prediction of Remaining Time on Site for E-Commerce Users: A SOM and Long Short-Term Memory Study’. *Journal of Forecasting* 40 (7): 1274–1290. https://doi.org/10.1002/for.2771.

Keller, K.L., and D.R. Lehmann. 2003. ‘How Do Brands Create Value?’ *Marketing Management* 12 (May): 26–31.

Kim, Jiyeon, and Sandra Forsythe. 2008. ‘Adoption of Virtual Try-on Technology for Online Apparel Shopping’. *Journal of Interactive Marketing* 22 (2): 45–59. https://doi.org/10.1002/dir.20113.

Ko, Sang Min, Won Suk Chang, and Yong Gu Ji. 2013. ‘Usability Principles for Augmented Reality Applications in a Smartphone Environment’. *International Journal of Human–Computer Interaction* 29 (8): 501–515. https://doi.org/10.1080/10447318.2012.722466.

Koreng, Regina, and Heidi Krömker. 2021. ‘User Interface Pattern for AR in Industrial Applications’. *Information* 12 (6): 6. https://doi.org/10.3390/info12060251.

Kress, Bernard. 2020. *Human Factors*. PM316 (January): 25–37. https://doi.org/10.1117/3.2559304.ch5.

Le Corbusier. 2000. *The Modulor: A Harmonious Measure to the Human Scale, Universally Applicable to Architecture and Mechanics*. 1st ed. With Fondation Le Corbusier. Basel ; Birkhäuser. https://doi.org/10.1515/9783035604092.

McKinsey & Company, and Thomas. 2014. ‘A Multifaceted Future: The Jewelry Industry in 2020’. February 1. https://www.mckinsey.com/industries/retail/our-insights/a-multifaceted-future-the-jewelry-industry-in-2020.

McLean, Graeme, and Alan Wilson. 2019. ‘Shopping in the Digital World: Examining Customer Engagement through Augmented Reality Mobile Applications’.

Computers in Human Behavior 101 (December): 210–224. https://doi.org/10.1016/j.chb.2019.07.002.

Meegahapola, Lakmal, and Indika Perera. 2017. 'Enhanced In-Store Shopping Experience through Smart Phone Based Mixed Reality Application'. *2017 Seventeenth International Conference on Advances in ICT for Emerging Regions (ICTer)*, September 2017, 1–8. https://doi.org/10.1109/ICTER.2017.8257810.

Neufert, Ernst. 1970. *Architects' Data.* 1st English language ed.; Edited and Revised by Rudolf Herz from translations from the German by G. H. Berger [and others]. With Rudolf Herz. London: Lockwood.

Nielsen, Jakob. 1994. 'Enhancing the Explanatory Power of Usability Heuristics'. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York, NY, USA), CHI '94, 24 April 1994, 152–158. https://doi.org/10.1145/191666.191729.

Obermeier, G., S. Jain, A. Auinger, and D. Werth. 2021. 'The Impact of Prior Experience on Customers Using a Mixed-Reality Shopping Assistant'. Paper presented at 27th Annual Americas Conference on Information Systems, AMCIS 2021. 2021. Scopus.

Oyman, Mine, Dondu Bal, and Serhat Ozer. 2022. 'Extending the Technology Acceptance Model to Explain How Perceived Augmented Reality Affects Consumers' Perceptions'. *Computers in Human Behavior* 128 (March): 107127. https://doi.org/10.1016/j.chb.2021.107127.

Peffers, Ken, Tuure Tuunanen, Marcus A. Rothenberger, and Samir Chatterjee. 2007. 'A Design Science Research Methodology for Information Systems Research'. *Journal of Management Information Systems* 24 (3): 45–77. https://doi.org/10.2753/MIS0742-1222240302.

Rantala, Inka, Ashley Colley, and Jonna Häkkilä. 2018. 'Smart Jewelry: Augmenting Traditional Wearable Self-Expression Displays'. *Proceedings of the 7th ACM International Symposium on Pervasive Displays* (New York, NY, USA), PerDis '18, 2018, 1–8. https://doi.org/10.1145/3205873.3205891.

Recalde, Daniella, Tunmin Catherine Jai, and Robert Paul Jones. 2024. 'I Can Find the Right Product with AR! The Mediation Effects of Shopper Engagement on Intent to Purchase Beauty Products'. *Journal of Retailing and Consumer Services* 78 (May): 103764. https://doi.org/10.1016/j.jretconser.2024.103764.

Rempel, David, Kirsten Willms, Jeffrey Anshel, Wolfgang Jaschinski, and James Sheedy. 2007. 'The Effects of Visual Display Distance on Eye Accommodation, Head Posture, and Vision and Neck Symptoms'. *Human Factors* 49 (5): 830–838. https://doi.org/10.1518/001872007X230208.

Rese, Alexandra, Daniel Baier, Andreas Geyer-Schulz, and Stefanie Schreiber. 2017. 'How Augmented Reality Apps Are Accepted by Consumers: A Comparative Analysis Using Scales and Opinions'. *Technological Forecasting and Social Change* 124 (November): 306–319. https://doi.org/10.1016/j.techfore.2016.10.010.

Silva, Manoela, Rafael Roberto, Iulian Radu, Patricia Cavalcante, Bertrand Schneider, and Veronica Teichrieb. 2024. 'Development of Design Principles for AR Authoring Tools for Education Based on Teacher's Perspectives'. *IEEE Transactions on Learning Technologies* 17: 677–690. https://doi.org/10.1109/TLT.2023.3327592.

Slovic, Paul, Ellen Peters, Melissa L. Finucane, and Donald G. MacGregor. 2005. 'Affect, Risk, and Decision Making'. *Health Psychology* (US) 24: S35–S40. https://doi.org/10.1037/0278-6133.24.4.S35.

Speicher, Maximilian, Brian D. Hall, and Michael Nebeling. 2019. 'What Is Mixed Reality?' *Proceedings of the 2019 CHI Conference on Human Factors in Computing Systems* (New York, NY, USA), CHI '19, 2 May 2019, 1–15. https://doi.org/10.1145/3290605.3300767.

Stremersch, Stefan, Allen M. Weiss, Benedict G.C. Dellaert, and Ruud T Frambach. 2003. 'Buying Modular Systems in Technology-Intensive Markets'. *Journal of Marketing Research* 40 (3): 335–350. https://doi.org/10.1509/jmkr.40.3.335.19239.

Tan, Desney S., Darren Gergle, Peter Scupelli, and Randy Pausch. 2003. 'With Similar Visual Angles, Larger Displays Improve Spatial Performance'. *Proceedings of the SIGCHI Conference on Human Factors in Computing Systems* (New York, NY, USA), CHI '03, 5 April 2003, 217–224. https://doi.org/10.1145/642611.642650.

Tanaka, Shoichiro, Nilesh Patel, and Ananth Murthy. 2020. 'No Longer a Pain in the Neck: Use of Operating Microscope for Palatoplasty'. *Plastic and Reconstructive Surgery. Global Open* 8 (October): e3196. https://doi.org/10.1097/GOX.0000000000003196.

Thomas, Derianna, and Lars Erik Holmquist. 2021. ‘Is Functionality All That Matters? Examining Everyday User Opinions of Augmented Reality Devices’. *2021 IEEE Conference on Virtual Reality and 3D User Interfaces Abstracts and Workshops (VRW)*, March 2021, 232–237. https://doi.org/10.1109/VRW52623.2021.00050.

Thomke, Stefan, and Eric von Hippel. 2002. ‘Customers as Innovators: A New Way to Create Value’. Innovation. *Harvard Business Review*, 1 April 2002. https://hbr.org/2002/04/customers-as-innovators-a-new-way-to-create-value.

Venkatesh, Viswanath. 2000. ‘Determinants of Perceived Ease of Use: Integrating Control, Intrinsic Motivation, and Emotion into the Technology Acceptance Model’. *Information Systems Research* 11 (4): 342–365. https://www.jstor.org/stable/23011042.

Venkatesh, Viswanath, John A. Aloysius, Hartmut Hoehle, and Scot Burton. 2017. ‘Design and Evaluation of Auto-ID Enabled Shopping Assistance Artifacts in Customers’ Mobile Phones: Two Retail Store Laboratory Experiments’. *MIS Q.* 41 (1): 83–113. https://doi.org/10.25300/MISQ/2017/41.1.05.

Venkatesh, Viswanath, and Fred D. Davis. 1996. ‘A Model of the Antecedents of Perceived Ease of Use: Development and Test’. *Decision Sciences* 27 (3): 451–481. https://doi.org/10.1111/j.1540-5915.1996.tb00860.x.

Wang, Rebecca Jen-Hui. 2020. ‘Branded Mobile Application Adoption and Customer Engagement Behavior’. *Computers in Human Behavior* 106 (May): 106245. https://doi.org/10.1016/j.chb.2020.106245.

Wojciechowski, Rafał, and Wojciech Cellary. 2013. ‘Evaluation of Learners’ Attitude toward Learning in ARIES Augmented Reality Environments’. *Computers & Education* 68 (October): 570–585. https://doi.org/10.1016/j.compedu.2013.02.014.

Xi, N., J. Chen, F. Gama, H. Korkeila, and J. Hamari. 2024. ‘Acceptance of the Metaverse: A Laboratory Experiment on Augmented and Virtual Reality Shopping’. *Internet Research* 34 (7): 82–117. Scopus. https://doi.org/10.1108/INTR-05-2022-0334.

Zimmermann, Robert, Daniel Mora, Douglas Cirqueira, Markus Helfert, Marija Bezbradica, Dirk Werth, Wolfgang Jonas Weitzl, René Riedl, and Andreas Auinger. 2023. ‘Enhancing Brick-and-Mortar Store Shopping Experience with an Augmented Reality Shopping Assistant Application Using Personalized Recommendations and Explainable Artificial Intelligence’. *Journal of Research* *in Interactive Marketing* 17 (2): 273–298. https://doi.org/10.1108/JRIM-09-2021-0237.

Appendix A

Questionnaire design and reliability

Construct	Measurement Variables	References	Cronbach α
Perceived Usefulness **(PU)**	PU1: If I want to buy jewellery, I could accomplish just what I might need with the MR Jewellery Configurator app in a mixed reality headset. PU2: Shopping with the MR Jewellery Configurator app in a mixed reality headset would make my life easier. PU3: The MR Jewellery Configurator app in a mixed reality headset would make shopping more productive. PU4: The MR Jewellery Configurator app with a mixed reality headset would improve my shopping decision-making ability. PU5: With the MR Jewellery Configurator app, I couldn't get the product effects that I needed.	From (Davis 1989; Rese et al. 2017; Venkatesh 2000)	0.80
Perceived Ease of Use **(PEU)**	PEU1: Using the MR Jewellery Configurator app is clear and understandable. PEU2: Using the MR Jewellery Configurator app does not require a lot of mental effort. PEU3: This MR Jewellery Configurator app is easy to use. PEU4: I would find it easy to get the MR Jewellery Configurator app to do what I want it to do.	From (Davis 1989; Huang and Liao 2015; Kim and Forsythe 2008)	0.78
Perceived User Interface Design **(PUID)**	PUID1: The layout of the MR Jewellery Configurator app is user-friendly. PUID2: The computerised instruction provided by the MR Jewellery Configurator app is clear. PUID3: The layout of the MR Jewellery Configurator app is in good structure. PUID4: Overall, the user interface design of the MR Jewellery Configurator app is satisfactory.	From (Cho, Cheng, and Lai 2009)	0.69
Attitude Towards Using **(ATU)**	ATU1: In my opinion, using the *MR Jewellery Configurator app with mixed reality headsets in a brick-and-mortar retail store* is a good idea. ATU2: Altogether, I like shopping using *the mixed reality headset in the MR Jewellery Configurator app in a brick-and-mortar retail store.*	Adapted from (Ajzen 1991; Recalde, Jai, and Jones 2024; Venkatesh 2000)	0.86
Behavioural Intent to Use **(BIU)**	BIU1: I will use the mixed reality headset to purchase products in the future. BIU2: I will recommend using the mixed reality headset to purchase products. BIU3: Using the mixed reality headset to purchase products in the future is important to me.	From (Ajzen 1991; Rese et al. 2017)	0.86
Purchase Intent **(PI)**	PI1: *Based on my experience of this experiment, shopping with MR inside a real retail store* would make me more likely to purchase a product. PI2: *Based on my experience of this experiment, shopping with MR inside a real retail store would improve my desire to shop in brick-and-mortar stores in future.* PI3: *Based on my experience of this experiment, shopping with MR inside a real retail store* would make me want to return to shop at a store that uses MR for purchases. PI4: *Based on my experience of this experiment, shopping with MR inside a real retail store* would improve my enjoyment of shopping.	Adapted from (Inman and Nikolova 2017)	0.83

Text in italic denotes adapted sections.

Appendix B

Hierarchical regression of indirect hypothesis

Dependent variable	Independent variable	B	Std. Error	t	β	R^2	F value	p
PI	Constant	1.091	0.314	3.472	-	0.537	35.391	p<0.01
	PUID_dummy	0.180	0.177	1.018	0.091			N.S.
	ATU	0.632	0.080	7.896	0.707			p<0.01
BIU	Constant	0.688	0.334	2.062	-	0.566	39.766	p<0.05
	PUID_dummy	-0.040	0.188	-0.213	-0.019			N.S.
	ATU	0.742	0.085	8.727	0.756			p<0.01
PU	Constant	1.756	0.391	4.496	-	0.258	10.588	p<0.01
	PUID_dummy	0.041	0.210	0.195	0.023			N.S.
	PEU	0.494	0.115	4.308	0.500			p<0.01
BIU	Constant	1.719	0.490	3.508	-	0.184	6.874	p<0.01
	PUID_dummy	0.052	0.264	0.195	0.024			N.S.
	PEU	0.498	0.144	3.458	0.421			p<0.01
BIU	Constant	1.108	0.410	2.703	-	0.474	18.056	p<0.05
	ATU_dummy	0.612	0.230	2.660	0.299			p<0.05
	PEU_dummy	0.193	0.177	1.091	0.110			N.S.
	PU	0.509	0.138	3.695	0.426			p<0.01
BIU	Constant	0.395	0.323	1.224	-	0.634	34.707	N.S.
	PU_dummy	0.192	0.148	1.297	0.112			N.S.
	PEU_dummy	0.063	0.152	0.416	0.036			N.S.
	PI	0.806	0.096	8.428	0.735			p<0.01
PI	Constant	1.169	0.258	4.535		0.633	34.49	p<0.01
	PU_dummy	0.371	0.96	0.386				N.S.
	PEU_dummy	1.011	0.823	1.228				N.S.
	BIU	0.673	0.08	8.428				p<0.01

N.S.: p>0.05