Evaluating the User Experience of Augmented Reality in the Mobile Commerce Environment

Shereen Mohamed El-sayed Morsi *

(*) Shereen Mohamed El-sayed Morsi, Associate Professor of Business Information Systems, College of Management and Technology, Arab Academy for Science, Technology, and Maritime Transport. Research interests: e-commerce, m-commerce, Metaverse, Augmented Reality, User Experience.

Email: shereen_morsi@egypt.aast.edu

مستخلص

يتزايد استخدام تقنية الواقع المعزز (AR) بشكل مطرد ويتم استخدامها في مجموعة واسعة من تطبيقات الهاتف المحمول في قطاعات مختلفة، مثل التعليم والألعاب والتجارة الإلكترونية. تغطي تطبيقات الواقع المعزز للهواتف المحمولة المعلومات الرقمية في العالم الحقيقي، مما يوفر للمستخدمين تجربة أكثر غامرة وتفاعلية. وقد أدى ذلك إلى قيام منظمات التجارة الإلكترونية باستخدام هذه الحلول التكنولوجية بشكل متزايد لتحقيق أغراض مختلفة، بما في ذلك خلق قيمة مضافة للعملاء، وزيادة المبيعات، ووضع المنتجات بشكل مبتكر، وزيادة الوعي بالمنتج. ومع ذلك، غالبًا ما تواجه مؤسسات التجارة الإلكترونية التحدي المتمثل في تقييم تجربة المستخدم (UX) في تطبيقات التجارة عبر الهاتف المحمول AR. في هذا البحث، تم اختيار دراسة من حالتين (Zeelool وAR_Watches) لتقييم تجربة المستخدم للواقع المعزز في تطبيقات التجارة عبر الهاتف المحمول وتحديد فرص التطوير المستقبلي في مثل هذه التطبيقات. استخدم البحث مراجعة الأدبيات، واستبيان تجربة المستخدم (UXQ) كطريقة كمية، وبروتوكولات التفكير بصوت عالٍ كطريقة نوعية. وأظهرت النتائج أن تطبيقات الواقع المعزز المبتكرة في دراستي الحالة قدمت تجربة مستخدم أفضل. سجلت تطبيقات الهاتف المحمول هذه درجات أعلى في أبعاد تجربة المستخدم "الجدة" و"التحفيز". علاوة على ذلك، كانت نتائج طريقة التفكير بصوت عالٍ متسقة مع نتائج مقاييس UEQ الستة. تسلط هذه النتائج الضوء على أهمية الواقع المعزز كنقاط اتصال رقمية مبتكرة وتقدم توصيات عملية لتطويرها، مما يجعلها أكثر جاذبية وسهولة في الاستخدام، مما يؤدي في النهاية إلى تعزيز تجربة العلامة التجارية لشركات التجارة الإلكترونية.

الكلمات المفتاحية : الواقع المعزز (AR)؛ تجربة المستخدم (UX)؛ التجارة المتنقلة (التجارة المتنقلة)؛ تطبيقات الهاتف المحمول AR؛ تطبيقات التجارة الإلكترونية عبر الواقع المعزز؛ تقييم تجربة المستخدم؛ تجربة المستخدم للتجارة الإلكترونية عبر الواقع المعزز.

Abstract

The utilization of augmented reality (AR) technology is on a steady rise and is being used in a wide range of mobile applications in different sectors, such as education, gaming, and electronic commerce. AR mobile applications overlay digital information in the real world, providing users with a more immersive and interactive experience. This has led e-commerce organizations to increasingly use these technological solutions to achieve various purposes, including creating added value for customers, increasing sales, positioning products innovatively, and raising product awareness. However, e-commerce organizations often face the challenge of evaluating user experience (UX) in AR mobile commerce applications. In this research, a two-case study (Zeelool and AR_Watches) was selected to evaluate the UX of AR in mobile commerce applications and to identify opportunities for future development in such applications. The research employed a literature review, a user experience questionnaire (UXQ) as a quantitative method, and think-aloud protocols as a qualitative method. The results showed that the innovative AR applications in the two case studies delivered a better user experience. These mobile applications scored higher in the user experience dimensions of "Novelty" and "Stimulation". Furthermore, the results from the think-aloud method were consistent with the results of the UEQ six scales. These findings highlight the significance of AR as innovative digital touchpoints and provide practical recommendations for their development, making them more engaging and user-friendly, ultimately enhancing the brand experience of e-commerce companies.

Keywords ***Augmented Reality (AR); User Experience (UX); mobile commerce(m-commerce); AR mobile applications; AR m-commerce applications; UX evaluation; UX for AR m-commerce.***

1. INTRODUCTION

The fast-paced advancement of technology has introduced novel prospects for application development and interaction. Among these emerging technologies, augmented reality (AR) stands out as having promising potential in diverse fields such as marketing, engineering, education, and electronic commerce (e-commerce) (Olalde, and Guesalaga, 2013). AR is defined as the blending of real-world and digital information (Kipper, and Rampolla, 2013). This blending of the real and virtual realms has been utilized for diverse objectives and is acknowledged as a novel form of technology in contemporary human-computer interaction, significantly impacting the acceptance and adoption of technological interactions (Žilak, Car, and Culjak, 2022). Well-established business consulting firms and reputable statistical organizations are optimistic about the future of AR, foreseeing its evolution into a standalone industry, distinct from its current associations with games and movies (ARPost, 2017). AR has emerged as an alternative way to engage users more efficiently with applications (Scholz, and Smith, 2016).

In line with the widespread usage of smartphones and tablets, AR mobile applications have risen to prominence as a mainstream technology and have become a subject of great interest among researchers from various disciplines. Mobile AR refers to a form of augmented reality in which virtual content is superimposed on the real-world view captured by a mobile device, such as a smartphone or tablet, allowing users to interact with the virtual elements. AR mobile applications offer context-sensitive virtual content that can take on various forms, encompassing three-dimensional (3D) models, animations, annotations, videos, and more. Lately, well-liked mobile applications incorporating AR features have significantly altered the way developers and users perceive and engage with AR technology. These mobile applications have earnestly introduced AR to people's smartphones. Furthermore, the proliferation of toolkits designed for developing AR mobile applications has empowered even non-technical individuals to craft their own AR content for mobile

applications (Laine, 2018). This has further solidified the position of AR mobile applications as a mainstream technology for interaction.

In the field of mobile commerce (m-commerce), AR technology is causing a revolution in the manner consumers buy products from m-commerce platforms (Flavián, et al., 2019). Instead of having to visit brick-and-mortar stores, this technology allows prospective customers to directly evaluate products from their mobile devices (Park and Yoo, 2020). AR has the potential to assist retailers in lowering product return rates and improving customer satisfaction by offering a visual representation of how a product will appear and fit in real-life scenarios (Poushneh and Vasquez-Parraga, 2017). For example, customers can visualize how their living room will appear with new decor (Flavián, et al., 2019). Moreover, AR is particularly beneficial in the context of purchasing clothing, as it allows customers to "try on" clothes virtually before visiting a physical store (Flavián, et al., 2019). Consumers can also assess how products fit their individual physiques, as demonstrated by David et al. (2020). Compared to conventional web-based e-commerce, wearable products have a more direct impact on physical performance. AR platforms, on the other hand, offer a more compelling presentation of products by allowing consumers to experience a tangible understanding of the product's fit and appearance (Javornik, 2016). Furthermore, the adoption of product or service customization is emerging as a vital differentiating tactic, leading to a notable 26% rise in profitability and a 12% increase in market capitalization (Moreno-Armendáriz, et al., 2022).

Although the User Experience (UX) of AR mobile applications has received some attention from researchers (Olsson, et al., 2013; Ritsos, Ritsos, and Gougoulis, 2011), only a few researchers have considered the evaluation of UX for AR m-commerce applications (Uhm, et al., 2022; Yoo, 2020; Olsson, and Salo, 2011). Additionally, UX in AR m-commerce applications is an important factor that influences whether consumers purchase from online retailers. It is essential to investigate the behavior and perception outcomes, uncover the complicated interactive nature between the technology and the users, and open the black box of the underlying cognitive processes undertaken by the end-users while interacting with AR technology. Therefore, there is a need for more

investigations and studies that focus on the UX of AR m-commerce applications from the perspective of online shopping. To address this need, the main objective of this study is to evaluate the UX of two AR m-commerce applications and provide recommendations for future development and opportunities associated with AR m-commerce application development from the UX perspective. This study aims to provide insights to researchers, practitioners, and e-retailers intending to embed AR in their systems. The results can be used as a reference for interactive studies of UX between users and e-commerce companies designing their applications.

The rest of the paper is organized as follows: Section 2 provides a literature review of mobile augmented reality, mobile user experience, AR, and user experience for mobile augmented reality. In Section 3, research methods are explained and two AR m-commerce applications are presented as case studies. Section 4 presents the results of mixed-method evaluations conducted on the two case studies. Section 5 describes the discussion of the findings. In section 6 the conclusion is provided.

2. Literature Review

2.1. Mobile Augmented Reality

AR technology has a long history, dating back to the 1960s, but it only gained mainstream popularity in the early 2000s (Billinghurst and Kato, 2002). The fundamental concept of AR is to overlay digital information onto the real world, precisely at the object or location it corresponds to (Azuma, 1997). This ability to seamlessly blend computer-generated content with physical objects has led to numerous applications in various fields, including entertainment, education (Carlson and Gagnon, 2016; Kysela and Štorková, 2015), retail (Javornik, 2016), and travel (Loureiro et al., 2020). AR is recognized as a powerful tool for enhancing customer experiences in e-commerce by offering new perspectives on their surroundings (Wang et al., 2013). Consequently, numerous AR and AR mobile applications have been developed for the m-commerce sector, with studies demonstrating their potential for improving customer experiences.

The field of mobile AR is experiencing rapid growth and development within AR, drawing significant attention in the literature (McLean and Wilson, 2019; De Sa, and Churchill, 2013; Van Krevelen and Poelman, 2010). Mobile AR applications not only offer interactive functionalities similar to traditional websites but also provide supplementary features like information search, product/service visualization, and feedback. Smartphones and their applications enable convenient access to information anytime and anywhere, thus holding tremendous potential for assisting customers in various ways. According to (Schapsis, Chiagouris, & Pham, 2021), AR plays a crucial role in influencing customer purchase intentions. Moreover, AR applications help customers gain a comprehensive understanding of products and services, enabling valuable experiences (Nhan, Dung, & Vu, 2022). In recent years, numerous Mobile AR applications have been introduced to inform customers' purchasing decisions and provide them with a better understanding of the products they are interested in. By doing so, Mobile AR enhances overall customer experiences (Papakostas, et al., 2021) and significantly benefits the online.

2.2. Mobile User Experience (UX)

Despite over a decade's worth of research on User Experience (UX), the concept continues to face challenges due to its ambiguous and wide-ranging definitions. This is apparent from the twenty-seven distinct definitions of UX that emerged from the Dagstuhl Seminar on Demarcating User Experience (Roto, et al., 2018). UX is a multidimensional phenomenon (Tokkonen, and Saariluoma, 2013) in which numerous factors influence success, and it has been studied for many years (Dirin, 2016). Carlos et al. (2011) points out that users, context, interaction, and artifacts are the fundamental components of User Experience (UX). furthermore, Hassenzahl (2008) characterizes UX as the "quality of interactive technology," emphasizing the significance of the human experience beyond just the product itself. Moreover, Hassenzahl and Tractinsky (2006) argue that in the era of technological progress, interactive products and services should not only be functional and user-friendly but also incorporate trendy and fashionable elements.

User Experience (UX) holds particular significance in mobile applications, primarily because of the constraints posed by mobile devices, such as screen size, and the contextual awareness facilitated by embedded sensors. In recent times, considerable efforts have been devoted to improving mobile UX, employing evaluation metrics and design approaches as part of these endeavors. Väätäjä and Roto (2010) suggested using mobile questionnaires for mobile UX evaluation, emphasizing the importance of clear and simple structures in the design of the questionnaires, including questions, icons, items, and scales. Pelet and Taieb (2018) focused on mobile application design to promote UX and provide recommendations on how color contrast can have positive effects on behavioral intentions. Yong (2013) suggested UX evaluation techniques for mobile devices that assess users' emotional reactions along three dimensions: visceral, behavioral, and reflective. Moreover, Dirin and Nieminen (2015) introduced a usability and UX framework specifically designed for mobile learning applications. The framework has been proven to enhance UX in mobile-based applications by incorporating adjustability, delightfulness, and reliability, all of which contribute to the overall dimension of UX. The current methods for evaluating and designing mobile UX can be adapted to some extent for AR m-commerce applications. Nonetheless, it is crucial to recognize that UX design for AR m-commerce applications varies from conventional mobile UX design. AR m-commerce applications require users to be mentally and physically engaged with the application.

2.3 Mobile Augmented Reality (AR) and User Experience (UX)

Existing research on mobile AR from a UX standpoint lacks clarity and precision, indicating the need for additional investigation in this area (Irshad, et al., 2014). The scarcity of mobile AR UX research and design guidelines can be attributed to the relatively recent emergence of mobile AR as a mainstream technology. Significant strides in the development of mobile AR have taken place primarily over the last decade (Arth, 2015). The primary milestone occurred when smartphones equipped with advanced technologies became prevalent (Prochazka, et al., 2011). However, there are researchers who have explored the domain of mobile AR UX, as we will briefly elucidate below. Irshad et al. (2014) conducted

a comprehensive review of mobile AR UX research published between 2005 and 2014. They provided a categorization of the mobile AR UX domain, encompassing aspects like UX as a phenomenon, UX as a field of study, and UX as a practice. Moreover, they advocated for the utilization of User-Centered Design as a recommended approach for developing mobile AR applications. Our examination of past research on mobile AR UX revealed that mobile AR applications, which took UX into explicit consideration, were either developed and studied through case study evaluations or constructed based on mobile AR application development frameworks. In both scenarios, the user of the application typically remains at the core of the design and development process, thus corroborating the findings of Irshad et al. For instance, Rashid et al. (2017) proposed a user-centered design -based framework for creating mobile AR tourism applications. In another case, Olsson et al. (2013) and Olsson and Väänänen-Vainio-Mattila (2011) extensively examined a mobile AR application through a case study, concluding that designers must proactively understand users and their fundamental requirements to ensure the acceptance of mobile AR applications by potential users. This aligns with the essence of most user-centered design frameworks, which emphasize involving end-users early in the design process.

Although User Experience (UX) research encompasses a broad range, scholars have put forth diverse methods for analysing UX, both qualitatively and quantitatively. Both approaches in UX studies have the potential to uncover specific patterns in users' behaviour and perceptions, reflecting their experiences when using a product. However, qualitative approaches delve deeper into narrative insights, explaining "how" and "why" certain behaviours emerge when users interact with a product (Lazar et al., 2017; Rohrer, 2014). These stories can then be measured to recognize common themes, leading to a more thorough comprehension of patterns in the data.

On the contrary, quantitative UX studies aimed to address questions related to "how many" and "how much" (Rohrer, 2014). Tullis and Albert (2013) expound that the concept of UX can be quantitatively measured through various observable metrics, encompassing aspects like efficiency, effectiveness, and user satisfaction, which reflect the user's individual

experience with a product. These UX metrics can be categorized into four types: (1) performance metrics; (2) self-reported metrics; (3) issue-based metrics; and (4) behavioural and psychological metrics. The performance metrics described by Tullis and Albert (2013) also gauged the usability of a product, encompassing factors like task success rate, time on task, error frequency, and learnability. This illustrates that usability is just one of the facets that contribute to the overall UX. Overall, it is important to gather a mix of quantitative and qualitative data to get a comprehensive understanding of the user experience with AR m-commerce applications

Our examination of the literature indicates a growing interest among researchers in the realm of User Experience (UX) for AR mobile applications, with a majority of related publications emerging in recent years. Prior studies have primarily concentrated on UX and usability evaluations of mobile AR applications. However, there remains a gap in our understanding of how users perceive AR m-commerce applications and the factors that influence their usage of such applications. Additionally, there is room for improvement in the field, with further investigation needed to identify areas where enhancements can be made.

3 Research Design

The subsequent sections outline the research questions, participants, and methodologies utilized to assess the two case study applications, as detailed in Section 4.

3.1. Research Questions

It is clear that the UX of a mobile application varies significantly from that of AR m-commerce applications (Agarwal, et al., 2014). This study seeks to explore the impact of User Experience (UX) on the development and evaluation of AR m-commerce applications. To achieve this, the research aims to address the following two questions using two AR m-commerce case studies.

1. How do users perceive and interact with AR m-commerce applications?

2. What are the opportunities for improvements associated with AR m-commerce UX?

The mixed-method approach comprising quantitative and qualitative methods were chosen to analyze the two case studies.

3.2. Research Methods

3.2.1. User Experience Questionnaire (UEQ)

Numerous tools have been created to assess User Experience (UX) through surveys, and among them is the User Experience Questionnaire (UEQ). This instrument was specifically designed to gauge six factors related to UX and usability: novelty; attractiveness; efficiency; perspicuity; dependability; and stimulation (Laugwitz et al., 2008). The assessment comprises 26 elements that gauge both traditional usability aspects and user experience factors.

The UEQ provides a convenient method for rapidly assessing users' interactions with interactive products and their overall experience. Its format is designed to enable users to instantly express their emotions, impressions, and attitudes they encounter while using a product (which in this study is mobile commerce application). The UEQ scales encompass a broad spectrum of user experiences, encompassing traditional usability aspects such as efficiency, perspicuity, and dependability, along with user experience elements like novelty and stimulation (User Experience Questionnaire, 2017). The original version of the UEQ was developed in the German language back in 2006 (Laugwitz, Schrepp, Held, 2006). A handbook (Schrepp, 2017) provided guidance on handling and interpreting the results obtained from the questionnaire. In its current form, the UEQ is user-friendly and allows for reliable and valid measurement of user experience. The data collected through this questionnaire can complement the information gathered from other evaluation methods that include subjective quality ratings (Laugwitz, Held, Schrepp, 2008).

The UEQ consists of six scales with a total of 26 items (Schrepp, Hinderks, Thomaschewski, 2017b). Each scale comprises four pairs of terms representing opposite meanings that span a semantic dimension. Table 1 illustrates the UEQ scales and their explanations.

Table 1. The scales of UEQ and its explanation.

Scale	Explanation
Attractiveness	The general perception of the product's appeal. Do users like or dislike it?
Perspicuity	Does the product offer a user-friendly experience, making it effortless to become acquainted with and grasp its usage? Perspicuity - How important is it that the AR m-commerce app is easy to use? How crucial is it for the AR m-commerce app to be easily comprehensible? These questions aim to gauge the significance of complexity levels in the app's user experience for its users.
Dependability	Does the user experience a sense of authority over the interaction? Is the product perceived as secure and dependable in its predictability? To what extent does the credibility of the source matter when it comes to developing the AR m-commerce app? How significant is it for the users to perceive the app as trustworthy and secure? The first question aims to explore if users value the reputation of the app's developer, such as a well-known company. The second question addresses the aspect of security.
Stimulation	Does the product elicit excitement and motivation during its usage? Is it enjoyable and entertaining to use? How important is it that the AR m-commerce app is interesting to use? How important is it that the AR m-commerce app is fun to use? This scale pertains to the level of engagement and excitement experienced while using an application.
Novelty	Does the product exhibit creativity in its design? Does it capture the attention and interest of users? How important is it that the AR m-commerce app has a creative interface? How important is it that the AR m-commerce app has creative features? Building upon the previous questions, this further emphasizes the aspects of creativity and innovation.
Efficiency	Do users find it easy to accomplish their tasks without unnecessary exertion? Does it respond promptly and swiftly? How important is fast time response in an AR m-commerce app? How important is it that the AR m-commerce app is functional to use?

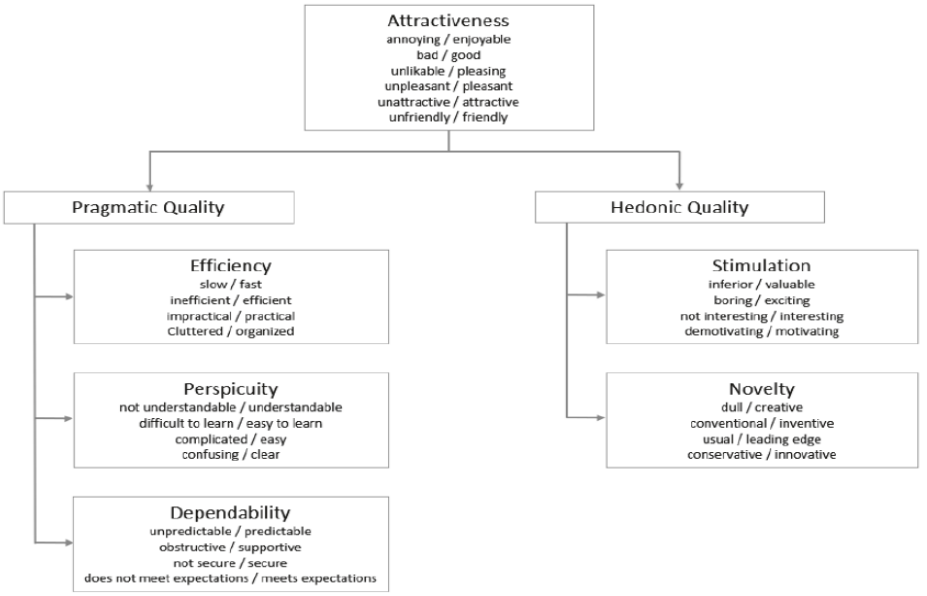

Figure 1: The structure of the UEQ scales

Source: Schrepp, Hinderks and Thomaschewski, 2017

3.2.2 Think - aloud protocols

In qualitative analysis research, verbal reports are frequently employed to gather participants' authentic cognitive thinking processes. The think-aloud protocols, initially introduced by Ericsson and Simon (1984) for psychology purposes, were later adapted by Lewis (1982) for human-computer interface studies, specifically usability testing. There exist three types of think-aloud protocol methods (Alhadreti, and Mayhew, 2018; Ericsson, and Simon, 1993; Ericsson; Simon, 1984). The first type is known as the concurrent think-aloud protocol, where participants verbalize their thoughts while simultaneously performing the experimental task, allowing researchers to record and analyse the verbal reports. The second type is referred to as the retrospective think-aloud protocol, where participants articulate their thoughts after completing the experimental task. The third type is a hybrid think-aloud protocol that combines the aforementioned two methods. Among these, the concurrent think-aloud protocol is the most commonly utilized for usability testing,

where participants speak in real-time while operating the system (McDonald, Edwards, and Zhao, 2012). Apart from these three types of think-aloud protocol methods, new usability evaluation approaches have been suggested, like one that assesses eye gaze concurrently with verbal responses and analyses both sets of data together (Alekhya, 2012; Li, et al., 2012). Boren and Ramey (2000) emphasized that there is a distinction between the original intent of the think-aloud protocol, which was to study natural human cognitive processes, and its application in usability testing. Hence, it is advisable to minimize participant interventions during the experiment to avoid any potential alteration of their thought processes (Alhadreti, and Mayhew, 2017). However, in usability testing, the objective is to capture the user's thoughts and identify usability issues. To achieve this, it is essential to encourage participants to speak as much as possible without prolonged silence. This is typically managed by prompting users to speak after specific intervals of silence or by practicing verbal expression before commencing the experiment. When intervening with participants during the experiment, it is crucial for the experimenter to maintain a neutral voice and refrain from expressing their opinions. Therefore, in this study, think-aloud protocols were employed to interview users, enabling them to articulate their ideas and thought processes, facilitating a better understanding of their thinking during the experiments based on the interview questions and content.

3.3. AR Applications as case study: The Zeelool and AR-Watch applications have been chosen as m-commerce applications due to its offering AR in its applications (details of these applications in sections 3.3.1 & 3.3.2). These particular applications were chosen based on their popularity, relevance to research objectives, and target audiences. They also do not necessitate long-term user commitment and are compatible with both Android and iOS mobile operating systems. Additionally, the applications are easily understandable in a short amount of time, enabling an evaluation of their features and characteristics. Furthermore, these applications are currently popular among customers.

***3.3.1. Zeelool AR application*:** utilizes the power of AR to bridge the gap between online shopping and the traditional in-store experience. By leveraging the capabilities of smartphones and tablets, users can access the application and access an extensive collection of eyeglasses and sunglasses from the comfort of their own homes. Zeelool's AR application provides virtual glasses onto the user's face in real-time, using the device's camera. This technology enables customers to see how different styles, shapes, and colours of eyewear look on them, providing a more accurate representation of how the glasses would appear in person. Users can filter their search based on various criteria such as frame shape, frame material, lens type, and more. Once a user finds a pair of glasses they are interested in, they can simply click on the "try-on" button, activating the AR feature and instantly seeing themselves wearing the selected glasses.

Beyond the virtual try-on feature, the Zeelool AR application also provides users with additional information and tools to enhance their shopping experience. Users can access detailed product descriptions, view high-resolution images, and read customer reviews to make informed decisions. The application also offers the option to save and share favourite styles, enabling users to seek opinions from friends and family before finalizing their purchase.

***3.3.2. The AR-Watches application*:** The primary feature of the AR-Watches app is its ability to overlay virtual watch designs onto the user's wrist in real-time. By utilizing the device's camera and AR technology, users can browse through an extensive collection of virtual watches and see how they look on their own wrist, as if they were wearing an actual timepiece. This virtual try-on experience allows users to explore various styles, colors, and materials, helping them find the perfect watch to match their personal style and preferences. In addition, the app offers a user-friendly interface, making it easy to navigate and customize the virtual watches. Users can filter their search based on different criteria such as brand, type, size, and strap material. They can also adjust the virtual watch's position, size, and orientation on their wrist, ensuring a realistic and personalized experience. Additionally, users can access detailed specifications, such as watch dimensions, movement type, water resistance, and other technical details. The app also provides high-

resolution images and 360-degree views of the watches, allowing users to examine every angle and detail before making a purchasing decision.

3.4. Participants

This study recruited 79 undergraduate and master students at Arab Academy for Science and Technology in Egypt on a voluntary basis and have experience with online shopping. The users were asked to download on their mobile devices two applications (Zeelool, and AR-Watches). For encouraging them to interact with AR tool on the applications, they were asked to complete specific tasks before the survey (on Zeelool – try on virtual sunglasses, take pictures, and share them on social media) for (AR-Watches -try out different styles from watches, test features, take pictures and share them on social media). Then, they were asked to fill in the UEQ questionnaire and answer on a scale based on their thinking of different factors when it comes to UX. The questionnaire incorporates closed questions to gather general information about the participants, as well as their perceptions of perspicuity, efficiency, dependability, stimulation, and novelty as factors contributing to UX attractiveness (Laugwitz, Held & Schrepp 2008). Following these closed questions, the participants were asked to select the two factors they value the most from the aforementioned list.

3.5 Data Collection

Data for this study were gathered using UEQ through a distributed survey. The collected data encompassed respondents' answers to the UEQ questionnaire, reflecting their experiences while using Zeelool and AR-Watches. All data obtained were anonymized to ensure the participants' identities remain confidential throughout the presentation of the study results. An Excel-based calculation tool was employed to analyse the UEQ data, comprising several worksheets, including; observed data for the items in each scale in a sheet, the observed data concerning the importance ratings of the scales in another sheet, the means, standard deviation, and confidence intervals for the scales also in sperate sheet. In addition, Cronbach's alpha value and correlation of all items in each scale are computed in another sheet, and finally, an overall Key Performance

Indicator (KPI) was calculated from the items and importance ratings in another sheet.

4. Results

This section provides details of the findings related to the research.

4.1 Demographic data of participants

Table 2 displays the participant demographics. Among the participants, 46.7% were male, and 53.3% were female. A majority of the participants, accounting for 95%, had prior experience with online shopping. Moreover, 89% of the participants had used online shopping to make purchases of physical products. Additionally, in the use of AR to buy things, most participants had no experience in AR purchases, with the proportion reaching 99%. Finally, because in this study is focus on user experience with AR in mobile shopping, so the sub processes of shopping which are putting products in shopping cart and checkout payment are not needed as it is crucial to explore the perspectives of the participants regarding whether the entire system can enhance their willingness to make purchases using AR technology. All participants expressed that the implementation of this system would indeed increase their willingness to buy.

Table (2): Demographic data results

Items	Qs	N	%
Age	20- less than 25	68	85%
	25- less than 35	11	15%
Gender	Male	37	46.7%
	Female	42	53.3%
Academic Level	Undergrade	56	72%
	Post-grade	23	28%
Have you ever bought something from the internet	Yes	70	89%
	No	9	11%
Did you purchase anything by using AR	Yes	1	1%
	No	78	99%

4.2 Zeelool user experience

In this section, the Zeelool UX is evaluated based on the six scales of the UEQ, and the results are presented in Table 3. The mean values were transformed from -3 to +3, and all the results obtained were positive. The

mean values for all the scales were greater than 1, indicating an excellent outcome for the Zeelool application. Moreover, the confidence intervals for all the values were greater than 1, signifying a good level of confidence in the results. Among the dimensions, novelty received the highest rating with a score of (2.418), followed by stimulation with a score of (2.411). The lowest rating was given to dependability with a score of (1.630). Additionally, the UEQ calculates Cronbach's alpha, indicating the consistency of the user's opinions across all scales, as shown in Table 4. All the scales displayed a Cronbach's alpha value greater than 0.7, indicating a high level of consistency across all scales. This means the overall UX evaluation is positive.

Table 3: Mean and confidence interval per scale for Zeelool

Scale	Mean	Std. Dev.	N	Confidence	Confidence interval	
Attractiveness	2.346	0.383	79	0.084	2.262	2.430
Perspicuity	1.826	1.102	79	0.243	1.583	2.069
Efficiency	1.902	0.892	79	0.197	1.705	2.099
Dependability	1.630	0.856	79	0.189	1.441	1.818
Stimulation	2.411	0.498	79	0.110	2.301	2.521
Novelty	2.418	0.355	79	0.078	2.339	2.496

Table 4. Scale consistency of the UEQ from the Zeelool case study

Scale	Cronbach Level
Attractiveness	0.82
Perspicuity	0.83
Efficiency	0.71
Dependability	0.70
Stimulation	0.85
Novelty	0.89

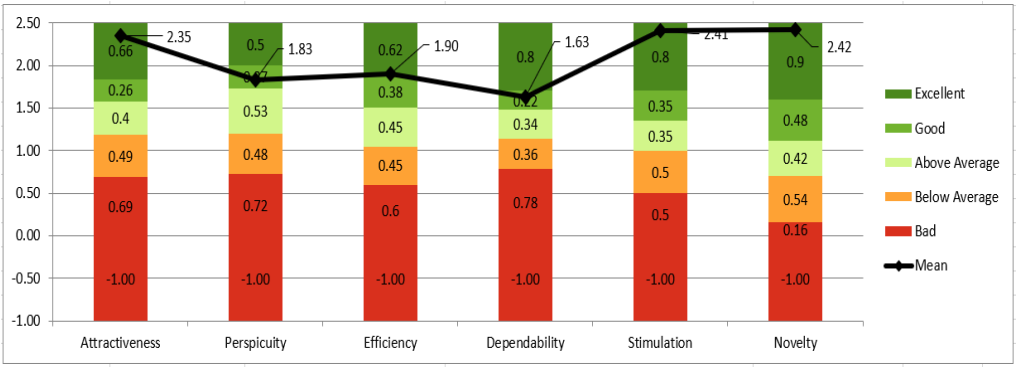

Figure 2: UX evaluation total results for Zeelool application

4.3. *Results related to AR-Watches user experience*

Similar to Zeelool, this study also assessed the User Experience (UX) of AR-Watches using the six scales of the UEQ: Novelty, Attractiveness, Perspicuity, Efficiency, Dependability, and Stimulation. The results of the six scales are displayed in Table 5, where the mean values were transformed to a range from -3 to +3. All scales showed positive mean values, indicating that the users deemed all the scales used in the measurement to be relevant to the UX of AR-Watches. Among the dimensions, stimulation received the highest rating with a score of (2.307), followed by novelty with a score of (2.253). The lowest rating was given to perspicuity scale with a score of (1.775). Furthermore, all scales displayed a Cronbach's alpha value greater than 0.70, indicating that the adapted version of the UEQ used in measuring AR-Watches' UX exhibited excellent consistency. A Cronbach's alpha value higher than 0.70 is considered fairly high and adequate (Taber, 2016), and the value for each scale is provided in Table 6.

Table 5. Mean and confidence interval per scale for AR_Watches

Scale	Mean	Std. Dev.	N	Confidence	Confidence interval	
Attractiveness	2.378	0.385	79	0.085	2.293	2.462
Perspicuity	1.775	1.100	79	0.243	1.533	2.018
Efficiency	2.082	0.736	79	0.162	1.920	2.245
Dependability	1.842	0.572	79	0.126	1.716	1.968
Stimulation	2.307	0.429	79	0.095	2.212	2.402
Novelty	2.253	0.486	79	0.107	2.146	2.360

Table 6. Scale consistency of the UEQ from the AR_Watches case study

Scale	Cronbach Alfa
Attractiveness	0.79
Perspicuity	0.70
Efficiency	0.74
Dependability	0.73
Stimulation	0.82
Novelty	0.83

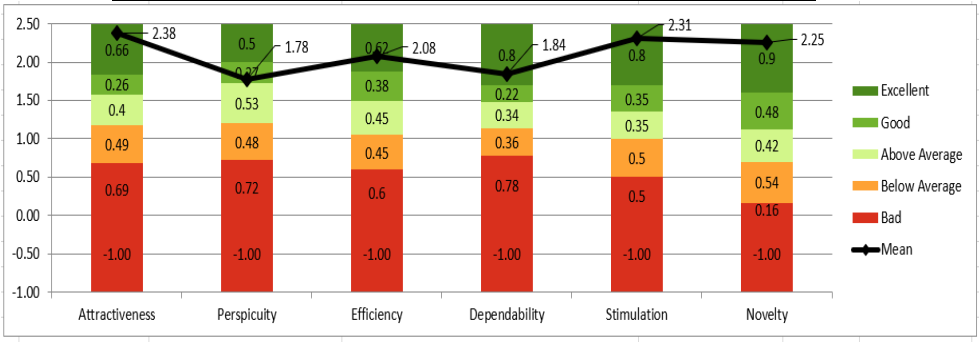

Figure 3: UX evaluation total results for AR_Watches application

From the above results, the users surveyed in this study rate Zeelool and AR_Watches as more exciting, interesting, and motivating than traditional m-commerce applications. Furthermore, users perceive these applications as more innovative and creative, which, in turn, likely influences their perception of the brand. Rauschnabel, Felix, and Hinsch (2019) arrived at similar conclusions, indicating that experiencing hedonic benefits through AR usage can result in a shift in brand attitude.

4.4. Results of think‑aloud method

The Think-Aloud Protocols were utilized as one of the research methods to evaluate the UX of AR m-commerce applications. This qualitative technique involved participants verbalizing their thoughts, actions, and emotions while using the selected AR m-commerce applications. Each participant engaged in individual sessions with the AR m-commerce applications, encouraged to think aloud and express their thoughts and interactions throughout the entire experience. The qualitative data of the participants were analyzed and organized to obtain insights into users' perceptions and behaviors while using AR m-commerce applications.

The following section presents the results of the think-aloud analysis from the experiments. Initially, some users expressed fear when asked to allow access to their mobile cameras by the applications, but they agreed to allow it only during the trial of these applications. Most participants were pleasantly surprised by the realism of virtual objects (glasses and watches) on their faces and hands, prompting them to try on many different glasses frames and watch styles to become familiar with and experiment with the products in the applications. Some participants criticized the try-on of glasses in the Zeelool application as being too sensitive when placed far from their faces at the beginning. A few participants also encountered difficulties in quickly finding desired products in the watch categories.

Regarding interaction, participants expressed a desire for a greater variety of products to interact with within the applications. They emphasized that having more content to interact with would enhance the overall attractiveness of the AR environment, making users more inclined to remain engaged. To achieve this, the system should fully simulate the type and functionality of the items, enabling users to interact, experience, and comprehend the products, thus leading to prolonged engagement in the AR environment.

In terms of action feedback, a majority of the participants expressed that the AR system effectively simulates real products and provides a closer sense of trying real products in physical stores.

In terms of realism, certain participants described the AR experience as incredibly realistic, making them feel as if they were in the real world, leading to a comfortable experience. However, other participants held a contrasting opinion, finding the AR environment lacking in realism and refinement compared to actual physical stores. They felt that the sensory experience was too close to the screen, resulting in discomfort and making the overall experience less enjoyable.

Regarding emotional responses, users exhibited positive emotional reactions, such as excitement and delight, when exploring AR-enhanced product presentations and virtual try-ons. These emotional reactions indicate the potential of AR technology to create enjoyable shopping experiences.

The participants praised the novelty of this AR approach in m-commerce (on the novelty scale). They appeared to have fun accessing the two applications and showed high interactivity from the start of the experiments. Many participants were thrilled by "how fast and easy it is to learn the application and try on the product before buying." After successfully placing their chosen objects, participants left a very satisfied impression, describing their experience with the applications as positive, and their enthusiasm for Zeelool and AR_Watches applications was noticeable. Some respondents also mentioned that the control system was easy to operate and well-received. Overall, the respondents felt that this application was beneficial in supporting purchasing, viewing it as an exciting and interesting alternative for trying on products (the perceiving of stimulation dimension). Participants appreciated applications with intuitive navigation and straightforward interactions, with AR features that were easy to access and use, contributing to a smoother and more enjoyable user experience.

5. Discussion

The present research aimed to evaluate the UX of AR in the m-commerce environment, given the increasing popularity of AR technology in various sectors, including education, gaming, and electronic commerce. AR mobile applications offer a unique experience by overlaying digital information in the real world, providing users with

enhanced immersion and interactivity. As a result, e-commerce organizations have increasingly adopted AR technology to achieve diverse objectives, such as adding value for customers, boosting sales, introducing innovative product positioning, and increasing product awareness. Despite these opportunities, e-commerce organizations often encounter challenges in effectively evaluating the user experience of AR mobile commerce applications.

In order to address this need, the research employed a two-case study approach, focusing on the AR mobile applications Zeelool and AR_Watches as AR m-commerce applications. The study utilized a combination of quantitative and qualitative research methods, including a literature review, a UXQ as a quantitative tool, and think-aloud protocols as a qualitative approach. The results of the study demonstrated that the innovative AR applications in both case studies delivered a superior user experience. Notably, the mobile applications scored higher in the UX dimensions of "Novelty" and "Stimulation." These findings align with the research on AR's potential as an innovative digital touchpoint, enriching the user experience in the m-commerce context.

The use of think-aloud protocols as a qualitative method complemented the quantitative findings, as the results from this approach were consistent with the results obtained through the UXQ's six scales. The congruence between these methods lends credibility to the study's findings and reinforces the importance of understanding the user's subjective experience while interacting with AR technology.

The practical implications of the research are noteworthy, as it provides valuable recommendations for designing AR applications that are engaging and user-friendly. By addressing the "Novelty" and "Stimulation" dimensions, e-commerce companies can enhance the overall brand experience and positively impact customer perception and engagement with their products. In addition, the opportunities for improvements associated with AR m-commerce could be that AR offers exclusive chances to innovate and develop new user interfaces. Interacting with AR objects (sunglasses or hand watches) exemplifies novel user interface components that can be integrated into AR

applications. Furthermore, AR opens up unprecedented interaction experiences for mobile applications that were previously impractical. This includes natural communication with digital objects and enhancing user interfaces by moving beyond mere text labels and 2D graphics. AR presents a unique opportunity for e-marketers to promote products and services. Integrating AR into mobile product advertisements enhances users' perception of the product and fosters a deeper emotional connection. In m-commerce applications, AR facilitates richer and more interactive experiences, allowing users to engage emotionally with products in a two-directional manner.

6. Conclusions

The rapid advancement of technology has given rise to various emerging technologies, among which AR stands out with its promising potential in diverse fields like engineering, education, marketing, and e-commerce. AR mobile applications, in particular, have gained prominence as a mainstream technology, providing users with an immersive and interactive experience by overlaying digital information in the real world. The widespread usage of smartphones and tablets has facilitated the integration of AR technology into mobile applications, transforming the way developers and users perceive and engage with AR. Notably, well-liked mobile applications incorporating AR features have brought AR technology earnestly to people's smartphones. The availability of toolkits for developing AR mobile applications has further democratized AR content creation, empowering even non-technical individuals to craft their own virtual experiences.

In the context of m-commerce, AR technology is causing a revolution in the way consumers interact with products from online retailers. AR's ability to provide visual representations of products in real-life scenarios enables prospective customers to make informed decisions without physically visiting brick-and-mortar stores. From visualizing how furniture would appear in their living room to virtually trying on clothes before making a purchase, AR enhances the UX in m-commerce platforms. Despite the promising potential of AR in m-commerce, there is a notable gap in research regarding the evaluation of UX for AR m-

commerce applications. While some attention has been given to the UX of AR mobile applications, only a few studies have specifically explored the UX in the context of m-commerce. Understanding the user's behavior, perception outcomes, and cognitive processes while interacting with AR technology is crucial for e-commerce organizations to optimize their applications and improve customer satisfaction. In this study, a two-case approach was employed to evaluate the UX of AR in m-commerce applications, focusing on Zeelool and AR_Watches. The research utilized both quantitative and qualitative methods, including a UXQ and think-aloud protocols. The results demonstrated that the innovative AR applications in the case studies delivered a superior user experience, with higher scores in the dimensions of "Novelty" and "Stimulation." The congruence between the results from the UXQ and think-aloud protocols further validated the findings and highlighted the significance of AR as an innovative digital touchpoint. By providing practical recommendations for designing engaging and user-friendly AR applications, this study offers valuable insights to researchers, practitioners, and e-retailers aiming to embed AR technology in their systems.

In conclusion, this research highlights the growing significance of AR technology in the m-commerce environment and its potential to revolutionize the way users interact with products and services. By evaluating the UX of AR mobile applications and offering practical recommendations, this study contributes to the broader understanding of how AR can be effectively leveraged by e-commerce organizations to optimize user engagement and achieve business goals. As AR continues to evolve, future research should continue to explore its applications in various sectors and its impact on user experiences to inform and shape the development of AR technology in m-commerce and beyond.

Reference

Abdel-Khalek, G., Mazloum, M.G. and El Zeiny, M.R.M., 2019. Military expenditure and economic growth: the case of India. *Review of Economics and Political Science*, *5*(2), pp.116-135.

Abdulameer, M., Mansoor, M.M., Alchuban, M., Rashed, A., Al-Showaikh, F. and Hamdan, A., 2022. The Impact of Artificial Intelligence (AI) on the Development of Accounting and Auditing Profession. In *Technologies, Artificial Intelligence and the Future of Learning Post-COVID-19: The Crucial Role of International Accreditation* (pp. 201-213). Cham: Springer International Publishing.

Akinadewo, I.S., 2021. Artificial Intelligence and Accountants' Approach to Accounting Functions. *Covenant University Journal of Politics & International Affairs (Special Edition)*, pp.40-55.

Aljaaidi, K., Alwadani, N. and Adow, A., 2023. The impact of artificial intelligence applications on the performance of accountants and audit firms in Saudi Arabia. *International Journal of Data and Network Science*, *7*(3), pp.1165-1178.

Allam, Z. and Dhunny, Z.A., 2019. On big data, artificial intelligence and smart cities. *Cities*, *89*, pp.80-91.

Ameen, N., Hosany, S. and Tarhini, A., 2021. Consumer interaction with cutting-edge technologies: Implications for future research. *Computers in Human Behavior*, *120*, p.106761, pp.1-7.

Andiola, L.M., Masters, E. and Norman, C., 2020. Integrating technology and data analytic skills into the accounting curriculum: Accounting department leaders' experiences and insights. *Journal of Accounting Education*, *50*, p.100655, pp.1-18.

Ardichvili, A., 2022. The impact of artificial intelligence on expertise development: implications for HRD. Advances in Developing Human Resources, 24(2), pp.78-98.

Arrieta, A.B., Díaz-Rodríguez, N., Del Ser, J., Bennetot, A., Tabik, S., Barbado, A., García, S., Gil-López, S., Molina, D., Benjamins, R. and Chatila, R., 2020. Explainable Artificial Intelligence (XAI): Concepts, taxonomies, opportunities and challenges toward responsible AI. *Information fusion*, *58*, pp.82-115.

Baidoo-Anu, D. and Owusu Ansah, L., 2023. Education in the era of generative artificial intelligence (AI): Understanding the potential benefits of ChatGPT in promoting teaching and learning. *Available at SSRN 4337484*, pp.52-62.

Bakarich, K.M. and O'Brien, P.E., 2021. The robots are coming… but aren't here yet: The use of artificial intelligence technologies in the public accounting profession. *Journal of Emerging Technologies in Accounting*, *18*(1), pp.27-43.

Banța, V.C., Rîndașu, S.M., Tănasie, A. and Cojocaru, D., 2022. Artificial Intelligence in the Accounting of International Businesses: A Perception-Based Approach. *Sustainability*, *14*(11), p.6632, pp.1-12.

Bao, Y., Hilary, G. and Ke, B., 2022. Artificial intelligence and fraud detection. *Innovative Technology at the Interface of Finance and Operations: Volume I*, pp.223-247.

Berdiyeva, O., Islam, M.U. and Saeedi, M., 2021. Artificial Intelligence in Accounting and Finance: Meta-Analysis. *International Business Review*, *3*(1), pp.56-79.

Bertino, E., Kantarcioglu, M., Akcora, C.G., Samtani, S., Mittal, S. and Gupta, M., 2021, April. AI for Security and Security for AI. In *Proceedings of the Eleventh ACM Conference on Data and Application Security and Privacy* (pp. 333-334).

Busulwa, R. and Evans, N., 2021. *Digital transformation in accounting*. Routledge, pp.1-9.

Chahar, V., 2023. The Impact of Artificial Intelligence on Innovation. *Best Journal of Innovation in Science, Research and Development*, *2*(7), pp.199-235.

Chan, L., Hogaboam, L. and Cao, R., 2022. Artificial intelligence in accounting and auditing. In *Applied Artificial Intelligence in Business: Concepts and Cases* (pp. 119-137). Cham: Springer International Publishing.

Christian, B., 2020. *The alignment problem: Machine learning and human values*. WW Norton & Company, pp.150-154.

Chukwudi, O., Echefu, S., Boniface, U. and Victoria, C., 2018. Effect of artificial intelligence on the performance of accounting operations among

accounting firms in South East Nigeria. *Asian Journal of Economics, Business and Accounting*, *7*(2), pp.1-11.

Damerji, H. and Salimi, A., 2021. Mediating effect of use perceptions on technology readiness and adoption of artificial intelligence in accounting. *Accounting Education*, *30*(2), pp.107-130.

Das, P.K., Impact of Artificial Intelligence on Accounting), pp.17-24.

Dogru, T., Line, N., Mody, M., Hanks, L., Abbott, J.A., Acikgoz, F., Assaf, A., Bakir, S., Berbekova, A., Bilgihan, A. and Dalton, A., 2023. Generative artificial intelligence in the hospitality and tourism industry: Developing a framework for future research. Journal of Hospitality & Tourism Research, p.10963480231188663, pp.1-19.

Dwivedi, Y.K., Hughes, L., Ismagilova, E., Aarts, G., Coombs, C., Crick, T., Duan, Y., Dwivedi, R., Edwards, J., Eirug, A. and Galanos, V., 2021. Artificial Intelligence (AI): Multidisciplinary perspectives on emerging challenges, opportunities, and agenda for research, practice and policy. *International Journal of Information Management*, *57*, p.101994, pp.1-47.

Emetaram, E. and Uchime, H.N., 2021. Impact of Artificial Intelligence (AI) on Accountancy Profession. *Journal of Accounting and Financial Management E-ISSN*, *7*(2), pp.15-25.

Gonog, L. and Zhou, Y., 2019, June. A review: generative adversarial networks. In 2019 14th IEEE conference on industrial electronics and applications (ICIEA) (pp. 505-510). IEEE.

Gotthardt, M., Koivulaakso, D., Paksoy, O., Saramo, C., Martikainen, M. and Lehner, O., 2020. Current state and challenges in the implementation of smart robotic process automation in accounting and auditing. *ACRN Journal of Finance and Risk Perspectives*, pp.90-102.

Goksel, N. and Bozkurt, A., 2019. Artificial intelligence in education: Current insights and future perspectives. In Handbook of Research on Learning in the Age of Transhumanism (pp. 224-236). IGI Global.

Gusai, O.P., 2019. Robot human interaction: role of artificial intelligence in accounting and auditing. *Indian Journal of Accounting*, *51*(1), pp.59-62.

Kaya, C.T., Türkyılmaz, M. and Birol, B., 2019. Impact of RPA technologies on accounting systems. *Muhasebe ve Finansman Dergisi*, (82), pp.235-250.

Khan, H.M.R., Ahmad, S., Javed, R. and Nasir, N., 2023. The Significance of Artificial Intelligence in Business and Accounting: A Bibliometric Analysis. *Pakistan Journal of Humanities and Social Sciences*, *11*(2), pp.1088-1110.

Kiger, M.E. and Varpio, L., 2020. Thematic analysis of qualitative data: AMEE Guide No. 131. *Medical teacher*, *42*(8), pp.846-854.

Kommunuri, J., 2022. Artificial intelligence and the changing landscape of accounting: a viewpoint. *Pacific Accounting Review*, *34*(4), pp.585-594.

Kureljusic, M. and Karger, E., 2023. Forecasting in financial accounting with artificial intelligence–A systematic literature review and future research agenda. *Journal of Applied Accounting Research*, pp.1-24.

Lachman, R. and Joffe, M., 2021. Applications of artificial intelligence in media and entertainment. In *Analyzing future applications of AI, sensors, and robotics in society* (pp. 201-220). IGI Global.

Lee, C.S. and Tajudeen, F.P., 2020. Usage and impact of artificial intelligence on accounting: Evidence from Malaysian organisations. *Asian Journal of Business and Accounting*, *13*(1), pp.213-239.

Lehner, O.M., Ittonen, K., Silvola, H., Ström, E. and Wührleitner, A., 2022. Artificial intelligence based decision-making in accounting and auditing: ethical challenges and normative thinking. *Accounting, Auditing & Accountability Journal*, *35*(9), pp.109-135.

Lu, C.P., 2017. AI, native supercomputing and the revival of Moore's Law. *APSIPA Transactions on Signal and Information Processing*, *6*, p.e9, pp.1-10.

Maguire, M. and Delahunt, B., 2017. Doing a thematic analysis: A practical, step-by-step guide for learning and teaching scholars. *All Ireland Journal of Higher Education*, *9*(3), pp. 3351-33514.

Malali, A.B. and Gopalakrishnan, S., 2020. Application of artificial intelligence and its powered technologies in the indian banking and financial industry: An overview. *IOSR Journal Of Humanities And Social Science*, *25*(4), pp.55-60.

Mardini, G.H. and Alkurdi, A., 2021. Artificial Intelligence Literature in Accounting: A Panel Systematic Approach. In *The Fourth Industrial Revolution: Implementation of Artificial Intelligence for Growing*

Business Success (pp. 311-323). Cham: Springer International Publishing.

Meryem, A.Y.A.D. and EL MEZOUARI, S., 2022. Research on the implication of artificial intelligence in accounting subfields: current research trends from bibliometric analysis, and research directions. *International Journal of Accounting, Finance, Auditing, Management and Economics*, *3*(5-1), pp.503-522.

Mhlanga, D., 2020. Industry 4.0 in finance: the impact of artificial intelligence (ai) on digital financial inclusion. *International Journal of Financial Studies*, *8*(3), p.45, pp.1-14.

Mishra, V., Agarwal, S.M. and Puri, N., 2018. Comprehensive and comparative analysis of neural network. International Journal of Computer Application, 2(8), pp.126-137.

Mohamad, Z.Z., 2022. The Effect Of Artificial Intelligence On The Accounting Profession. *International Journal of Accounting*, *7*(45), pp.438-447.

Mohammad, S.J., Hamad, A.K., Borgi, H., Thu, P.A., Sial, M.S. and Alhadidi, A.A., 2020. How artificial intelligence changes the future of accounting industry. *International Journal of Economics and Business Administration*, *8*(3), pp.478-488.

Naja, I., Markovic, M., Edwards, P. and Cottrill, C., 2021. A semantic framework to support AI system accountability and audit. In *The Semantic Web: 18th International Conference, ESWC 2021, Virtual Event, June 6–10, 2021, Proceedings 18* (pp. 160-176). Springer International Publishing.

Nasif, A., Othman, Z.A. and Sani, N.S., 2021. The deep learning solutions on lossless compression methods for alleviating data load on IoT nodes in smart cities. Sensors, 21(12), p.4223.

Nóbrega, V., Costa, R.L.D., Gonçalves, R., Dias, Á., Pereira, L. and Dorner, K., 2023. The impact of artificial intelligence in accounting: application in SMEs. *International Journal of Electronic Finance*, *12*(2), pp.192-214.

Nwosu, L.I., Bereng, M.C., Vorster, H. and Segotso, T., Artificial Intelligence And Its Effects On The Accounting Profession For Future Accountants: A Systematic Literature Review, pp.1-16.

Oberoi, S., Kumar, S., Sharma, R.K. and Gaur, L., 2021. Determinants of artificial intelligence systems and its impact on the performance of accounting firms. In *Machine Learning, Advances in Computing, Renewable Energy and Communication: Proceedings of MARC 2020* (pp. 411-427). Singapore: Springer Singapore.

Pilling, F. and Coulton, P., 2019. Forget the Singularity, its mundane artificial intelligence that should be our immediate concern. *The Design Journal*, *22*(sup1), pp.1135-1146.

Qasim, A. and Kharbat, F.F., 2020. Blockchain technology, business data analytics, and artificial intelligence: Use in the accounting profession and ideas for inclusion into the accounting curriculum. *Journal of emerging technologies in accounting*, *17*(1), pp.107-117.

Rai, A., 2020. Explainable AI: From black box to glass box. *Journal of the Academy of Marketing Science*, *48*, pp.137-141.

Rashwan, A.R.M.S. and Alhelou, E.M., 2020. The impact of using artificial intelligence on the accounting and auditing profession in light of the Corona pandemic. *Journal of Advance Research in Business Management and Accounting*, *6*(9), pp.97-122.

Rikap, C., Same End by Different Means: Google, Amazon, Microsoft and Facebook's Strategies to Dominate Artificial Intelligence. *Amazon, Microsoft and Facebook's Strategies to Dominate Artificial Intelligence*, pp.1-30.

Russell, S.J., 2010. *Artificial intelligence a modern approach*. Pearson Education, Inc., pp.1-1095.

Siau, K., Nah, F., Eschenbrenner, B., Chen, L. and Qian, Y., 2022, July. AI in accounting: A value-focused thinking study. In *2022 Annual Pacific Asia Conference on Information Systems (PACIS 2022): Artificial Intelligence, Information Systems, In Pacific Asia (Ai-Is-Asia)* (p. 343). Association for Information Systems (AIS), pp.1-5.

Silva, A.P., Azevedo, G. and Marques, R.P., 2022, June. Artificial Intelligence in Accounting: Literature Review. In *2022 17th Iberian Conference on Information Systems and Technologies (CISTI)* (pp. 1-6). IEEE.

Singh, R., Bansal, R. and Niranjanamurthy, M., 2023. Use and Application of Artificial Intelligence in Accounting and Finance: Benefits and

Challenges. *Data Wrangling: Concepts, Applications and Tools*, p.251-272.

Smith, S.S., 2018. Digitization and financial reporting–how technology innovation may drive the shift toward continuous accounting. *Accounting and Finance Research*, *7*(3), pp.240-250.

Stancheva-Todorova, E.P., 2018. How artificial intelligence is challenging accounting profession. *Journal of International Scientific Publications" Economy & Business*, *12*, pp.126-141.

Stancu, M.S. and Duţescu, A., 2021. The impact of the Artificial Intelligence on the accounting profession, a literature's assessment. In *Proceedings of the International Conference on Business Excellence* (Vol. 15, No. 1, pp. 749-758).

Vărzaru, A.A., 2022. Assessing the Impact of AI Solutions' Ethical Issues on Performance in Managerial Accounting. *Electronics*, *11*(14), p.2221, pp.1-11.

Whittlestone, J. and Clarke, S., 2022. AI challenges for society and ethics. *arXiv preprint arXiv:2206.11068*, pp.1-14.