Functional Requirements and Design Strategy of E-sports Chair Based on the KANO Model

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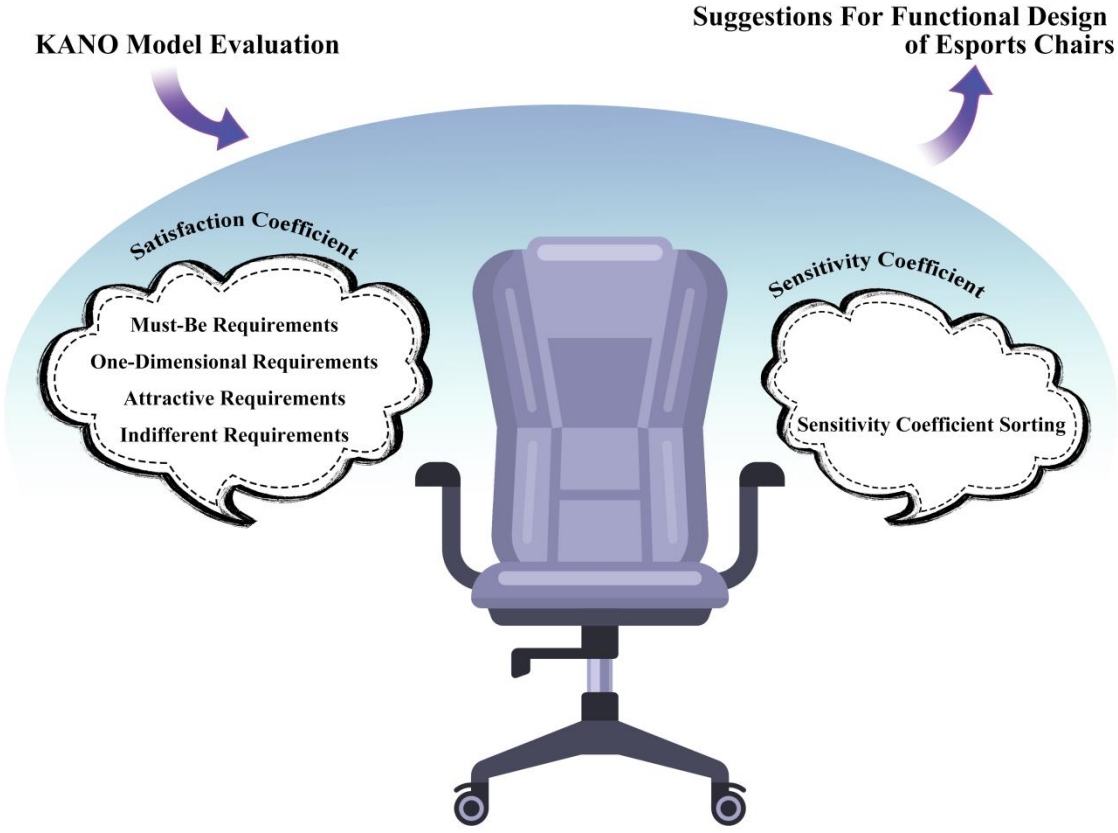
GRAPHICAL ABSTRACT



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A design strategy was developed, based on the KANO model, for health-centric and sustainable e-sports chair products. Specifically, this study investigated the functional requirements of e-sports chairs using interviews and questionnaires to guide their subsequent design. The functional requirements of the e-sports chair were evaluated using the KANO model. In addition, a satisfaction coefficient was introduced to optimize the traditional KANO model and to obtain the functional requirement classification of the e-sports chair. The sensitivity coefficient was used to evaluate whether the e-sports chair functions attract users. The research results show that users have clear functional requirements for e-sports chairs, and there is a significant correlation between satisfaction and sensitivity. Moreover, the adjustability and air permeability of the e-sports chair greatly improves user satisfaction, and the non-difference function can simplify the process by reducing production costs. This research develops a hierarchical model of demand for e-sports chairs and categorizes the results by essential, one-dimensional, attractive, non-differentiated, and sensitivity requirements. Furthermore, the main attributes of user preferences for e-sports chairs are explored, which provides a certain theoretical basis for the subsequent design and production of e-sports chairs.

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Keywords: KANO model; E-sports chair; Functional requirement; Design strategy

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INTRODUCTION

In recent years, the e-sports field has developed rapidly and globally, and the number of active users has grown exponentially. As a result, this activity has been recognized as a sport by the International Olympic Committee and the Asian Olympic Committee in 2018 (Seo 2013). E-sports has also developed rapidly in China. According to recent statistics, the number of e-sports users in China has exceeded 500 million in 2021, making it one of the main forms of public entertainment (Zhao *et al.* 2020). At the same time, products related to e-sports continue to emerge; among them, e-sports chairs have become an important and popular product. E-sports chairs are ergonomic chairs designed and produced by combining the technology of racing chairs with ergonomic principles suitable for computer work (Li and Zhang 2021). Owing to their specialized seating properties, e-sports chairs are typically designed with better wrap-around support and with

a wide range of colors that can match different trendy styles and form personalized color schemes that blend in with their surroundings (Du *et al.* 2022). In addition, many e-sports chair designs currently use wooden construction, giving them excellent environmental performance and an attractive appearance. Therefore, e-sports chairs built with wooden components are expected to achieve better user satisfaction, gaming success, and comfort. Furthermore, the ergonomic comfort provided by e-sports chairs has not only led people to use them for recreational gaming, but also to replace traditional office chairs as the primary seating option for professional work. This integration of leisurely relaxation into the work process has expanded the usage scenarios for e-sports chairs. Consequently, both domestic and international researchers have gradually begun to delve into the design and research of e-sports chairs. For example, Yang and Wu (2021) analyzed the overall comfort of commonly used e-sports chair brands through the induction and summarization method and produced a more comfortable e-sports chair style. Wang and Lv (2022) started with common e-sports occupational diseases, based on ergonomics, combined with traditional Chinese medicine acupoints, and improved the design of e-sports chairs to stimulate the back acupoints effectively when leaning back, thereby achieving the effect of relieving pain and promoting health. Yin and Fang (2021) analyzed the effects of sitting posture and duration on user psychology based on ergonomic principles and improved the front, side, and back of existing e-sports chairs through streamlined design to make them more compatible with users' physiological and psychological needs. Gutierrez *et al.* (2019) proposed an e-sports chair design with an arm support system aimed at guiding the scapula to the proper position, thus improving the user posture. The research conclusions of scholars show that adjustability, comfort, and appearance are the main research attributes in the design of e-sports chairs. Adjustability enables users to adapt to different seating postures; comfort can enable users to maintain a comfortable seating posture for a long time without fatigue, ensuring their physical health; and appearance can make users look more professional and improve their psychological comfort.

Data shows that the size of China's esports market exceeded 165 billion yuan in 2021, and it is expected to reach 218.6 billion yuan by 2024, an increase of 32.5%. However, with the increasing competition in the e-sports chair market, existing products are of uneven design quality and suffer from serious homogenization. Apart from differences in appearance and color, their functional structure is largely the same, and additional features are lacking, making it difficult to meet the personalized needs of users (Tseng 2020). Furthermore, e-sports often require maintaining a seated position for extended periods, potentially resulting in significant health damage (Yang *et al.* 2024). This presents new requirements for e-sports chair design and materials. In response to current market demand, a new design strategy is needed to meet the health and sustainability requirements of the product, bringing innovation and vitality to e-sports chair design.

The KANO model is a well-known cognitive model developed by Noriaki Kano, a famous management scientist from the Tokyo Institute of Technology (Materla *et al.* 2019; Liu and Li 2020). It accurately reflects the non-linear relationship between customer quality, attributes, performance, and overall satisfaction, and is primarily used for analyzing and acquiring user requirements. It is an essential tool for designers in the early research stages (Shan *et al.* 2022). Wu *et al.* (2024) integrated the KANO model into the innovative design of bamboo furniture, transforming subjective user needs into more rigorous indicators of demand using the KANO model, thus addressing the product's design positioning issues. Wang and Zhou (2023) conducted a comprehensive study involving

desktop research, user journey mapping, and user interviews to capture the needs of their target users. Subsequently, they employed the KJ method for hierarchical analysis. Following this, they utilized the KANO model to cluster user requirements, thus revealing distinct categories and priority rankings. Finally, by integrating the KANO model with the QFD model, they constructed a comprehensive model of requirements and features from which they extracted crucial design elements for in-depth development. Many people have applied the KANO model to household products (Li and Wang 2023), industrial products (Qi *et al.* 2023), souvenirs (Tama *et al.* 2015), and other products, demonstrating the wide-ranging application of the KANO model in improving design. In this study, the KANO model evaluation method was used to obtain the design requirements for e-sports chairs. The satisfaction coefficient and sensitivity coefficient were used to optimize the model, and a series of design principles for e-sports chairs that promote health and sustainability were proposed based on the research results, providing theoretical support for the improvement of e-sports chair design.

EXPERIMENTAL

Research Methodology

This study developed a health-centric and sustainable design strategy for the development of e-sports chair products based on the KANO model (Fig. 1).

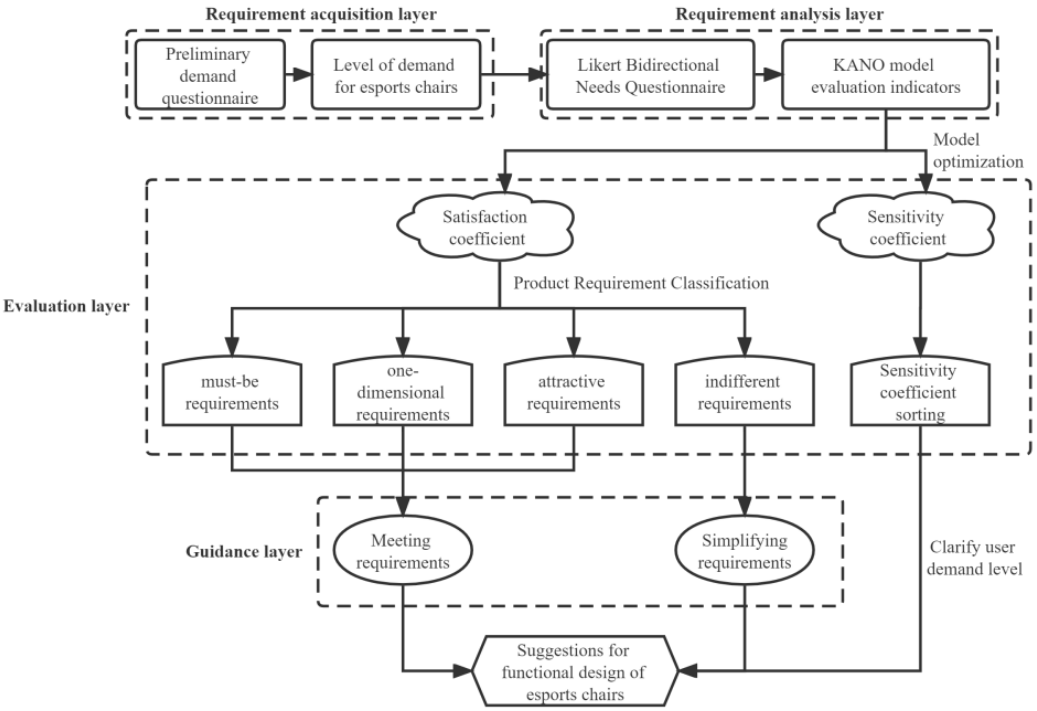

Fig. 1. Research method of e-sports chair product design strategy

The e-sports chair product design strategy includes four levels: requirement acquisition, requirement analysis, evaluation, and guidance level. The requirement acquisition level obtains users' design requirements for e-sports chairs through methods such as questionnaire surveys and interviews, and it establishes the requirement hierarchy of e-sports chairs based on this. Then, at the requirement analysis level, a Likert

bidirectional requirement questionnaire is designed according to the hierarchical model to obtain user evaluation indicators based on the KANO model. At the evaluation level, the satisfaction coefficient and sensitivity coefficient are used to optimize the KANO model, realizing the classification of e-sports chair product requirements and importance ranking. Finally, design principles are determined to develop innovative design strategies for e-sports chair products.

Research Process

Acquisition of e-sports chair design requirements

The functional requirements of the e-sports chair are similar to those of office chairs, aimed at preventing occupational diseases caused by long-term sitting and enabling users to use them more comfortably and for longer periods. In this study, the design requirements of e-sports chairs were discussed through interviews and questionnaires in the requirement acquisition layer. The specific implementation process was as follows:

The relevant questions for the e-sports chair interview were determined by visiting the extensive e-sports chair market in the Zhejiang Province, China and by conducting user surveys. Based on the suggestions obtained from the interview, the requirement questionnaire focused on the seven main unit components of the e-sports chairs' structural composition, including the seat cushion, backrest, armrest, headrest, lumbar support, footrest, chair legs, and overall requirements, to explore the needs of the functional aspects of each unit component and ultimately determine the design requirements of the e-sports chair (Fig. 2 and Supporting Information).

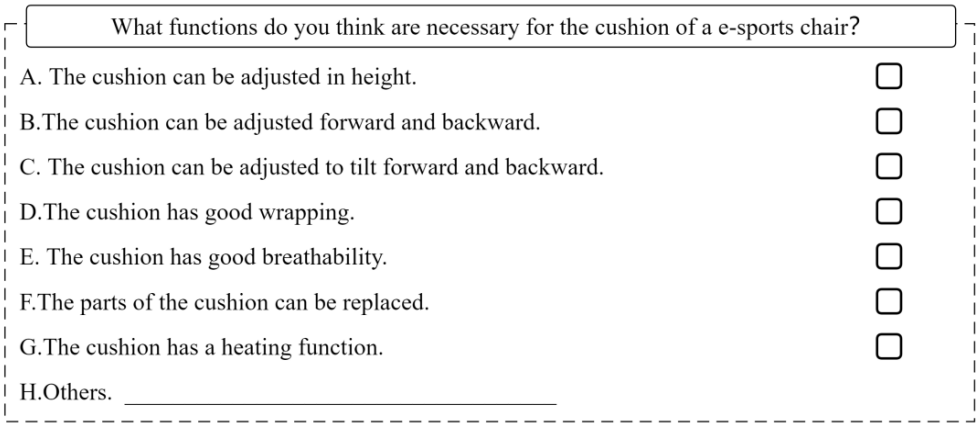

Fig. 2. Sample e-sports chair demand questionnaire

The data gathered from the design requirements of the e-sports chair directly supported the hierarchical requirements. The investigation of functional elements in e-sports chairs entailed the distribution of 47 questionnaires, yielding 43 valid responses. Subsequently, a total of 22 design prerequisites for e-sports chairs were identified and systematically categorized to establish the hierarchical requirements of these chairs. This included three requirements for the cushion, four requirements for the backrest, seven requirements for the armrest, two requirements for the headrest, two requirements for the lumbar support, one requirement for the footrest, two requirements for the chair legs, and one requirement for overall optimization (Table 1).

Table 1. Research Results of Esports Chair Design Function Requirements

E-sports chair components	Problem No.	Function Requirement
Seat Cushion	Q1	The seat cushion of the e-sports chair can adjust the forward and backward tilt.
	Q2	The seat cushion of the e-sports chair can adjust the height up and down.
	Q3	The seat cushion of the e-sports chair has good breathability.
Backrest	Q4	The shape of the backrest of the e-sports chair can fit the curve of the human body.
	Q5	The backrest of the e-sports chair can adjust forward and backward.
	Q6	The backrest of the e-sports chair can adjust backward to a lying position, becoming a recliner.
	Q7	The backrest of the e-sports chair has good breathability.
Armrest	Q8	The armrest of the e-sports chair can be raised and lowered.
	Q9	The armrest of the e-sports chair has an additional operating surface.
	Q10	The armrest component of the e-sports chair can be replaced.
	Q11	The armrest of the e-sports chair has a cup holder function.
	Q12	The armrest of the e-sports chair can rotate left and right.
	Q13	The armrest of the e-sports chair can tilt forward and backward.
	Q14	The armrest of the e-sports chair has good breathability.
Headrest	Q15	The position of the headrest of the e-sports chair can be adjusted.
	Q16	The headrest component of the e-sports chair can be replaced.
Lumbar Support	Q17	The height of the lumbar support of the e-sports chair can be adjusted.
	Q18	The lumbar support of the e-sports chair can fit the rotation of the human body left and right.
Footrest	Q19	The footrest of the e-sports chair can be supported by a bracket when pulled out, without hanging in the air.
Chair Legs	Q20	The casters of the e-sports chair can be locked.
	Q21	The chair legs of the e-sports chair have footrests.
Overall	Q22	The e-sports chair can optimize the overall structure for easy transportation.

According to the research results shown in Table 1, the main functional requirements of the design of e-sports chairs included adjustability and breathability of the seats. Except for the footrest and chair legs, users expressed the demand for adjustability in parts of the e-sports chair that directly contact the human body. The adjustment method was multi-dimensional and conformed to the changes in human body movement, which reflected more rigorous requirements for ergonomic products from the users. In terms of breathability, users hoped that the seat, backrest, and armrests, which were in closest contact with the human body, had good breathability. However, most of the current e-sports chair products on the market use leather as the covering material, which shows that existing products cannot meet this requirement very well.

Analysis of requirements hierarchy

According to the KANO model, a Likert five-level bidirectional survey questionnaire was designed based on the identified design requirements for the e-sports chair (Vaez Shahrestani *et al.* 2020). The questionnaire contained the 22 functional requirements listed in Table 1. A separate survey was conducted for each functional requirement, with each question including two aspects: "having this function" and "missing this function." The questionnaire answer options were set to 5 points, where 1 point indicated a very dissatisfied response to the questionnaire description, whereas 5 points indicated a very satisfied response to the questionnaire description (Fig. 3 and Supporting

Information) (Yu *et al.* 2021; Xiong *et al.* 2023). Respondents rated the described situations based on their level of satisfaction.

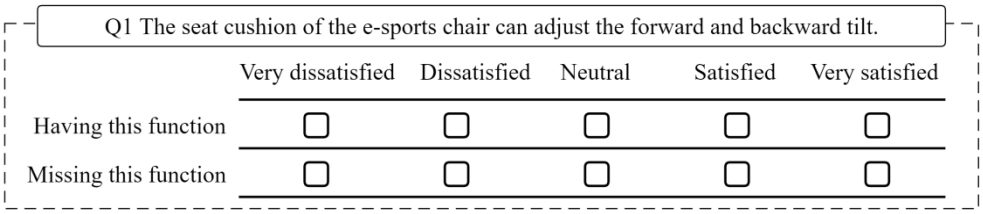

Fig. 3. Example of Likert's bidirectional needs questionnaire

The KANO model survey garnered a total of 776 valid responses, all of which were characterized by impartial and objective evaluations from the participants. After the collection of Likert bidirectional survey questionnaire, the scoring results of the positive and negative questions were entered into the KANO evaluation model, and the intersection point of satisfaction ratings for "having this function" and "missing this function" was used as the attribute of the demand type for each function (Table 2) (Li *et al.* 2022).

Table 2. KANO Evaluation Model

Having this function	Not having this function				
	Very satisfied	Satisfied	Neutral	Dissatisfied	Very dissatisfied
Very satisfied	Q	A	A	A	O
Satisfied	R	I	I	I	M
Neutral	R	I	I	I	M
Dissatisfied	R	I	I	I	M
Very dissatisfied	R	R	R	R	Q
M represents must-be requirements; O stands for one-dimensional requirements; A is attractive requirements; I represents indifferent requirements; R and Q correspond to reverse requirements and suspicious items, and are generally excluded.					

The traditional KANO model can simply classify product requirements based on their frequency of occurrence (Yin *et al.* 2022). However, according to the classification shown in the evaluation model table, other requirement types only appeared when users selected extremely satisfied or extremely dissatisfied options; otherwise they were classified as indifferent requirement types (Ma *et al.* 2019). Therefore, according to the traditional KANO model classification, the frequency of indifferent requirement types was higher than that of other types (Wang *et al.* 2019).

To address this issue, this study optimized the traditional KANO model by introducing a consumer satisfaction coefficient to further confirm the requirement types. The formula for calculating the satisfaction coefficient is as follows,

$$SI = (A+O)/(A+O+M+I) \quad (1)$$

$$DSI = -(O+M)/(A+O+M+I) \quad (2)$$

where SI represents the satisfaction coefficient, and DSI represents the dissatisfaction coefficient.

The satisfaction coefficient SI reflects the increase in user satisfaction with this function, which is the proportion of attractive requirements (A) and one-dimensional requirements (O) in the overall demand. The larger the value, the more the user's satisfaction increases with this function, indicating a high level of desire for this function. Contrarily, the dissatisfaction coefficient DSI reflects the decrease in user satisfaction without this function, which is the proportion of one-dimensional requirements (O) and must-be requirements (M) in the overall demand. The dissatisfaction coefficient is usually negative, and the larger the absolute value, the more the user's satisfaction decreases when missing this function, indicating a high level of requirement for this function, which is essential to achieving customer satisfaction (Haber *et al.* 2020; Jin *et al.* 2022; Liu *et al.* 2024). Based on this, this study also introduces the sensitivity coefficient to determine the user's sensitivity to the functional requirements (Zhu *et al.* 2023a).

The sensitivity calculation formula is given in Eq. 3,

$$\omega = \sqrt{SI^2 + DSI^2} \quad (3)$$

where ω represents the sensitivity coefficient, and the closer its value is to 1, the higher the sensitivity of the functional requirement to users, indicating a higher level of demand.

RESULTS AND DISCUSSION

Analysis of the KANO Model Results

To understand the impact of customer satisfaction and dissatisfaction on the demand types of e-sports chairs, the index coefficients of each demand item were calculated using Eqs. 1 and 2 based on the results of the Likert two-way questionnaire survey. Using the satisfaction index SI value as the horizontal axis and the dissatisfaction index DSI value as the vertical axis, and taking the average value as the critical line of the horizontal and vertical axes, a scatter plot of the demand satisfaction level of e-sports chair products was plotted in four-quadrants (Fig. 4) (Chen *et al.* 2021).

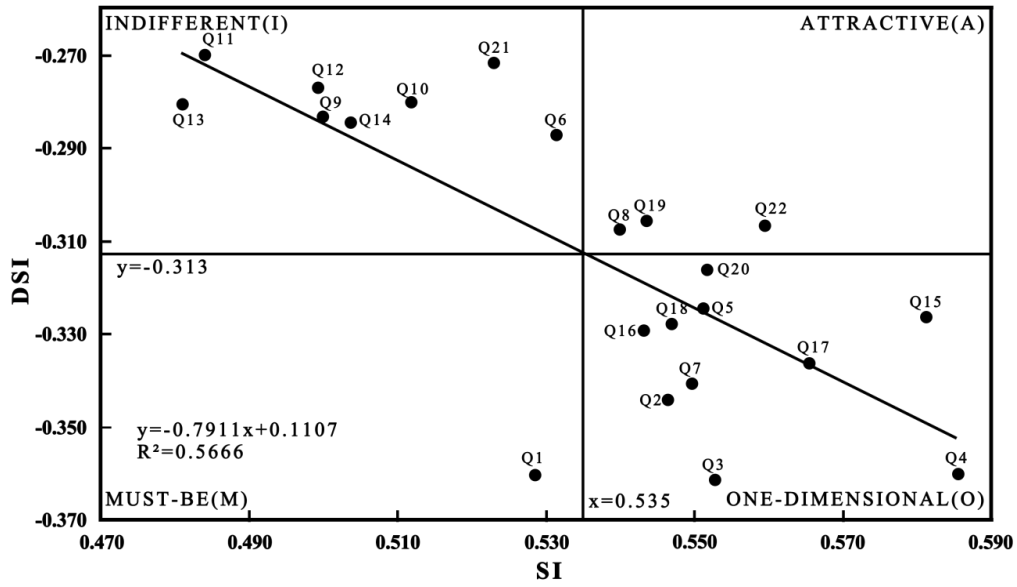

Fig. 4. Four-quadrant scatter plot of satisfaction coefficient for e-sports chairs

From Fig. 4, the 22 indicators of e-sports chair requirements exhibited a linear distribution in the second and fourth quadrants, with an R^2 value of 0.5666 and a good fitting degree (Wang 2022). This trend showed that users have a clear attitude towards the e-sports chair functional requirements proposed in this study; that is, the satisfaction level increased with the presence of the function and decreased with the absence of the function in a positive correlation.

Examining the quadrants, the first quadrant included three functional indicators, Q8, Q19, and Q22. The points in this quadrant had high SI values and low absolute DSI values, indicating that having these functions significantly increased user satisfaction, but the absence of these functions did not affect user satisfaction, which belonged to the attractive requirements (A). The second quadrant included eight functional indicators, Q6, Q9-Q14, and Q21. The points in this quadrant had low absolute values of both SI and DSI, indicating that whether these functions were present or not had a small impact on user satisfaction, which belonged to the indifferent requirements (I). The third quadrant only included one functional indicator, Q1. The points in this quadrant had low SI values and high absolute DSI values, indicating that users were not concerned whether they have this function, but the absence of this function had a significant impact on their satisfaction, which belonged to the requirements (M). The fourth quadrant included ten functional indicators, Q2-Q7, Q15—Q18, and Q20. The points in this quadrant had high absolute values of both SI and DSI, indicating that whether these functions were present or not had a significant impact on user satisfaction. Having these functions can greatly increase user satisfaction, while the absence of these functions can greatly reduce user satisfaction, which belongs to the one-dimensional requirements (O).

Analysis of Satisfaction and Sensitivity of Design Requirements

According to the survey questionnaire, the satisfaction and sensitivity coefficients were calculated (Table 3). Users were more sensitive to the adjustability of the e-sports chair. Several functions related to the adjustment of the e-sports chair, such as Q4, Q15, and Q17, had higher sensitivity coefficients, indicating that users hoped that the e-sports chair could be more flexible in adapting to people with different body sizes and sitting habits. This multi-adjustable design made the e-sports chair closer to the definition of ergonomics and more comfortable to use. Q3 and Q7 were ranked third and fifth, respectively, indicating that users were also very concerned about the breathability of the e-sports chair.

Good breathability can provide users with a more comfortable experience when using e-sports chair products. The excellent breathability of the seat cushion and backrest helped the skin ventilate and perspire, making it more comfortable to sit for a long time, while reducing the breeding of bacteria and mites, and maintaining the product material clean and tidy. The sensitivity coefficients of the three attractive requirements (A) functions, Q22, Q19, and Q8, were all in the middle of the ranking results, indicating that users had a mixed attitude towards these functions. The sensitivity coefficients of various functions in the indifferent requirements (I) were relatively low, indicating that users are less concerned about these functions.

Table 3. Functional Demand Satisfaction Coefficient and Sensitivity Coefficient of E-sports Chair

Problem	SI	DSI	Baseline Classification	Adjusted Classification	Sensitivity Coefficient ω	Ranking
Q1	0.529	-0.360	indifferent I	must-be M	0.640	7
Q2	0.546	-0.344	indifferent I	one-dimensional O	0.646	6
Q3	0.553	-0.361	indifferent I	one-dimensional O	0.660	3
Q4	0.585	-0.360	indifferent I	one-dimensional O	0.687	1
Q5	0.551	-0.325	indifferent I	one-dimensional O	0.640	8
Q6	0.531	-0.287	indifferent I	indifferent I	0.604	15
Q7	0.550	-0.341	indifferent I	one-dimensional O	0.647	5
Q8	0.540	-0.308	indifferent I	attractive A	0.621	14
Q9	0.500	-0.283	indifferent I	indifferent I	0.575	19
Q10	0.512	-0.280	indifferent I	indifferent I	0.584	17
Q11	0.484	-0.270	indifferent I	indifferent I	0.554	22
Q12	0.499	-0.277	indifferent I	indifferent I	0.571	20
Q13	0.481	-0.281	indifferent I	indifferent I	0.557	21
Q14	0.504	-0.285	indifferent I	indifferent I	0.579	18
Q15	0.581	-0.326	indifferent I	one-dimensional O	0.667	2
Q16	0.543	-0.329	indifferent I	one-dimensional O	0.635	12
Q17	0.565	-0.336	indifferent I	one-dimensional O	0.658	4
Q18	0.547	-0.328	indifferent I	one-dimensional O	0.638	10
Q19	0.544	-0.306	indifferent I	attractive A	0.624	13
Q20	0.552	-0.316	indifferent I	one-dimensional O	0.636	11
Q21	0.523	-0.272	indifferent I	indifferent I	0.589	16
Q22	0.559	-0.307	indifferent I	attractive A	0.638	9

Essential Requirements Must Be Met

The function of Q1, which was the adjustable tilt of the e-sports chair seat cushion, was the only essential requirement, but it was not commonly found in existing e-sports chair products. However, the adjustable tilt of the seat cushion could accommodate people with different sitting habits and also helped alleviate health problems caused by prolonged sitting in the same position. It was an important feature that could optimize the comfort of the e-sports chair and improve user satisfaction. Therefore, this function should be provided in the design of e-sports chairs.

The One-dimensional Requirements Should Be Met

Q2—Q5, Q7, Q15—Q18, and Q20 were one-dimensional requirements, which were the functions that users hoped to have. Therefore, the one-dimensional requirements of the e-sports chair should be met as the basic functions in the design (Fofan *et al.* 2019). The specific design strategy was as follows:

Q2 was a common function in existing chair products. However, some existing products use fixed cushions or have insufficient height adjustment range to meet daily use needs. Meanwhile, the rise of sit-stand working methods has also prompted the need for more comprehensive height adjustment solutions (He *et al.* 2021). Q3 and Q7 were both requirements for breathability. This feature has been well developed in office chair products, but it needs improvement in the application of e-sports chairs (Dewi and Nugraha 2021). E-sports chair design should meet this functional requirement. Q4 and Q5 could provide better support for the back muscles. Compared with traditional backrests with fixed and non-fitting single or multiple point supports, a surface area support with an appropriate

angle and close fitting to the human back curve could make muscle force more evenly distributed, effectively relieving back muscle fatigue caused by prolonged sitting (Bai et al. 2022). According to the relevant knowledge of traditional Chinese acupoints, the design could also incorporate massage balls for full acupoint massage while fitting the back, to achieve the effect of fatigue relief (Wang and Lv 2022). Most e-sports chairs have a fixed headrest position and limited adjustment range, and the headrest position may not be suitable and cannot be effectively adjusted. Therefore, Q15 should be considered in subsequent e-sports chair designs, providing an independent adjustment mechanism for the headrest to meet the needs of users with different body types. At the same time, based on the ergonomics of the headrest, new headrest schemes with different shapes, functions, and usage experiences can be proposed, and Q16 can be used to replace headrest components to achieve a comprehensive improvement in the headrest usage experience. Q17 and Q18, combined, enabled 3D adjustment of the lumbar support, making the support more flexible and fitting to the body's movements, thereby solving the slippage phenomenon caused by local movements on the chair, and improving the comfort of the e-sports chair during use. Q20 allows the e-sports chair to temporarily abandon the function of moving casters, thereby achieving better stability. This excellent stability can enable users to perform richer movements on the e-sports chair, protecting the user's personal safety (Zhu *et al.* 2023b).

Attractive Requirements Should Be the Design Goal

The attractive requirement attributes of e-sports chairs can be used as bonus points in the design of e-sports chairs, making them a highlight of the design. Function Q8 could adapt to the usage situation of different body types and sitting postures, providing more suitable support for the elbows and reducing physical fatigue during use. Function Q19 solved the psychological safety concerns of the users by providing support for the floating footrest, making the e-sports chair look more secure and comfortable to use. In addition, most existing e-sports chair products are relatively bulky, and the installation steps for first-time users are cumbersome, while subsequent disassembly and transportation are more troublesome. Optimizing the overall structure of e-sports chairs, improving the integrated frame, and ensuring the stability of the existing structure could make disassembly and assembly easier. Function Q22 could certainly impress users and enhance their satisfaction.

Non-essential Requirements

Regarding non-differentiated requirements, features such as Q6, Q9—Q14, and Q21 did not attract user interest, and the lack of these features did not reduce user satisfaction. Therefore, these features could be removed in the design process to optimize the overall structure of e-sports chairs and reduce production costs.

Sensitivity Requirements Must Be Met

The sensitivity coefficient reflects the degree of user requirements for a particular feature. A high sensitivity coefficient indicates that users truly require this feature, and it is also more popular among consumers in the market. Based on the sensitivity coefficient calculation results, Q4, Q15, Q3, Q17, and Q7 were the top five sensitive requirements. Therefore, when designing and developing e-sports chairs, priority should be given to implementing features with high sensitivity coefficients for that product to meet user expectations and truly address their needs. If the sensitivity coefficient conflicts with the requirements classification of e-sports chairs, factors such as production costs, logistics,

and market sales need to be comprehensively considered to determine whether to provide the feature.

CONCLUSIONS

This study used the KANO model to quantitatively analyze the required functions of the main components of the e-sports chair. A questionnaire was used to obtain 22 indicators of e-sports chair functions. Then, a Likert two-way questionnaire and satisfaction coefficient were used to classify the attributes of different functional needs. The sensitivity coefficient was used to obtain the priority of each function.

1. Based on the analysis results, five strategies for e-sports chair function design were proposed. One essential requirement was identified: the adjustable seat tilt angle. Ten one-dimensional requirements, including seat height adjustment, improved breathability, improved support structure, adjustable headrest and lumbar support, and optimized chair legs, were found to be necessary to meet user requirements. Three attractive requirements, including adjustable armrests, improved footrest functionality, and overall structural optimization, were used as the core selling points of the product to attract users. Eight non-differentiated requirements, such as backrest, armrest, and chair leg adjustments, could be simplified to help designers optimize the product structure and reduce manufacturing costs.
2. The findings from the satisfaction and sensitivity analysis of the design requirements revealed that adjustability and breathability are the pivotal attributes sought by users. These characteristics empower the e-sports chair to more effectively conform to users' usage patterns and deliver a heightened level of comfort. Hence, they should take precedence in the design of e-sports chairs.

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REFERENCES CITED

Bai, S., Lin, W., An, Y., Zhang, Y., and Ke, Y. (2022). "Research on muscle fatigue in alternate sitting and standing mode based on EMG," *Beijing Biomedical Engineering* 41, 32-37. DOI: 10.3969/j.issn.1002-3208.2022.01.005

Chen, M., Hsu, C., and Huang, C. (2021). "Applying the Kano model to investigate the quality of transportation services at mega events," *J. Retail Consum. Serv.* 60, article 102442. DOI: 10.1016/j.jretconser.2021.102442

Dewi, S. K., and Nugraha, A. (2021). "Quality of service evaluation based on importance performance analysis method and the Kano model," *Journal of Physics. Conference Series* 1764, article 12199. DOI: 10.1088/1742-6596/1764/1/012199

Du, L., Chen, H., Fang, Y., Liang, X., Zhang, Y., Qiao, Y., Guo, Z., Huihua, C., and Chen, H. (2022). "Research on the method of acquiring customer individual demand based on the quantitative Kano model," *Comput Intel Neurosc* 2022, 5052711-5052712. DOI: 10.1155/2022/5052711

Fofan, A. C., Oliveira, L. A. B. D., Melo, F. J. C. D., Jerônimo, T. D. B., and Medeiros, D. D. D. (2019). "An integrated methodology using PROMETHEE and Kano's model to rank strategic decisions," *Eng. Manag. J.* 31, 270-283. DOI: 10.1080/10429247.2019.1655351

Gutierrez, A. M. J., Cadiz, L., Filoteo, N., Juan, I., and Leopando, B. (2019). "Enhancement of gaming experience and performance through an ergonomically designed console chair," *International Conference on Industrial Engineering and Operations Management* 31-41. DOI: 10.46254/NA04.20190018

Haber, N., Fargnoli, M., and Sakao, T. (2020). "Integrating QFD for product-service systems with the Kano model and fuzzy AHP," *Total Qual Manag Bus* 31, 929-954. DOI: 10.1080/14783363.2018.1470897

He, L., Wu, Z., Xiang, W., Goh, M., Xu, Z., Song, W., Ming, X., and Wu, X. (2021). "A novel Kano-QFD-DEMATEL approach to optimise the risk resilience solution for sustainable supply chain," *Int. J. Prod. Res.* 59, 1714-1735. DOI: 10.1080/00207543.2020.1724343

Jin, J., Jia, D., and Chen, K. (2022). "Mining online reviews with a Kansei-integrated Kano model for innovative product design," *Int. J. Prod. Res.* 60, 6708-6727. DOI: 10.1080/00207543.2021.1949641

Li, C., and Wang, X. (2023). "Design of smart wardrobe based on Kano-interval intuition fuzzy QFD," *Journal of Forestry Engineering* 8(04), 175-184. DOI: 10.13360/j.issn.2096-1359.202212011

Li, M., and Zhang, J. (2021). "Integrating Kano Model, AHP, and QFD methods for new product development based on text mining, intuitionistic fuzzy sets, and customers satisfaction," *Math Probl. Eng.* 2021, 1-17. DOI: 10.1155/2021/2349716

Li, Z., Wang, Y., Hu, S., and Chen, J. (2022). "Study on the demands of Chinese traditional blue dyeing products based on Kano model," *Silk* 59, 103-110. DOI: 10.3969/j.issn.1001-7003.2022.05.014

Liu, Y., Zhu, W., Li, Z., Xin, R., He, Y., Yang, J., Li, S., Chen, M. (2024) "Bamboo-based cellulose nanofibers as reinforcement for polyurethane imitation wood" Ind. Crop. Prod. 210, 118177. DOI: org/10.1016/j.indcrop.2024.118177

Liu, Z., and Li, Q. (2020). "Research on light design of children's furniture based on KANO and TRIZ theory," *China Forest Products Industry* 57, 41-46. DOI: 10.19531/j.issn1001-5299.202008010

Ma, M., Chen, C., and Chang, Y. (2019). "Using Kano model to differentiate between future vehicle-driving services," *Int. J. Ind. Ergonom.* 69, 142-152. DOI: 10.1016/j.ergon.2018.11.003

Materla, T., Cudney, E.A., and Hopen, D. (2019). "Evaluating factors affecting patient satisfaction using the Kano model," *Int. J. Health Care Qual. Assur.* 32, 137-151. DOI: 10.1108/ijhcqa-02-2018-0056

Qi, Z., Tang, H., and Chen, L. (2023). "Research on user demand design of smart learning lamp based on KANO-AHP model," *Design* 36(23), 112-115. DOI: 10.20055/j.cnki.1003-0069.001383

Seo, Y. (2013). "Electronic sports: A new marketing landscape of the experience economy," *J. Market Manag.-Uk* 29, 1542-1560. DOI: 10.1080/0267257x.2013.822906

Shan, H., Fan, X., Long, S., Yang, X., Yang, S., Manuel, D.L.S., and De la Sen, M. (2022). "An optimization design method of express delivery service based on quantitative Kano model and Fuzzy QFD model," *Discrete Dyn. Nat. Soc.* 2022, 1-18. DOI: 10.1155/2022/5945908

Tama, I. P., Azlia, W., and Hardiningtyas, D. (2015). "Development of customer oriented product design using Kansei engineering and Kano model: Case study of ceramic souvenir," *Procedia Manufacturing* 4, 328-335. DOI: 10.1016/j.promfg.2015.11.048

Tseng, C. C. (2020). "An IPA-Kano model for classifying and diagnosing airport service attributes," *Research in Transportation Business & Management* 37, article 100499. DOI: 10.1016/j.rtbm.2020.100499

Vaez Shahrestani, H., Shahin, A., Teimouri, H., and Shaemi Barzoki, A. (2020). "Revising the Kano model for designing an employee compensation system: Developing one-dimensional attributes," *TQM journal* 32, 78-91. DOI: 10.1108/TQM-05-2019-0153

Wang, S., and Lv, J. (2022). "The improved design of e-sports chair in combination with e-sports occupational diseases and acupuncture points of Chinese medicine," *Furniture* 43, 50-53. DOI: 10.16610/j.cnki.jiaju.2022.03.012

Wang, X., Wong, Y.D., Teo, C., Yuen, K.F., and Li, K.X. (2019). "Decomposing service conveniences in self-collection: An integrated application of the SERVCON and Kano models," *Int. J. Phys. Distr. Log.* 49, 356-375. DOI: 10.1108/IJPDLM-10-2018-0336

Wang, Y. (2022). "Terrain factors related to hydrology in the loess plateau of Northern Shaanxi Based on DEM," *Acta Agriculturae Sinica* 12, 17-23. DOI: 10.11923/j.issn.2095-4050.cjas2020-0097

Wang, Y., and Zhou, M. (2023). "Design and research of outdoor folding chair based on KANO-QFD model," *International Conference on Artificial Intelligence and Industrial Design (AIID 2022) SPIE* 12612, 33-38. DOI: 10.1117/12.2673107

Wu, C., Song, S., Liu, Y., *et al.* (2024). "Innovative design of bamboo chairs based on KANO model and TRIZ theory," *Journal of Forestry Engineering* 9(01), 177-183. DOI: 10.13360/j.issn.2096-1359.202304015

Xiong, X., Cao, M., Ma, Q., *et al.* (2023). "Group classification and processing method of shaped parts for solid wood furniture," *Journal of Forestry Engineering* 8(06), 186-192. DOI: 10.13360/j.issn.2096-1359.202306023

Yang, J., and Wu, Z. (2021). "Survey and ergonomic evaluation of e-sports chairs," *Furniture* 42, 49-53. DOI: 10.16610/j.cnki.jiaju.2021.03.011

Yang, Y., Wang, Y., Yang, Y., *et al.* (2024). "Mechanical analysis and optimization of bamboo integrated tenon joint chair based on response surface method and MOGA algorithm," *Journal of Forestry Engineering* 9(01), 184-191. DOI: 10.13360/j.issn.2096-1359.202302007

Yin, H., and Fang, X. (2021). "Design concept of gaming chair based on streamlined style," *Packaging Engineering* 42, 284-289. DOI: 10.19554/j.cnki.1001-3563.2021.06.040

Yin, S., Cai, X., Wang, Z., Zhang, Y., Luo, S., and Ma, J. (2022). "Impact of gamification elements on user satisfaction in health and fitness applications: A comprehensive approach based on the Kano model," *Comput. Hum. Behav.* 128, article 107106. DOI: 10.1016/j.chb.2021.107106

Yu, M., Sun, D., Zou, W., *et al*. (2021). "Mechanical analysis of new Chinese solid wood chair based on ANSYS," *Journal of Forestry Engineering* 6(03), 178-184. DOI: 10.13360/j.issn.2096-1359.202006021

Zhao, S., Zhang, Q., Peng, Z., and Fan, Y. (2020). "Integrating customer requirements into customized product configuration design based on Kano's model," *J. Intell. Manuf.* 31, 597-613. DOI: 10.1007/s10845-019-01467-y

Zhu, W., Han, M., Kim, D., *et al.* (2023a). "Highly catalytic and durable nanocellulose fibers-based nanoporous membrane film for efficient organic pollutant degradation," *Journal of Water Process Engineering* 53, article 103620. DOI: 10.1016/j.jwpe.2023.103620

Zhu, W., Kim, D., Han, M., Jang, J., Choi, H., Kwon, G., Jeon, Y., Ryu, D. Y., Lim, S.-H., You, J., Li, S., and Kim, J. (2023b). "Fibrous cellulose nanoarchitectonics on N-doped carbon-based metal-free catalytic nanofilter for highly efficient advanced oxidation process," *Chemical Engineering Journal* 460, article 141593. DOI: 10.1016/j.cej.2023.141593

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APPENDIX, SUPPORTING INFORMATION

E-sports Chair Design Requirements Questionnaire

This questionnaire has a total of 18 questions and is expected to take 2 minutes. Thank you for taking the time out of your busy schedule to provide strong support for this questionnaire.

1. What is your gender?
○male
○female
2. What is your age?
○Under 18 years old
○18-30 years old
○30-40 years old
○Over 40 years old
3. What is your profession?
○student
○teacher
○Company white-collar workers
○Self media workers
○other
4. Do you have any ideas about entering the e-sports chair?
○yes
○No(If this option is selected, the survey will automatically redirect to the end section.)
5. What do you think are the attractions of e-sports chair for you?
☐Stylish appearance
☐Comfortable to use
☐Conducive to maintaining good health
☐High cost performance
☐Other
6. Where will you use the e-sports chair?
☐Office space
☐Study space
☐Entertainment space
☐Other spaces
7. What style of e-sports chair do you like?
☐Cartoon style
☐Tech style
☐Minimalist style
☐Other styles
8. Which type of frame structure would you like the e-sports chair to use?
☐One-piece all-steel frame structure
☐One-piece steel elastic band frame structure
☐Detachable structure
☐Other structures
9. Which type of filling material would you like the e-sports chair to use?
☐High resilience sponge
☐Slow resilience sponge
☐Latex
☐Other materials
10. Which type of upholstery material would you prefer for the e-sports chair?
☐PU leather
☐Genuine leather
☐Mesh fabric

☐PVC leather
☐Technical fabric
☐Other materials
11. What functions do you think are necessary for the cushion of an e-sports chair?
☐The cushion can be adjusted in height
☐The cushion can be adjusted forward and backward
☐The cushion can be adjusted to swivel left and right
☐The cushion can be adjusted to lean forward and backward
☐The cushion has good wrap-around support
☐The cushion has good breathability
☐The cushion parts are replaceable
☐The cushion has a heating function
☐Others
12. What functions do you think are necessary for the backrest of an e-sports chair?
☐The backrest shape should fit the curves of the human body
☐The backrest should be adjustable for leaning back
☐The backrest should be able to recline to become a lounge chair
☐The backrest should provide good support and wrap around the body
☐The backrest should have good breathability
☐The backrest should have heating function
☐Others
13. What functions do you think are necessary for the armrest of an e-sports chair?
☐Armrest height adjustment
☐Armrest swivel
☐Armrest tilt
☐Additional control panel on the armrest
☐Replaceable armrest parts
☐Heated armrest
☐Cup holder on the armrest
☐Good wrapping of the armrest
☐Good breathability of the armrest
☐Others
14. Which functions do you think are necessary for the headrest of an e-sports chair?
☐The position of the headrest can be adjusted
☐The headrest component is replaceable
☐The headrest provides good support and wrap-around comfort
☐The headrest has good breathability
☐Others
15. Which functions do you think are necessary for the lumbar support of an e-sports chair?
☐The height of the lumbar support can be adjusted
☐The lumbar support can be flipped forward and backward
☐The lumbar support can conform to the left and right rotation of the human body
☐The lumbar support can be extended forward and backward
☐The lumbar support component is replaceable
☐The lumbar support provides good support and wrap-around comfort
☐The lumbar support has good breathability
☐Others
16. Which functions do you think are necessary for the footrest of an e-sports chair?
☐The footrest should have a support stand when pulled out, to prevent it from dangling
☐The footrest components should be replaceable
☐The footrest should provide good wrap-around support
☐The footrest should have good breathability
☐Others
17. Which functions do you think are necessary for the legs of an e-sports chair?
☐The chair legs' casters should be lockable
☐There should be a footrest on the chair legs
☐The chair legs can have other designs
☐Others

18. What are some shortcomings of the existing e-sports chair in your opinion?
☐Lack of additional functions
☐Inconvenient to use
☐Inconvenient for transportation
☐Unattractive design
☐Dislike the color
☐Uncomfortable material
☐Others

The Dual-directional Requirements Questionnaire for E-sports Chair

This questionnaire is a two-way demand survey about the functions of e-sports chairs. The questionnaire is divided into two parts. The first part is for collecting basic information, including gender, age, and occupation. The second part is a KANO dual-demand survey questionnaire, with each question having both positive and negative aspects. You only need to rate the satisfaction of having or lacking a particular function for e-sports chairs based on your feelings.

This questionnaire consists of 26 questions and is estimated to take 3-5 minutes to complete. Thank you for taking the time to support this survey. This questionnaire is for research and statistical purposes only, and we will not disclose any of your privacy information, so please feel free to fill it out.

1. Your gender is
○Male
○Female
2. Your age group is
○Under 18 years old
○18-23 years old
○24-30 years old
○31-40 years old
○41-50 years old
○Over 50 years old
3. Your occupation is
○Student
○Teacher
○Company employee
○Self-media worker
○Civil servant
○Others
4. The seat cushion of the e-sports chair can adjust the forward and backward tilt.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

5. The cushion of the e-sports chair can be adjusted for height.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

6. The cushion of the e-sports chair has good breathability.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐

Missing this function	☐	☐	☐	☐	☐

7. The backrest of the e-sports chair is designed to fit the curve of the human body.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

8. The backrest of the e-sports chair can be adjusted forward and backward.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

9. The backrest of the e-sports chair can be adjusted to a lying position, transforming into a recliner.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

10. The backrest of the e-sports chair has good breathability.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

11. The armrest of the e-sports chair is height adjustable.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

12. The armrest of the e-sports chair has an additional table for operations.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

13. The armrest components of the e-sports chair are interchangeable.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

14. The armrest of the e-sports chair has a cup holder function.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

15. The armrest of the e-sports chair can be rotated left and right.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

16. The armrest of the e-sports chair can be tilted forward and backward.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

17. The armrest of the e-sports chair has good breathability.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

18. The position of the headrest of the e-sports chair is adjustable.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

19. The headrest components of the e-sports chair are interchangeable.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

20. The height of the lumbar support of the e-sports chair is adjustable.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

21. The lumbar support of the e-sports chair can fit the left and right rotation of the human body.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

22. When the footrest of the e-sports chair is pulled out, it will be supported by a stand and will not hang in the air.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

23. The casters of the e-sports chair can be locked.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

24. The foot of the e-sports chair is equipped with a footrest.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

25. The e-sports chair can optimize its overall structure for easy transportation.

	Very dissatisfied	Dissatisfied	Neutral	Satisfied	Very satisfied
Having this function	☐	☐	☐	☐	☐
Missing this function	☐	☐	☐	☐	☐

26. Any other comments or suggestions?


Supplementary materials2-E-spc


Supplementary materials3-The d