

The *Kansei* Engineering Method for Determining the Emotional Design Concept of the Metaverse Library Interface: Technical University Students Perspectives

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Abstract

The rise of metaverse technology has impacted the way education is experienced through immersive interfaces, making user interface (UI) design a critical factor in shaping its emotional impact on users; the key to fostering engagement and satisfaction. However, providing emotion-centric UI that effectively satisfy user demands and technological competencies is an ongoing challenge. For that reason, this study examines the emotional responses from students of a technical university regarding metaverse library interfaces, aiming to identify the mapping correlation between UI design factors and the user-demanded experience. This experiment employed *Kansei* Engineering (KE) method, incorporating 28 specimens and 60 *Kansei* Words (KWs). Through the application of multivariate statistical analysis, the emotionally demanding UI concepts for the metaverse library were determined, with “radiance”, “orderliness”, and “conciseness” identified as the most significant (72.68%). Drawing from these findings, this study provides valuable guidance for improving user experience (UX) and shaping future design strategies of the metaverse libraries in technical universities. This research not only enhances emotional experience through UI design but also contributes to the growing importance of digital literacy in modern technical-based education and educational technology development, aligned with the goal of Technical and Vocational Education and Training (TVET).

1. Introduction

There has been a substantial interest in applications designed for virtual experiences since the metaverse came to prominence, with the metaverse library is one of the revolutionary applications enabled by the emergence of this technology, offering users an immersive experience to explore a diverse array of digital resources in virtual environment (Raj et al., 2023; Zuo & Shen, 2024). This advancement holds a particular important in the field of Technical and Vocational Education and Training (TVET), where the emphasis is on providing students with practical-technological skills (Bonde, 2024). However, designing a metaverse library with a user interface (UI)

that balances practicality with technological progress, while also addressing the unique demands of users, presents a significant challenge (Pizzolante et al., 2023). By addressing this issue, designers can harness the full potential of the metaverse as a medium for more widely accepted knowledge dissemination. Therefore, to overcome this challenge, a methodical approach is necessary.

Kansei Engineering (KE) offers a methodical approach with proven success in addressing challenges associated with UI design (Nagamachi & Lokman, 2015). The utilization of KE method helps designers to accurately address the user emotional demands, establishing a strong basis for UI design. This method enables the UI to align dynamically with user's subjective perceptions, enhancing the overall engagement and satisfaction (Ahmad, Abdullah, et al., 2023). While emotional design and metaverse have garnered increasing attention, there is surprisingly a notable lack of studies at the intersection of these two domains. Although prior studies have investigated different methods for applying emotional design in the metaverse (Radovanović & Kovačević, 2022), there remains a significant gap in understanding how these approaches can enhance user experience (UX) within virtual environments, along with a lack of design recommendations tailored specifically for the metaverse applications. In contrast to this approach, (Pyae et al., 2023) have focused on evaluating the emotional experience of the metaverse learning system tailored for undergraduate students by exploring their emotions, in order to determine their level of satisfaction. Similarly, (Suh, 2023) examined how users' emotional experiences on commercial metaverse applications influence their tendency to stay engaged with the applications and their findings concluded that the continuance intention positively influenced by the technology engagement. Another scope of research is presented by Lokman, et al., (2023), which investigates the use of emotional keywords in the design of ubiquitous applications. However, their focus is rather limited to the identification of *Kansei* words.

Nevertheless, past literature did not address the design factors associated with user emotions in the context of the metaverse, particularly from the technical students' point of view, leaving a significant gap in the emerging field of UX, design efficacy, and TVET. Thus, the scarcity of research conducted in this domain underscores the need for further investigation. Recognizing this gap, the study aimed to explore the metaverse library applications within an Augmented Reality (AR) setting, as the focus of the study. By understanding and incorporating emotional factors into the evaluation process, the research aimed to optimize UX within the metaverse library by providing optimal design recommendation to foster deeper engagement and satisfaction. To achieve this goal, this study investigates the influence of technical university students' emotional factors on the metaverse library interface. As a result, this research proposed the emotional design concepts that significantly impact UX and should be taken into account when designing or redesigning the UI of the TVET university libraries.

2. Research Background

2.1 Metaverse Library

The metaverse, an immersive environment has emerged as a transformative innovation, blending the physical reality with digital virtuality. As a key component of the metaverse, augmented reality (AR) plays a crucial role in this shift, enabling new ways of digital interaction through the convergence of advanced technologies (Mystakidis, 2023; Zhou et al., 2024). The influence of the metaverse goes beyond the entertainment industry (Dhingra, 2024). Various sectors, such as education and libraries, are now embracing the opportunities and advantages this technology offers (Ahmad, et al., 2024; Amzat & Adewojo, 2023; Na & Park, 2023). An educational platform within the metaverse can create dynamic, interactive and highly personalized experiences. This virtual setting is also anticipated to have an important role in TVET field by providing students with hands-on experience in a simulated digital world, which aligns with the need for technological skills adaptation (Bonde, 2024; Ismail et al., 2026). The emergence of the metaverse library marks a significant progression in library usage and implementation, after digital libraries. As the metaverse gains traction, a significant transformation in education sector is expected. To stay current with technological progress and play a part in this mixed reality revolution, libraries must evolve their services. This is also consistent with the views of many scholars, who advocate for libraries to adopt new technology in order to ensure that the education sector continues to grow (Gupta & Walia, 2023; Iakovides et al., 2022; Uddin et al., 2023; Wang, 2023). The objective was to investigate the potential of this technology to improve user engagement and provide a more dynamic experience, which would ultimately foster greater usage and attract more patrons (Daradkeh, 2023; Guo et al., 2023; Uddin et al., 2023).

However, the integration of technology advancements into library applications should be in harmony with the UX. Sedianingsih et al., (2023) argued, ease of use is not the sole factor. In fact, the UI plays a critical role that influences the acceptance of the metaverse application among its users. Therefore, creating an effective virtual environment depends on a thoughtfully crafted UI design (Iakovides et al., 2022) to ensure satisfying experience. This perspective is further supported by (Broek et al., 2022; Oladokun et al., 2023), reflecting the scholarly agreement on the metaverse interface. In a metaverse environment that centered primarily on visual aspects, the UX is closely connected to UI design. Improper UI design may lead to challenges such as confusing iconography and imprecise instructions (Behnam & Budiu, 2022), resulting in difficult technology adaptability and lower user

acceptability (Baumgartner-Kiradi et al., 2018). Thus, (Broek et al., 2022; Far & Rad, 2022) urged for the continuous enhancement of UI design requirements, emphasizing the incorporation of additional constraints and considerations to enhance the overall UX effectively. As suggested by (Alkhwaldi, 2023; Dirin & Laine, 2018; Suh, 2023), the emotional aspect is vital in metaverse design. Hence, to form a visual appealing interface, it is essential to incorporate the targeted-user perception into its design (Iakovides et al., 2022; Sediyaningsih et al., 2023). This emphasizes the significance of conducting research that investigates metaverse experiences from an emotional perspective.

2.2 Technology Advancement and TVET

Globally, TVET education has grown significantly, focusing on enhancing learners' ability to engage with cutting-edge technologies. This initiative aims to equip individuals with the technical knowledge and competencies required in modern industries. In Malaysia, technical universities play a crucial role in realizing the TVET initiatives by focusing on engineering and technology courses, integrating digital tools and platforms including the metaverse, to improve learning outcomes and prepare students for future digital workplaces (Badawi & Drăgoicea, 2023; Bonde, 2024). As technology advances, the competencies required by employees are also transforming, necessitating continuous training and development initiatives to ensure graduates are equipped not only with technical skills but also soft skills that align with industry expectations (Salleh & Sulaiman, 2016a). Active involvement in technology-based activities, such as metaverse applications, further enriches the educational experiences and outcomes of students in technical universities.

The incorporation of metaverse technology into education offers a fresh setting for learning. Nevertheless, research and exposure to metaverse technology in TVET education is very limited in scope (Badawi & Drăgoicea, 2023; Ismail et al., 2026; Nasir et al., 2023). Several studies (Nasir et al., 2023; Yusop et al., 2023) have highlighted the potential of the metaverse within the TVET context. For instance, Nasir et al. (2023) explored its possible applications across both academic and non-academic settings in Malaysia. A positive finding from another research on gamified applications have demonstrated a notable increase in the motivation and engagement of TVET students in learning (Samah & Ismail, 2021). Studies have suggested that the metaverse can provide a platform to develop both technical and soft skills, as highlighted by Salleh and Sulaiman (2016b), who emphasized the importance of competencies that bridge technical knowledge with organizational needs. Despite this potential, Razak et al. (2022) argued that strong digital skills are a prerequisite for leveraging such technologies, requiring students to continuously build and refine their digital proficiency. This is further supported by Badawi and Drăgoicea (2023) and Yusop et al. (2023), who recommended active participation of TVET students with latest technologies to deepen their understanding of the true essence of TVET. The limited direct involvement of TVET students in hands-on activities or evaluations of metaverse applications highlights their potential as an ideal group focus for this research. As technology advances, the competencies required by employees are also transforming, necessitating continuous training and development initiatives (Salleh & Sulaiman, 2012).

Educational institutions, therefore, must not only integrate advanced technologies like the metaverse into their curricula but also focus on developing competencies that are aligned with industry expectations. This holistic approach ensures that graduates are not only knowledgeable but also adaptable to the rapidly changing technological landscape, ultimately enhancing their employability.

2.3 Emotional Design Through *Kansei* Engineering

The emotional design field has gained increasing interest from scholars as they explore its practical applications in various domains. In the field of metaverse, it is generally recognized that ignoring its potential would be a missed opportunity, highlighting the urgent need for further attention and investigation in this area (Nik Ahmad et al., 2022; Dirin & Laine, 2018). One of the widely used methods for evaluating users' emotional responses to product design is KE (Nagamachi, 2018). KE is known for its ability to translate users' emotions, known as "*kansei*", into product designs (Schütte et al., 2023). KE is a well-established methodology employed across various domains to enhance UX by integrating emotional design into UI. This method focuses on capturing and integrating user emotions through a structured process, including the identification of *Kansei* Words (KWs); descriptive terms that represent user emotions (Ahmad, Lokman, et al., 2023). KE method involves utilizing specimens as design references and going through statistical analysis to identify the most significant emotions, ensuring design effectively resonates with targeted users on an emotional level.

Prior research on emotional design employing KE has mainly concentrated on improving the UI design of mobile applications (Fischer, 2020; Mimura et al., 2020), web applications (Kandambi et al., 2022; Papantonopoulos & Karasavova, 2021; Redzuan et al., 2014), and ubiquitous applications (Ahmad, Lokman, et al., 2023). A previous study (Mimura et al., 2020) has conducted a *Kansei* experiment to uncover the suitable design concepts for a sale application which led them to uncover forty-two potential design elements, in which eight of them were selected as final features to be included in the application. While Fischer (2020) conducted research to investigate the emotional design concepts that affect user satisfaction with mobile applications using KE

method. Their research findings revealed that users prioritize 'ease of use' as a means to achieve higher levels of satisfaction in their study context. In another context, Kandambi et al. (2022) conducted a study that focused on how to use the color concepts to enhance the UX of web interfaces using KE, having designerwear websites as their specimens. The results of the study led to the development of guidelines for incorporating color concepts associated with the *Kansei* words 'Excited' and 'Stylish' into the website interface design. On the other hand, deviating from the focus of other studies, Papantonopoulos and Karasavova (2021) conducted a multivariate statistical *kansei* analysis on commerce product catalogue. Despite its primary focus on conventional UI design, (Ahmad, Lokman, et al., 2023) argues that, the scope of *Kansei* research should expand and evolve alongside technological advancements. Consequently, they have directed their KE research towards various pervasive applications, including the metaverse. Motivated by the achievements of prior research in the field and recognizing the gap in studies focused on emotional metaverse UI design especially for TVET students, this study applied the KE methodology to gain user's emotional response in determining the ideal design concepts for the metaverse library.

3. Methodology

This part details the method and steps taken to examine the users' emotional reactions to the metaverse library UI. The study adopts the KE method, leveraging multivariate statistical techniques to assess emotional factors specific to the metaverse library context. The method, which comprises of four phases; instrumentation, experiment, analysis, and results is depicted in Figure 1 and further discussed in the sections that follow.

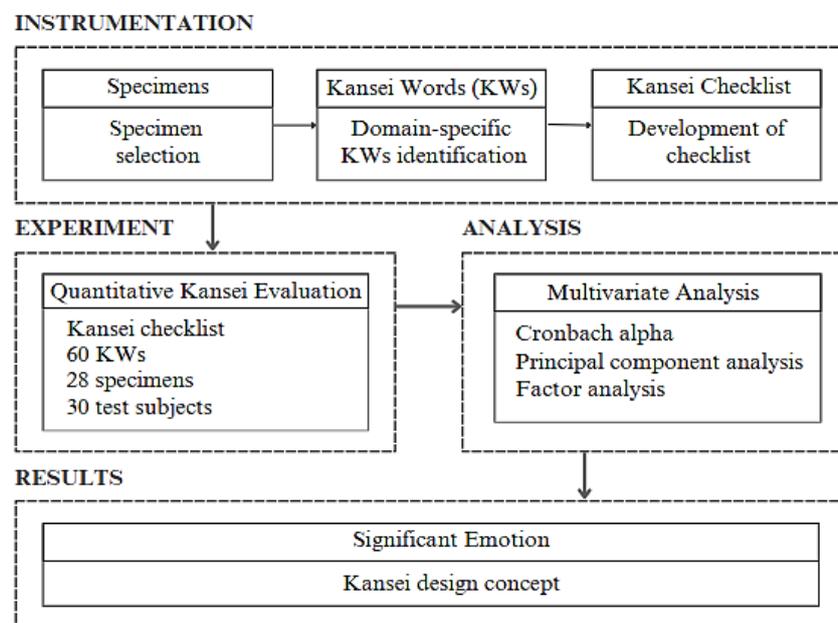


Fig. 1 The Kansei engineering method implemented in this study

3.1 Instrumentation

3.1.1 Specimens

In KE practice, selecting specimens that represent the key characteristics and features of the target domain is essential in achieving the desired design outcomes (Abdi & Greenacre, 2020; Ramadhan et al., 2022). In order to determine the appropriate specimens for the investigation, an initial count of 32 specimens were collected, sourced from a combination of online resources and university projects. This research scope is directed towards the AR angle, primarily utilizing AR library specimens to illustrate the concept of the metaverse libraries. Subsequently, a thorough screening procedure was carried out to eliminate redundancies and choose the specimens that best represent the metaverse library, resulting in 28 final AR library specimens. This step is crucial to ensure that the subsequent analysis is conducted on relevant product samples. Valid specimens provide reliable results, guiding decisions on design improvements, user engagement strategies, and the overall effectiveness of metaverse library implementations.

3.1.2 *Kansei* Words (KWs)

Another critical aspect of KE research is the identification of KWs that will be utilised within the research context. KWs are keywords that pertain to the emotive or affective aspects of beings, which also referred to as emotional keywords (Jia & Jin, 2020). It refers to the users' emotional responses towards metaverse library application as they engaged, interacted, or utilised it. Determining KWs is essential to the success of *Kansei* research. By identifying the right keywords in the domain area, the investigations will be more focused and targeted, resulting in more precise research outcomes. In this study, the KWs were derived from diverse sources, including journals, conference proceedings, periodicals, and magazines. These KWs were then going through a comprehensive validation process carried out by language and technical experts, as outlined in Ahmad et al. (2023). These sources consist of descriptive terms that reflect users' emotional perspectives related to the metaverse libraries, including terms like attractive, cheerful, and complicated. This step will produce a refined list of selected keywords that are pertinent to the study's context. This collection of keywords will serve as the basis for developing the *Kansei* checklist in the subsequent phase.

3.1.3 *Kansei* Checklist

After the KWs have been finalized, the next step is to transform them into the semantic differential (SD) scale structure known as *Kansei* checklist. This study employs all the 60 KWs attained from the prior step. As suggested by Nagamachi and Lokman (2011), this scale pattern employs five levels, ranging from 1 to 5, with a "Not" prefix indicating the lowest score (scale 1), and its absence representing the highest score (scale 5). For example, when analyzing the KW "Appealing," the presence of "Not" prefix (written as "Not Appealing") denotes the lowest score, while the absence of the prefix denotes the highest score. Next process involved transforming the SD Scale into a Google Form to streamline the online data collection.

3.2 Experiment

In KE, it has been proven that the *Kansei* structure remains consistent across different sample sizes, as demonstrated by Lokman et al. (2009), who experimented with 30, 60, 90, and 120 samples. The results consistently produced a similar design structure with no significant difference. Hence, this evaluation involved 30 undergraduate students from one of the Malaysia technical universities as test subjects for this quantitative study. The instruments used for the evaluation consisted of 28 specimens and 60 KWs in SD scale form. The experiment was conducted in a computer lab at a local university, where participants received a briefing and were shown a video demonstration of each specimen. They were also provided with a link to an online *Kansei* checklist via Google Form, which allowed them to record their responses based on the specimens presented to them. The session extended for approximately three hours. During this session, participants were presented with 28 AR specimens. They were then instructed to record their feelings about each specimen using a checklist containing 60 emotional keywords.

3.3 Analysis

In order to facilitate the process of data analysis, a review was conducted on the gathered experimental data, which was subsequently averaged and subjected to multivariate statistical analysis. To ensure the reliability and validity of the data, a series of statistical analyses was conducted, including Cronbach's Alpha, Principal Component Analysis (PCA) and Factor Analysis (FA). Cronbach's Alpha was employed to verify the internal consistency of the KWs. Subsequently, PCA was applied to explore the data structure and the key components that represent the underlying emotional dimensions. Following this, FA was performed to uncover latent factors that grouped the KWs into meaningful and interpretable factors. These statistical methods establish the consistency and structure of the KWs, ensuring the reliability and validity of the findings.

4. Results And Discussion

4.1 Specimens

Kansei analysis relies on a diverse range of specimens with distinct design variations for effective evaluation (Ahmad et al., 2024). Following a rigorous selection process, this research has determined 28 final specimens, chosen based on their distinctive characteristics and relevance to the research context. As highlighted in the methodology section, the scope of this research focuses on the AR angle, aiming to investigate users' emotional preferences within the metaverse library context. Therefore, the specimens are selected among the AR category of mobile library applications. These specimens will be utilized in the subsequent phases of the research, serving as a base reference for the investigation. The following Table 1 presents the specimen samples used in this study,

providing details on their key design variations and characteristics and labeled as SPC.A, SPC.B, SPC.C to indicate Specimen A, B, and so on.

Table 1 Selected specimen samples and their key design characteristics

ID	Specimen	Characteristics
SPC.A		<ul style="list-style-type: none"> - Neutral color scheme - High contrast text - Minimalistic icons - Plain background - Tooltips for guidance - Advanced search bar - Subtle visual cues
SPC.B		<ul style="list-style-type: none"> - High contrast elements - Dark-theme color - Detailed background - Bold and multicolored icons - Bold typography - Highlighted sections as menus - Text-based directions
SPC.C		<ul style="list-style-type: none"> - Monochromatic color scheme - Bright accents - Thin, outlined icons - Bold visual cues - Vertical layout with sidebar - Progress bars and step markers - Clear directional cues

4.2 Kansei Words (KWs)

To ensure the selection of the most applicable keywords for this research, the formulation of the keywords was carried out with the involvement of UI/UX designers, AR professionals, librarian as well as language experts. As a result, 60 domain-specific emotional keywords were finalized, each designated with a sequential code (such as KW.1, KW.2, continuing up to KW.60) to facilitate easy identification and organization, as presented in Table 2. These emotive keywords encompass the spectrum of feelings that users may encounter while engaging with the metaverse library. Given the abundance of keywords (sixty keywords), the identification of the most influential KWs is essential to accurately capture the user's emotional perceptions of the investigated specimens. Therefore, it is important to identify the most significant keywords that strongly associate with these emotions. This process will be further explored in the subsequent step of data analysis. Table 2 lists all the emotional keywords associated with the metaverse library.

Table 2 *Kansei words for metaverse library*

Code	<i>Kansei</i> Word	Code	<i>Kansei</i> Word	Code	<i>Kansei</i> Words
KW.1	Appealing	KW.2	Attractive	KW.3	Balanced
KW.4	Boring	KW.5	Bright	KW.6	Cheerful
KW.7	Clean	KW.8	Clear	KW.9	Cluttered
KW.10	Colorful	KW.11	Complicated	KW.12	Comprehensible
KW.13	Concise	KW.14	Confusing	KW.15	Consistent
KW.16	Cool	KW.17	Creative	KW.18	Crowded
KW.19	Dull	KW.20	Easy	KW.21	Elegant
KW.22	Engaged	KW.23	Enjoyable	KW.24	Exciting
KW.25	Fanciful	KW.26	Fascinating	KW.27	Fresh
KW.28	Friendly	KW.29	Fun	KW.30	Guided
KW.31	Harmonious	KW.32	Helpful	KW.33	Inconsistent
KW.34	Informative	KW.35	Interactive	KW.36	Interesting
KW.37	Joyful	KW.38	Latest	KW.39	Messy
KW.40	Minimalist	KW.41	Modern	KW.42	Neat
KW.43	New	KW.44	Nice	KW.45	Organized
KW.46	Outdated	KW.47	Precise	KW.48	Prestigious
KW.49	Professional	KW.50	Realistic	KW.51	Satisfactory
KW.52	Simple	KW.53	Soft	KW.54	Sophisticated
KW.55	Straightforward	KW.56	Trendy	KW.57	Unclear
KW.58	Understandable	KW.59	Up-to-date	KW.60	Vibrant

4.3 *Kansei* Checklist

This research employs all 60 KWs obtained from the preceding phase. The KWs were then structured into a Google form questionnaire or checklist, utilizing a five scale Likert range. Figure 2 displays the sample of the *Kansei* checklist. In order to aid the user in determining which specimen the questionnaire pertains to, images of the specimen have been appended to the checklist.

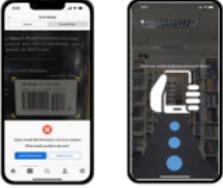
Specimen C								
No.	<i>Kansei</i> Word	Score					<i>Kansei</i> Word	
1.	Appealing	5	4	3	2	1	Not Appealing	
2.	Attractive	5	4	3	2	1	Not Attractive	
3.	Balanced	5	4	3	2	1	Not Balanced	
4.	Boring	5	4	3	2	1	Not Boring	
5.	Bright	5	4	3	2	1	Not Bright	
6.	Cheerful	5	4	3	2	1	Not Cheerful	
7.	Clean	5	4	3	2	1	Not Clean	

Fig. 2 *Sample of the Kansei checklist used in this study*

4.4 Experiment

This phase involved assessing participants' emotional reactions to the specimens, with the goal of determining their capacity to evoke user emotions and identifying the specific emotional responses triggered by the metaverse library specimens. The evaluation took place in a controlled computer lab environment, where participants were guided through specimens' demonstration, and their responses were collected via an online Google Form. The data gathered from this process will form the basis for further analysis. Consequently, this stage concludes with a full summary of the questionnaire results, which will undergo further refinement and analysis in the subsequent phases, as detailed in Section 4.5.

4.5 Analysis

This step is vital in determining the KWs that exhibit the strongest correlation with the metaverse library specimens, using a comprehensive collection of 60 emotional keywords. This important procedure will ensure that the design recommendations align with the predominant user emotions, resulting in an impactful UX. To achieve this, the participants' evaluation responses are aggregated into an average value, which is then used as the basis for the following step in the process. Table 3 presents a partial overview of the participants' responses, with columns representing the *Kansei* Words and rows indicating the specimens.

Table 3 A partial overview of the average scores of the participants' evaluation responses

SPECIMEN	KW.1	KW.2	KW.3	KW.4	KW.5	KW.6	KW.7	...	KW.60
SPC.A	3.272	2.602	4.031	3.000	4.032	3.000	4.100	...	2.777
SPC.B	2.071	2.703	2.502	2.632	2.300	2.671	2.371	...	3.833
SPC.C	2.403	2.771	2.605	2.504	2.471	2.633	2.474	...	3.631
SPC.D	2.401	2.630	2.533	3.831	2.501	3.574	2.600	...	3.133
SPC.E	1.972	2.330	2.137	2.035	2.032	2.200	2.031	...	2.800
SPC.F	2.402	2.673	2.602	2.837	2.573	2.831	2.403	...	3.571
SPC.G	2.000	2.231	2.176	2.073	2.031	2.003	2.033	...	2.700
SPC.H	2.034	2.474	2.173	3.906	2.071	3.931	2.071	...	3.233
SPC.I	2.403	2.574	2.334	2.207	2.104	2.272	2.100	...	3.674
SPC.J	2.370	2.731	2.531	4.104	2.703	4.072	2.605	...	3.231

In the next phase, the data collected from the questionnaires underwent multivariate statistical techniques, as discussed below.

4.5.1 Cronbach's Alpha

Cronbach's Alpha is a useful tool for assessing data reliability, with values above 0.7 indicating that the data is reliable for further multivariate analysis (Schrepp, 2020). Therefore, Cronbach's Alpha is used to assess the reliability of the collected data before proceeding further with the analysis. As seen in Table 4, the Cronbach's Alpha calculation produced a result of 0.829. The obtained value surpasses 0.7, signifying that the data is deemed reliable and can be utilized in the next analysis procedure.

Table 4 Results of the Cronbach's Alpha

Cronbach's Alpha	No. of Items
0.829	60

4.5.2 Principal Component Analysis (PCA)

PCA is a technique used in this study to uncover the correlation between KWs and specimens in order to visualize the strength of emotions within the *Kansei* structure (Hadiana, 2022; Taharim, 2013). As presented in Figure 3, the results analysis observed a significant pattern in the PCA loading plot, where the distributions of emotions along the positive x-axis indicated the preferred UI design, portrayed by emotional keywords like 'balanced' and 'professional', whereas those along the negative x-axis are evaluated less favourably, such as 'inconsistent' and 'messy'.

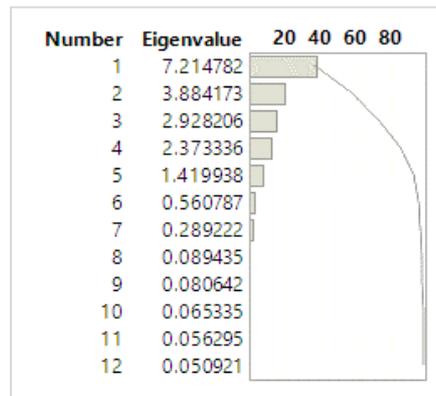


Fig. 5 Bar graph of Eigenvalues

This analysis is further validated by the factor contribution portrayed in Table 5. It is evident from the table that the first factor, F1 accounts for 37.45% of the variables, the second factor accounts for 20.23%, and the third factors accounts for 14.99%. These three factors account for the majority of factor contributions, comprising 72.68%. This indicates that Factor1, Factor2, and Factor 3 have a significant impact on the emotions of the respondents. The fourth and fifth factors account for a low proportion of variability (<2.5) and may be regarded as insignificant.

Table 5 Factor contribution table

Factor	Eigenvalue	Percentage	Cumulative Percentage
F1	7.2	37.45	37.45
F2	3.8	20.23	57.69
F3	2.9	14.99	72.68
F4	2.3	12.31	85.00
F5	1.4	7.34	92.34

The analysis was extended with factor loadings calculation to determine the strength of each variable’s contribution to the factor. Higher factor loadings indicate its greater significance in capturing the underlying construct (Bandalos & Finney, 2018). The results of the factor loading are displayed in Table 6, where variables with higher scores are regarded as key factors in the UI design of the metaverse library. The study established a reference score of 0.85, as recommended by (Lokman et al., 2023).

Table 6 Factor loading

	F1	F2	F3
Vibrant	0.932	Neat 0.980	Comprehensible 0.970
Colorful	0.932	Minimalist 0.977	Helpful 0.954
Modern	0.927	Organized 0.973	Understandable 0.934
Trendy	0.925	Balanced 0.966	Informative 0.901
Cheerful	0.923	Clean 0.964	Clear 0.866
Up-to-date	0.919	Professional 0.945	
Bright	0.901	Fresh 0.936	
Creative	0.898	Simple 0.934	
Attractive	0.878		

From the FA results, it is evident that the *Kansei* design concept of the metaverse library is structured by three factors, with the first factor (F1) features the concept of 'Radiance', F2 as 'Orderliness', and F3 represents the concept of 'Conciseness'. These findings reveal the demanded experiences of the technical university students

regarding the metaverse library UI design. It can be observed that their preferences emphasize practicality in design; element that is critical for supporting technical-based learning and technological engagement. Prioritization was given to the interface that emphasize visual clarity (Radiance), good structure (Orderliness), and information accuracy (Conciseness). These three concepts explain 72.689% of the total data, and considered to be indicators to the design of metaverse library that embeds a targeted emotional concept, especially for TVET university libraries. Therefore, incorporating these three emotional design concepts into the metaverse library's design is recommended, drawing on the variations in design elements identified in SPC.A, SPC.K, and SPC.L.

In light of the key findings, the identified design concepts provide practical directions for improving UIs in digital library applications, particularly within TVET environments. Designers and educational institutions can strategically integrate these concepts into their interface design to better meet user emotional demands. Incorporating the concept of 'orderliness' in design, by maintaining a consistent layout with clear navigation guide can help minimize user frustration and support intuitive interaction. In addition, emphasizing 'conciseness' in content delivery by keeping information short and focused, or using icons and visual cues, can reduce cognitive load and improve accessibility, especially for users with varying levels of digital literacy. Furthermore, promoting 'radiance' through visually engaging interfaces by using a well-balanced color scheme or applying a gentle contrast to highlight important features, may help sustain user's attention. These recommendations provide a foundational guide for developers and educators in TVET settings to design more user-aligned digital experiences. Implementing these design recommendations will evoke the positive emotional response from users, which in turn will improve their overall metaverse UX.

5. Conclusion

This research has investigated the factors that influence emotional preferences of the technical university students on metaverse library interface using *Kansei* engineering analysis. The research proves that a correlation exists between the UI and the emotions experienced by users, emphasizing the role of *Kansei* emotive keywords that characterize the visual appearance of the interface. The research has successfully identified the significant *Kansei* factors for metaverse library using PCA and FA. The statistical analysis suggested that technical students favored more practical designs, with the UI concepts of 'orderliness', 'conciseness', and 'radiance' significantly influenced their preferences for metaverse UX. This offers valuable insights for designers to develop future metaverse libraries aimed at evoking specific emotions for TVET institutions, where the new library concept could incorporate these three prospective concepts. These recommendations optimize the UI for a more immersive and impactful experience, bridging the gap between higher education and TVET goals in terms of the skills alignment. This research makes two significant contributions, with the findings contribute to the body of knowledge in affective engineering and emotional design, as well as a practical contribution by offering design strategy recommendations for metaverse libraries of technical universities, emphasizing the essential emotional concepts for enhanced metaverse experiences. Given that this study represents the initial phase of a broader research project, it is currently confined to TVET institutions with a limited participant pool. Subsequent studies should consider examining other university categories and expanding the sample size to facilitate cross-comparative analysis and provide further insights into UI preferences and engagement. It is also hoped that more studies will be conducted in the future on the adaptation of advanced technology in TVET institutions to support skill development, and explore its potential for revolutionizing educational strategies.

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Conflict of Interest

Authors declare that there is no conflict of interests regarding the publication of the paper.

Author Contribution

Nik Azlina Nik Ahmad provided essential resources for the research, managed data collection, and played a pivotal role in authoring the manuscript. Ezwan Shah Abd Majid, and Ahmad Iqbal Hakim Suhaimi contributed their expertise in the subject matter and supported the overall research process. Anitawati Mohd Lokman was instrumental in developing the research concept, coordinating among the authors, and effectively editing and formatting the manuscript's storyline.

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