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Evaluation of User Experience (UX) Design for Emerging Technologies

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Abstract. *The unique challenges inherent in designing for emerging technologies. As these technologies often lack established design principles, UX designers are confronted with the task of navigating uncharted territory. This section examines the complexities associated with understanding user behaviors, expectations, and preferences when interacting with cutting-edge technologies. Adaptive design, user-centered approaches, and iterative prototyping are among the strategies discussed to ensure a user-centric approach that accommodates the evolving nature of these technologies. Special attention is given to the integration of human-computer interaction (HCI) theories and cognitive psychology principles to enhance the overall user experience. UX design for emerging technologies places humans at the center of technological innovation. Research in this area ensures that new technologies align with user needs, preferences, and behaviors, fostering a more natural and intuitive interaction between users and technology. The dynamic nature of emerging technologies necessitates continuous adaptation. Research in UX design provides insights into evolving user expectations, enabling designers and developers to future-proof their practices. This adaptability ensures that design solutions remain relevant and effective as technologies advance. The COPRAS-G method requires identifying selection criteria; evaluating information related to these criteria, and developing methods to evaluate Meeting the participant's needs Criteria for doing in order to assess the overall performance of the surrogate. Decision analysis involves a Decision Maker (DM) Situation to do consider a particular set of alternatives and select one among several alternatives, usually with conflicting criteria. For this reason, the developed complexity proportionality assessment (COPRAS) method can be used. From the result Voice Assistant is got the first rank whereas is the VR headset is having the lowest rank.*

Keywords: *Human-computer interaction, user experience; design; digital innovation; web-based technology; business model (design); UX principles*

1. INTRODUCTION

"Bringing User Experience Design to Bear on STEM Education emphasizes the application of user-centric design principles in the development of STEM (Science, Technology, Engineering, and Mathematics) educational experiences. By prioritizing the needs, preferences, and engagement of learners, UX design aims to enhance the overall educational journey. This approach involves creating intuitive interfaces, interactive content, and adaptive learning pathways to optimize comprehension and retention. In essence, the integration of UX design in STEM education fosters a more user-friendly and effective learning environment, ultimately improving the accessibility and effectiveness of educational materials for students pursuing these critical fields."[1] In the realms of interaction design and human-computer interaction (HCI), the term "user experience" (UX) has gained significant attention. With technological advancements, interactive devices have evolved into not only practical and user-friendly tools but also sought-after, fashionable items. Practitioners and researchers alike are recognizing UX as a compelling alternative to traditional HCI, driven by the belief that a narrow emphasis on interactive products as mere tools overlooks the diverse and expanding aspects of technology usage. Indeed, the term introduces a fresh perspective and a subtle shift in focus, avoiding explicit limitations. In the domains of interaction design and human-computer interaction (HCI), the buzz surrounding "user experience" (UX) has intensified. As technology has progressed, interactive devices have transitioned from practical tools to desirable and trendy items that are also easy to use. UX is rapidly gaining popularity as a competitive option to the conventional HCI approach, as observed by both practitioners and researchers. This shift is likely driven by the recognition that a narrow focus on interactive products as mere tools fails to capture the diverse and expanding facets of technology utilization. Indeed, the term presents a novel viewpoint and a subtle redirection without becoming overly explicit [2] UX is a complex phenomenon that has existed for an extended period. Its fundamental elements encompass individuals, context, interaction, and artifacts. Several factors can impact an organization's effectiveness in UX. Moreover, user experience (UX) emphasizes prioritizing the user over the product, defining it as the "quality of interactive technology." According to Hassenzahl and Tractinsky, as technology advances, interactive goods and services not only become practical and usable but also gain a sense of style and contemporaneity. In their study, user experience (UX) is characterized as the emotions a person experiences when engaging with a product, service, or application. The recent rise of design thinking, recognizing emotional involvement as a crucial element facilitating the sustainable use of mobile applications, is attributed to this definition [3] The main objectives of assessment methods include aiding in the choice of the most suitable design, ensuring that the development is on track as intended, and evaluating whether the final product meets the initial UX goals. [4] Web-based technologies, products, and services rely on user experience (UX) since user-centered design (UCD) emphasizes the importance of delivering an engaging, efficient, uncomplicated, and accessible experience for all users. [5] Establishing user experience goals is crucial for steering the design process of industrial systems. By defining clear objectives, designers can ensure that the user experience aligns with the specific needs and expectations of the system's users. These goals may encompass factors such as efficiency, safety, ease of use, and overall user satisfaction. By focusing on user experience goals, designers can create industrial systems that not only meet functional requirements but also provide a positive and effective interaction for the individuals using the system in an industrial contex .[6] User Experience (UX) measurement is a comprehensive process aimed at evaluating the quality of user interactions with a product, system, or service. It involves the use of various methods and metrics to gain insights into users' perceptions, behaviors, and satisfaction levels. Surveys, questionnaires, and usability testing capture subjective and observational feedback, while analytics tools provide quantitative data on user engagement and other key performance indicators. The combination of qualitative and quantitative metrics, such as task success rate, error rates, and system performance, helps organizations assess usability and technical efficiency. Additionally, Net Promoter Score (NPS) and Customer Satisfaction (CSAT) offer overall satisfaction insights. UX measurement is crucial for identifying areas of improvement, optimizing user experiences, and ultimately enhancing the overall effectiveness of products or services. [7] The area of software development and research dedicated to crafting user interfaces that are user-friendly is known as user experience, or UX. It is closely linked to both usability and human-computer interaction (HCI). Teaching UX can pose challenges for many educators. UX design is an interdisciplinary, multicultural, and multidimensional field that demands a profound comprehension of various domains. [8] In addition to the widely adopted field of human-computer interaction, significant application areas involve the utilization of virtual reality (VR) and augmented reality (AR) technologies. Rather than relying on conventional human-machine interfaces like Windows, VR enables users to completely immerse themselves in a three-dimensional computer-generated environment. This integration of VR incorporates various technologies, including artificial intelligence, sensing, and three-dimensional computer graphics. Augmented reality (AR), built upon VR technology, employs computer graphics and display technology to introduce and position virtual objects and information. It utilizes sensing technology to accurately "place" these virtual objects in the real world, seamlessly merging them with real objects through specialized equipment. This integration facilitates the blending of physical and virtual worlds, offering observers a form of real-time engagement. AR and VR technologies find frequent applications in sectors such as construction, education, and healthcare, the military, and entertainment. [10] This comprehensive framework delves into the intricacies of designing user-centric interactions within IoT environments. Emphasizing intuitive and efficient experiences, the model encompasses elements like user interface design, information architecture, and rigorous usability testing. Within the Living Labs setting, this framework acts as a dynamic guide, fostering collaborative innovation and real-world testing. It addresses the unique challenges of IoT, ensuring a seamless user experience amidst the diverse devices and data streams. In essence, the UX Framework and Model serve as a sophisticated roadmap, shaping immersive and cohesive user experiences in the evolving landscape of IoT-enabled environments. [11] The User Experience (UX) design for a smart-mirror-based personalized training system is crafted with a meticulous focus on seamlessly blending technology with user interaction. In this innovative approach, the smart mirror serves as a dynamic interface for delivering personalized training experiences. The UX design prioritizes user engagement by integrating intuitive controls and responsive feedback mechanisms. Users can access tailored workout routines, real-time performance metrics, and instructional content directly through the smart mirror's reflective surface. The interface is designed to be visually appealing, providing an immersive training environment that adapts to individual preferences and progress. Emphasis is placed on creating a user-friendly journey, from initial setup to ongoing use, ensuring that the smart mirror becomes an integral and enjoyable part of the user's personalized training regimen. This UX design not only leverages the capabilities of smart mirror technology but also enhances the overall user experience by seamlessly combining fitness guidance with cutting-edge interactive design.[12]

2. MATERIALS AND METHOD

Alternative parameters: Smart Glasses, AR Headset, VR Headset, Voice Assistant, Wearable Tracker. ***Evaluation parameters:*** Ease of Use, Innovation, Cost, and Privacy & Security.

Smart Glasses: Smart glasses refer to a type of wearable technology that incorporates a display, computing power, and various sensors into a pair of eyeglasses or sunglasses. These devices often have the capability to provide information directly to the user's field of view, typically through a heads-up display (HUD) or augmented reality (AR) technology. Smart glasses can offer features such as real-time navigation, notifications, hands-free communication, and the ability to interact with digital content. The technology behind smart glasses allows users to access and display information without the need for a separate screen, such as a smart phone or computer. Some smart glasses also come equipped with cameras, microphones, and other sensors to capture and analyze the surrounding environment, enabling features like image recognition, voice commands, and gesture controls.

AR Headset: An AR headset, short for Augmented Reality headset, is a type of wearable device that combines physical reality with computer-generated information or virtual elements. AR headsets are designed to overlay digital content onto the user's real-world view, enhancing their perception and interaction with the environment. AR headsets typically incorporate transparent or semi-transparent displays that allow users to see both the virtual and real-world simultaneously. This is in contrast to virtual reality (VR) headsets, which completely immerse users in a computer-generated environment.

VR Headset: A VR headset, or Virtual Reality headset, is a head-mounted device that immerses the wearer in a computer-generated virtual environment. It is designed to create a simulated reality that replaces or augments the real-world sensory experiences with virtual content. VR headsets are commonly used in various applications, including gaming, simulations, training, entertainment, and virtual tourism.

Voice Assistant: A voice assistant is a digital assistant that uses voice recognition, natural language processing, and speech synthesis to perform tasks, provide information, or interact with users. These assistants are typically found in various devices such as smart phones, smart speakers, smart TVs, and other smart devices. Users can communicate with voice assistants by speaking commands or asking questions, and the assistant responds with relevant information or performs the requested actions.

Wearable Tracker: A wearable tracker, often referred to as a fitness tracker or wearable fitness device, is a type of wearable technology designed to monitor and track various aspects of an individual's physical activity, health, and overall well-being. These devices are typically worn on the body, often as a wristband or attached to clothing, and use sensors to collect data related to the user's movements, heart rate, sleep patterns, and other health-related metrics.

Method: COPRAS (Complex Proportionality Assessment) is one of the most used (MCTM) methods, and the ratio of the best solution Determining the solution with the best rate in the set of possible alternatives by Provides a better alternative Bad Solution. This technique has Decision making problems various to solve used by researchers [12]. The COPRAS-G method requires identifying selection criteria; evaluating information related to these criteria, and developing methods to evaluate Meeting the participant's needs Criteria for doing in order to assess the overall performance of the surrogate. Decision analysis involves a Decision Maker (DM) Situation to do consider a particular set of alternatives and select one among several alternatives, usually with conflicting criteria. For this reason, the developed complexity proportionality assessment (COPRAS) method can be used [13]. In 1996 in Lithuania COPRAS (Complex Proportion evaluation) method was developed. Construction economics, real estate and management. One of the articles assesses the risks involved in construction projects. The assessment is based on various multi-objective assessment methods. The risk assessment indices are selected considering the interests, objectives and factors of the countries that influence the construction efficiency and real estate price increase [14] to describe and consider the task model. Complex Proportionality Assessment (COPRAS) Method Similar to any many other criteria will make the decision (MCDM) tool, first Proposed COBRAS method of several related criteria basically for alternatives Used to prioritize criterion weights. This method is better and Worst-Best Solutions Best decision considering Selecting alternatives [15]. Cobras approach is used for device tool choice; Because of this the triangle Ambiguous numbers are selected their computational performance. Three area specialists are selected to assign weights and by way of combining the fuzzy cobra’s method, System 1 (MC1) and device 2(MC2) similarly are ranked, with way of ma chine three and four. -based totally approach is utilized in mixture with fuzzy. COPRAS assess the complexity of consumer dating management (CRM) performance. A combined choice matrix is obtained from a panel of 20 specialists offered 3 options with set, and 5 criteria Assessment are done [16].COPRAS to resolve MCDM issues, wherein the weights of the criteria and Performance ratings of alternatives are absolute Based on linguistic terms are calculated. Comparison of criteria Importance calculated and Cobras method become used to assess renovation strategies [17].This have a look at ambitions to develop the impact of latest overall performance metrics in TPM and COPRAS in an ambiguous context Primarily multi-criteria selection based on opinions Use the do method. Looseness of paper is prepared as follows. Section 1 provides an overview of the disruption and a literature review. Section 2 focuses on the Cobras-G approach and the corresponding literature review. Sections three and four introduce the core principles of the Cobras-G methodology, emphasizing its utilization based on the recommended approach, which is described as COPRAS-G. This complex proportional estimation approach employs numerical data represented using the Grey Systems Theory framework. The Cobras-G concept approach is rooted in Grey Systems Theory programs, real-world decision-making scenarios, and duration-based standard values. Diploma [18].COPRAS method changed into the most relevant social media platform Rank and choose is used. Proposed Applicability of the structure We proved and proved the character [19].COPRAS (Complex Proportionality Assessment) To examine Cumulative of an alternative Performance, it is essential become aware of the maximum vital criteria, examine the options and compare the facts Depending on those criteria to fulfill the wishes of the DMs to compare grades evaluation involves a situation in which a DM must pick amongst several downloaded alternatives given a selected set of commonly conflicting standards. For this motive, the developed complex proportionality evaluation (COPRAS) method can be used in real situations, alternatives The criteria for assessment are vague is related to the factor, And the values of the standards are real Cannot be expressed with numbers [20].

3. RESULTS AND DISCUSSION

TABLE 1. Evaluation of User experience (UX) design for emerging technologies.

	Ease of Use	Innovation	Cost	Privacy & Security
Smart Glasses	8.5	9	7,500	25
AR Headset	9.2	8.5	10,000	45
VR Headset	8	9.5	9,000	75
Voice Assistant	9.5	8.2	150	80
Wearable Tracker	8.8	7.8	200	100

Table 1 shows compare above values Ease of Use: Voice Assistant has the highest rating at 9.5, indicating that users find it very easy to use. AR Headset follows closely with a rating of 9.2. Smart Glasses and Wearable Tracker have scores of 8.5 and 8.8, respectively. VR Headset is rated the lowest in terms of ease of use with a score of 8. Innovation: VR Headset has the highest innovation rating at 9.5, indicating it is perceived as highly innovative. Smart Glasses and AR Headset follow closely with scores of 9 and 8.5, respectively. Voice Assistant and Wearable Tracker have innovation scores of 8.2 and 7.8, respectively. Cost: Voice Assistant is the most cost-effective at 150. Wearable Tracker is also relatively affordable with a cost of 200. Smart Glasses, AR Headset, and VR Headset have higher costs ranging from 7,500 to 10,000. Privacy & Security: Smart Glasses have the lowest privacy and security score at 25. AR Headset and Voice Assistant have scores of 45 and 80, respectively, indicating higher privacy and security concerns. VR Headset and Wearable Tracker have the highest privacy and security scores at 75 and 100, respectively.

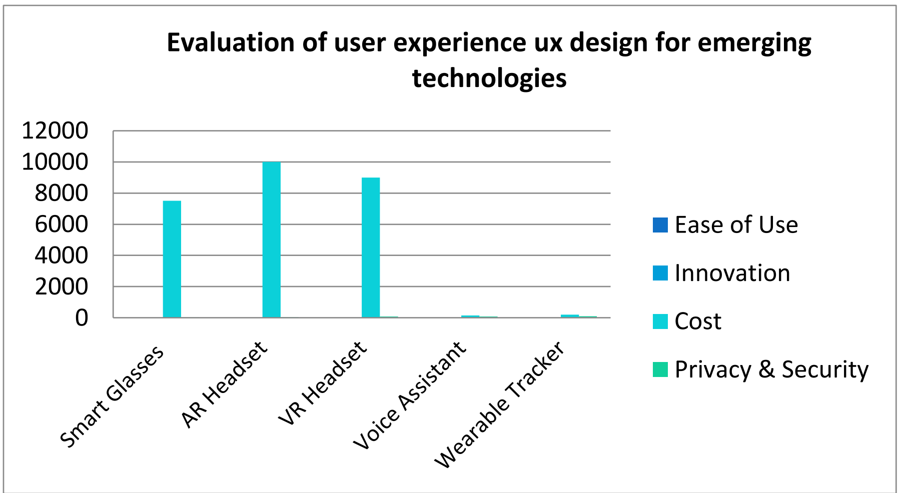

FIGURE 1. Evaluation of User experience (UX) design for emerging technologies.

Figure 1 illustrates the graphical representation of User experience (UX) design for emerging technologies.

TABLE 2. Normalized Data.

Ease of Use	Innovation	Cost	Privacy & Security
0.1932	0.2093	0.2793	0.0769
0.2091	0.1977	0.3724	0.1385
0.1818	0.2209	0.3352	0.2308
0.2159	0.1907	0.0056	0.2462
0.2000	0.1814	0.0074	0.3077

Table 2 shows the explanation of normalized data. Ease of Use: Normalized values range from 0.1818 to 0.2159. The values indicate the relative ease of use of the system, with higher values suggesting higher ease of use. Innovation: Normalized values range from 0.1814 to 0.2209. These values represent the degree of innovation associated with the system, with higher values indicating a higher level of innovation. Cost: Normalized values range from 0.0056 to 0.3724. These values signify the relative cost associated with the system, with lower values indicating lower costs and higher values indicating higher costs. Privacy & Security: Normalized values range from 0.0769 to 0.3077. These values represent the level of privacy and security offered by the system, with higher values suggesting a higher level of privacy and security.

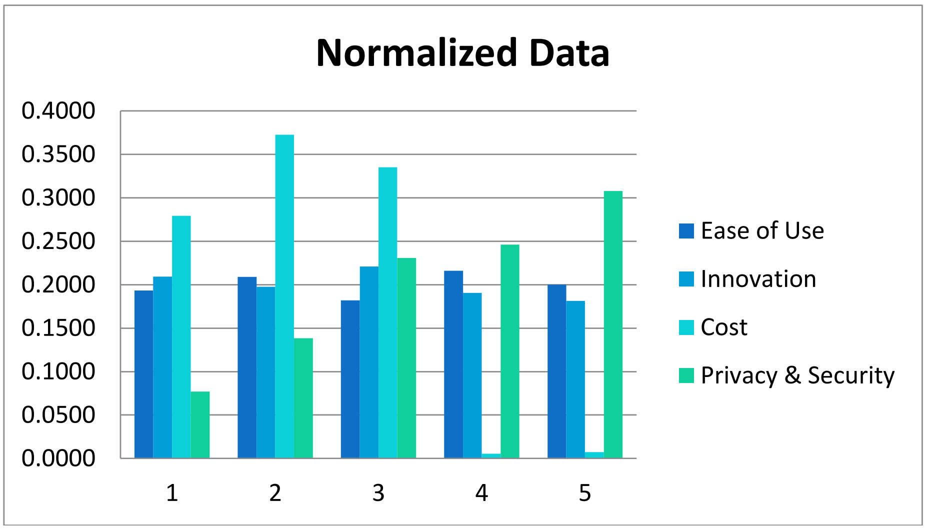

FIGURE 2. Normalized Data

Figure 2 illustrate the graphical representation of Normalized Data.

TABLE 3. Weight ages

Weight			
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25
0.25	0.25	0.25	0.25

Table 3 shows weight ages the interpretation of these weights suggests that all five approaches (Smart Glasses, AR Headset, VR Headset, Voice Assistant, and Wearable Tracker) are considered equally important in the assessment of User experience (UX) design for emerging technologies.

TABLE 4. Weighted normalized decision matrix

Weighted normalized decision matrix			
0.05	0.05	0.07	0.02
0.05	0.05	0.09	0.03
0.05	0.06	0.08	0.06
0.05	0.05	0.00	0.06
0.05	0.05	0.00	0.08

Table 4 shows weighted normalized decision matrix. The weights and normalized scores in the matrix are used to calculate a weighted sum or weighted average for each alternative. This allows decision-makers to compare and rank the alternatives based on their overall performance, considering the relative importance of the criteria. To calculate the overall performance score for the first alternative, would multiply each criterion's score by its respective weight, and then sum the products: Overall Performance (Alternative1)=(0.02* Weight1)+(0.06* Weight2)+(0.06* Weight3)+(0.05* Weight4).

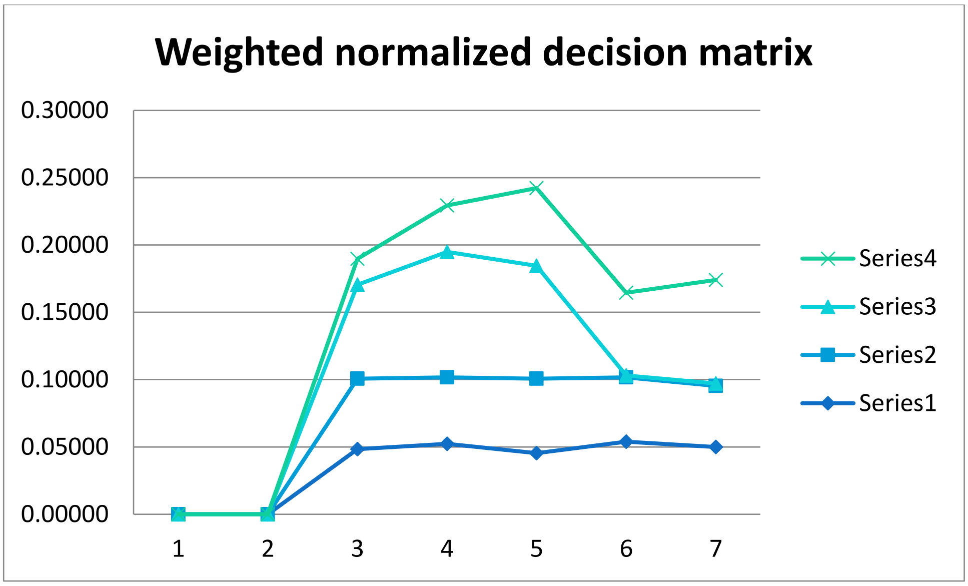

FIGURE 3.weighted normalized decision matrix

Figure 3 illustrate the graphical representation of weighted normalized decision matrix

TABLE5. Bi, Ci, Min (Ci)/Ci

Bi	Ci	Min(Ci)/Ci
0.101	0.089	0.7066
0.102	0.128	0.4927
0.101	0.141	0.4448
0.102	0.063	1.0000
0.095	0.079	0.7988

Table 5 shows Bi, Ci and Min (Ci/Ci) Bi: This column (presumably labeled "Bi") contains values such as 0.101, 0.102, 0.101, 0.102, and 0.095. These values likely represent different measurements or assessments related to the user experience of emerging technologies. Ci: This column (presumably labeled "Ci") contains values such as 0.089, 0.128, 0.141, 0.063, and 0.079. Similar to the "Bi" column, these values likely represent different measurements or metrics related to the user experience of emerging technologies. Min (Ci)/Ci: This column seems to present the ratio of the minimum value in the "Ci" column to each corresponding value in the "Ci" column. For each row, "Min (Ci)" refers to the minimum value in the "Ci" column, and "Min (Ci)/Ci" is the result of dividing this minimum value by the corresponding value in the "Ci" column. The purpose of this ratio could be to highlight the relative significance or impact of each measurement in the "Ci" column, emphasizing the influence of the minimum value.

TABLE6. Final Result of User experience (UX) design for emerging technologies.

	Qi	Ui	Rank
Smart Glasses	0.203	82.3254	3
AR Headset	0.173	70.1766	4
VR Headset	0.165	66.9498	5
Voice Assistant	0.247	100.0000	1
Wearable Tracker	0.211	85.6125	2

Table 6 final result of user experience design for emerging technologies .Qi: This column (presumably labeled "Qi") contains values such as 0.203, 0.173, 0.165, 0.247, and 0.211. The "Qi" values likely represent some quantitative measure or score associated with the user experience of each technology. The nature of this score would depend on the evaluation criteria used. Ui: This column (presumably labeled "Ui") contains values such as 82.3254, 70.1766, 66.9498, 100.0000, and 85.6125. The "Ui" values seem to represent some numerical metric or performance indicator associated with each technology.

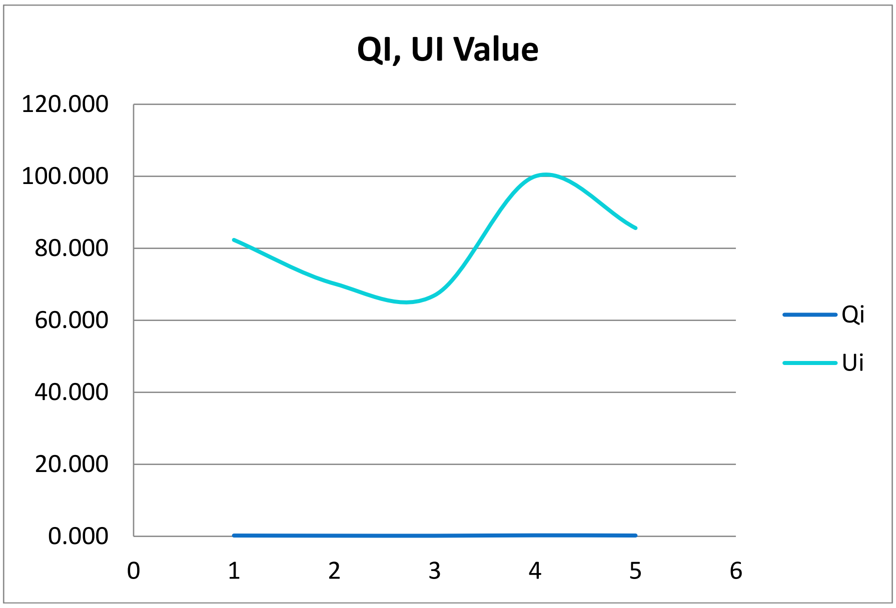

FIGURE 4. Qi, Ui value

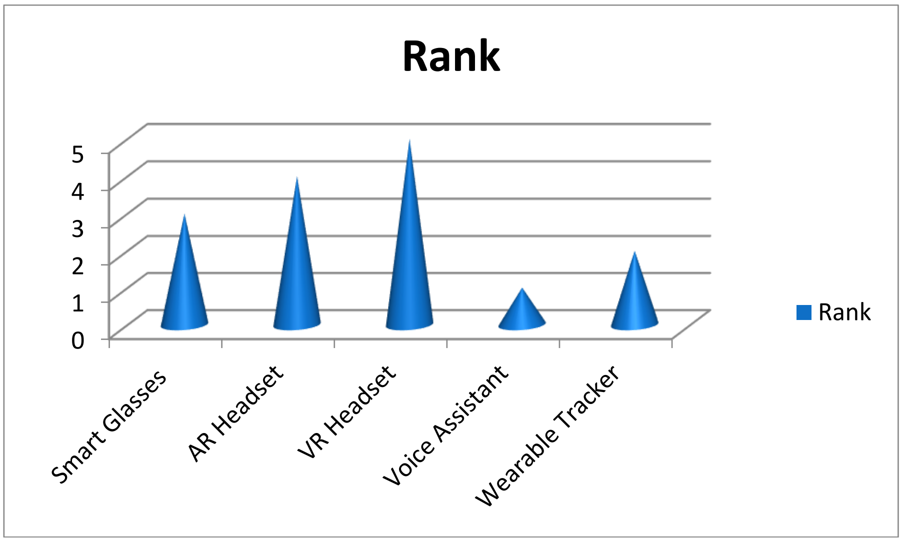

FIGURE 5. Rank

Figure 4 illustrate the graphical representation of Qi, Ui value. Figure 5 Shows ranking of User experience (UX) design for emerging technologies, voice Assistant is got the first rank whereas is the VR headset is having the lowest rank.

4. CONCLUSION

User experience (UX) design for emerging technologies is a dynamic and pivotal field that demands a holistic and forward-thinking approach. As we navigate the ever-evolving landscape of technology, from augmented reality to artificial intelligence, the role of UX design becomes increasingly significant in shaping how users interact with these innovations. The success of emerging technologies hinges not only on their functionality but equally on the seamless and intuitive experiences they offer. As UX designers, our responsibility extends beyond aesthetics to encompass an in-depth understanding of user behavior, needs, and expectations. Striking a delicate balance between innovation and usability is paramount, ensuring that the adoption of these technologies is not hindered by complex interfaces or unintuitive interactions. Ultimately, a user-centric mindset, coupled with adaptability to evolving trends, is the cornerstone of effective UX design for emerging technologies, paving the way for a harmonious integration of cutting-edge innovations into our daily lives.

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