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The Design of Undergraduate Students' Learning Product Service System Based on User Behavioural Persuasion

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Abstract. The article investigates the application of user behavior and persuasive design theories in product design and develops a design model based on user behavioral persuasion. The research collects data on study habits observed from undergraduate students and subsequently examines the patterns and variations within this cohort. The investigation leads to the development of a product service system that integrates motivational education to encourage undergraduate students to cultivate positive study habits and enhance the overall quality of their learning experience. The study builds a logical and efficient design model and hits the pain points of undergraduate students learning behaviors, delivering effective design solutions and improving the match between product strategies and design requirements by combining with motivational education.

Keywords. User behavior, persuasive design, motivational education, product service system design

To realize the ambitious goal of the great rejuvenation of the Chinese people, it is imperative for China, a nation with a large population, to transition into a talent-rich country. In this regard, the pivotal role and profound significance of education, particularly at the undergraduate level, cannot be overlooked, where undergraduate education serves as a crucial mechanism for identifying and nurturing talented individuals. However, the realm of undergraduate education is today plagued by prevalent problems such as diminished student enthusiasm, unfavorable attitudes, and substandard learning quality. Most of the current solutions aimed at enhancing student learning quality mostly employ punitive mechanisms or untargeted incentive strategies without concrete product support and specific positive measures, hence significantly diminishing their effectiveness in implementation. To address the limitations, it is essential to apply design and educational theories to propose efficacious design strategies and outcomes base on real cases and data. This article presents a design model that is guided by theories of user behavior and persuasion design, analyzing the learning behavior of undergraduate students, introducing the

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concept of educational incentives to summarize the strategies for designing product service systems, which are to enhance the overall learning quality of undergraduate students, that align with the learning habits of two distinct types of students.

1. Design Model Construction

1.1. Design Method Based on User Behavior

According to Maslows hierarchy of needs theory, individuals are driven by their self-needs to develop behavioral motivations. Through their actions, they strive to fulfill increasingly higher levels of requirements until they ultimately attain the highest degree of psychological needs associated with self-identification. Therefore, when designing based on user behavior, it is essential to comprehend, compile, and analyze user needs, motivations, and behaviors in order to deliver design solutions that meet user expectations and needs.

Various scholars employ diverse methodologies centered upon user behavior in their research and product design processes. The research conducted by Song Xianping et al. focused on user behavior analysis, operational methodologies, and psychological motives when utilizing products, aiming to explore the design needs and implement innovative designs for household fire extinguishers [1]. Yu Ruyang et al. conducted an analysis of user behavior pertaining to the utilization of domestic floor-cleaning robots, where they successfully assessed the degree of satisfaction associated with diverse user requirements, subsequently formulating tailored strategies intended for enhancing the overall user experience [2]. Li Xin et al. conducted a study to investigate the behavioral features of women engaging in fitness exercises during pregnancy to examine the challenges and needs by acquiring user behavioral data in a suitable manner, employing scientific analysis techniques to discern requirements and formulate design strategies [3].

1.2. Related Theories of Persuasive Design

Persuasive technology is a multidisciplinary domain encompassing the fields of computer science and psychology. This discipline centers on the utilization of research, analysis, and design methodologies to change consumers attitudes, beliefs, and patterns of usage, as well as the intended functions of products. The application of persuasive technology has been observed in many sectors such as education, healthcare, commerce, and product design. The concept of persuasive design, initially introduced by Professor B.J. Fogg from Stanford University, involves a design approach that leverages persuasive technologies to effectively change user behavior or attitudes with design where it underscores the attainment of alterations and the direction of user conduct without resorting to coercion [7].

Simultaneously, Professor B.J. Fogg introduced the widely recognized FBM model of behavior persuasion. He noted that the three dimensions of motivation, capability, and trigger factors are the causes of conscious behavior. The model places emphasis on the necessity for individuals to possess adequate motivation, corresponding abilities, and triggering conditions to execute a particular behavior [5]. It elucidates the process through which behavior undergoes transformation as a

result of the influence exerted by these elements. Furthermore, it provides guidance to designers and researchers, encouraging them to adopt a systematic approach when considering the potential factors that can bring about behavioral change.

1.3. Design Model Construction Based on User Behavior and Persuasive Design Theory

Based on the preceding discourse, while analyzing user behavior, it is crucial to collect information regarding to user needs, motivations, and actions. Conversely, when conducting persuasive design, it is vital to concentrate on user motivations, abilities, and triggers. Indeed, there is a substantial overlap and reciprocal reinforcement between these two fields of study. The trigger factors and abilities considered within the framework of persuasive design theory can be matched with the requirements and behaviors identified in user behavior research. Thus, when establishing the design model, it is important to zero in solely on three key components: user demands and trigger factors, motivation, and behavior and abilities (see Fig. 1).

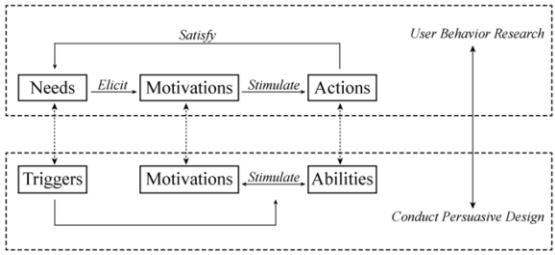

Figure 1. Relationship between user behavior research and persuasive design theory

In the data insights of these three parts, it is required to capture user behavior and analyze relevant data, sorting and defining the user journey along with activity chain, and focusing on optimizing the user experience. By gaining a deep understanding of user behavior, it is feasible to effectively categorize different user types, develop comprehensive personas, and analyze the user behavior chain which enables the identification of pain points and supports the exploration of design opportunities. On the basis of the findings, it can be achieved to provide specific solutions and design strategies, and to advance theoretical advancements towards the process of productization. Based on the aforementioned procedures, it is conceivable to develop a design model comprising three distinct levels, namely data gathering, theoretical proposal, and practical production. Each level operates as an autonomous unit, generating outcomes, while simultaneously advancing and establishing an interconnected and close-loop system (see Fig. 2).

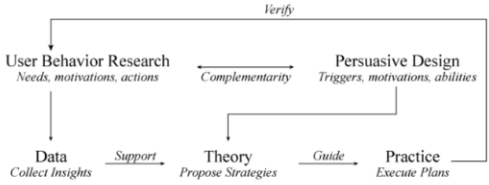

Figure 2. Design model based on user behavior and persuasive design

2. Insight Collection of Undergraduate Students' Learning Process

Prior to proposing design strategies, it is fundamental to collect the needs, triggering factors, motivation, behavior, and capabilities of the target users. Within the framework of this article, the requirements and triggers refer to enhancing the quality and reinforcing the achievements of learning. The research will collect data by interview and observation which will then be subjected to summarizing and testing with the goal to derive representative conclusions, and subsequently guide the development of practical and the outputs of design strategies.

2.1. Establishment of Typical User Roles

User role research is a systematic procedure that involves investigating the underlying user characteristics and associated attributes of the target audiences. This is accomplished through multiple methods, including engaging in conversations and conducting surveys where the findings of the research are subsequently conveyed to designers through multimedia platforms such as websites, text documents, reports, or illustrative models. Afterwards, the design elements are iteratively refined in accordance with these insights to achieve a comprehensive design solution [6]. In this research, it is undertaken through the utilization of interviews, questionnaire surveys, and observation to identify commonalities and variances within the collected samples, and thereafter summarize the results.

Segmentation of user groups. Observation was used to observe the study methods of 10 self-study locations in libraries and study rooms, and a questionnaire survey was distributed to 75 students to analyze statistically their study methods.

Definition of user categorization. The learning approach can generally be categorized into the two user categories.

Time-based users are individuals who engage in learning strategies that prioritize activities such as reading and memory. This type of user typically spends time studying with watching and reading while less time on writing.

Quantity-based users are individuals who engage in learning approaches that prioritize the act of writing and documenting information. This particular kind of users typically engages in extensive written learning events and writes more.

Statistics on Sample Group Classification. The undergraduate student group was split into two categories, time-based users (time-based) and quantity-based users (quantity-based), accounting for 44% and 56% of the group, respectively.

2.2. Establishment of User Behavior Chain

This section refers to the user activity chain testing conducted by He Xuemei in the service design of the campus printing facility. Initially, she conducted a rough segmentation of user behavior and objectives [7]. Following that, the researcher documented key touchpoints of user behavior as time indicators to draw the user behavior chain. The methodology used in this study is largely similar.

From the 75 survey respondents, five time-based users and five quantity-based users are selected and assigned tasks with certain restrictions to serve as the

information source for establishing the user behavior chain based on their activities. Peer communication is evaluated based on the quality of learning from various completion methods of the same user type.

Group 1: Five time-based users are segregated and given two 100-word articles to memorize and dictate. The assessment of learning quality is based on the criteria of total time and dictation performance.

Group 2: The five time-based users same as group 1 are grouped together and given two new 100-word articles to memorize and dictate. Discussion is permitted among individuals during the preparatory phase, but it is prohibited during the dictation phase. The assessment method of learning quality is the same as group 1.

Group 3: Five quantity-based users are separated and given two hours to accomplish a writing assignment. The completion quality indicators encompass both the quantity of words and the level of writing which are also applicable to group 4.

Group 4: The five quantity-based users same as the group 3 are grouped together and given two hours to complete a writing assignment. Discussion is facilitated among individuals involved in the process.

The evaluation examining the impact of peer communication is based on learning quality by comparing the results between Group 1 and Group 2, and between Group 3 and Group 4 as well. During the phase of completing Groups 2 and 4, the researchers diligently documented their behaviors, time nodes, and the fluctuations in user emotions to build a comprehensive behavior chain where the following codes shown on table 1 were employed.

Table 1. User behavior codes

User Behavior	Code
List Agenda	A
Read Material	B
Start Learning	C
Discuss with peers	D
Finish Preparation	E
Use Mobile Phone	F
Encourage each other	G
Take a rest	H
Check timing	J
Complete	K

Table 2. The behavior record and result upon completion of Time-based users (Remarks: The unit of duration is minutes, less than one minute is counted as one minute and rounded up in the statistics of user's time length, and the average time is retained as one decimal. The total score is presented in the percentage system with two parts where the total time (50%) in order of priority were assigned points 50, 45, 40, 35, 30 and the results of the score (50%) according to the wrong word each deduct one point.)

Category	Group	User I	User II	User III	User IV	User V	Average
Learning Process	1	A-B-C-H-J-E-K	B-C-H-J-H-E-K	B-C-H-J-E-K	A-B-C-E-J-K	A-B-C-H-J-E-K	-
	2	A-B-C-D-F-H-G-J-E-K	B-C-D-H-G-F-G-J-E-K	A-B-C-D-F-G-J-E-H-K	A-B-C-D-J-E-K	A-B-C-D-F-G-J-E-K	-
Total Duration	1	28	34	27	22	30	28.2
	2	23	24	23	19	22	22.2
Non-study Duration	1	3	9	2	1	6	4.2
	2	3	3	2	1	2	2.2
Score	1	86	65	95	98	80	84.8
	2	89	75	90	100	95	89.8

Table 3. The behavior record and result upon completion of Quantity-based users (Remarks: The unit of duration is minutes, less than one minute is counted as one minute and rounded up in the statistics of user's time length, and the average time is retained as one decimal. The score is presented in the percentage system.)

Category	Group	User VI	User VII	User VIII	User VI	User X	Average
Learning Process	3	B-C-H-J-H-J-K	B-C-J-H-K	B-C-H-J-K	A-B-C-H-J-K	A-B-C-J-K	-
	4	B-D-C-H-G-K	A-B-D-C-F-G-J-K	B-D-F-G-C-H-G-K	A-B-D-F-G-C-J-H-G-K	A-B-D-C-J-K	-
Non-study Duration	3	32	12	20	8	1	14.6
	4	10	5	12	8	1	7.2
Score	3	60	90	90	92	100	84.8
	4	85	92	90	94	100	92.2

2.3. Analysis of Group Behavior During User Learning

The examination of the learning outcomes between different groups in each user type experiment reveals that the inclusion of peer contact yields a noteworthy enhancement in the overall quality of learning. In the conducted tests involving Group 1 and Group 2, it was observed that the mean duration of non-learning intervals among users dropped from 4.2 minutes to 2.2 minutes. Simultaneously, the average score exhibited an increase from 84.8 points to 89.8 points. The members of Group 2 were able improve their approaches to learning, identify areas of difficulty, and enhance the overall quality of their learning experience through effective communication. The average non-learning time in tests on Groups 3 and 4 dropped by over 50.68%, while the average score climbed noticeably from 84.8 to 92.2 points. This phenomenon can be attributed to the fact that users were able to decrease non-learning behaviors through peer support and supervision, and acquire more effective learning strategies through communication, resulting in an overall enhancement in the average learning quality of the entire group.

3. Solution Proposal

The utilization of electronic media, including as television, computers, and mobile phones, for educational purposes, commonly referred to as e-learning, has undeniably emerged as a prevailing trend and area of growth. However, Zheng Yanfu adopted the independent sample t-test method to experimentally examine the gathered data and discovered that the observed impact of e-learning is not deemed sufficient [8]. The analysis of the survey revealed that students who utilize paper-based materials for studying have a comparatively profound comprehension of the subject matter and demonstrate enhanced proficiency in written language expression, resulting in superior performance on examinations. According to the research conducted by Pan Hui, it was seen that the overall reading comprehension score was marginally higher when assessed on paper as compared to a computer screen. Additionally, the analytical ability score was found to be slightly higher in the paper-based group compared to the e-learning group. Meanwhile, the scholars

discovered that mobile reading is conducive to dispersed and transitory learning, whereas paper reading is more conducive to in-depth learning.

Furthermore, with the proper cultivation of incentive spirit and mechanism, undergraduates have the potential to develop a sound ideology of striving and demonstrate a willingness to exert themselves towards its realization. The synergistic impact of this phenomenon on the objective of the present study necessitates the use of suitable incentive strategies. Incentive education refers to an educational approach wherein educators utilize specific incentive principles and appropriate methods to stimulate the motivation of students, correct their thinking and motivation, enhance their ideological consciousness, and mobilize their enthusiasm, initiative, and creativity. This method is based on educational goals and takes into account the needs and characteristics of the learners, aiming to guide them towards the predetermined educational objectives.

Drawing upon the scholarly contributions and theoretical frameworks posited by the aforementioned academics, alongside an examination of the findings derived from user research, the proposed design strategy shall commence with the utilization of conventional paper-based pedagogical approaches. This would be supplemented by the integration of incentive-based educational methodologies, culminating in the comprehensive design and development of the product-service system.

3.1. Overall Framework Proposal

By delineating typical user roles, constructing user behavior chains, and assessing the correlation between peer communication and the quality of learning, the pain points are investigated and anticipated requirements are formulated under the acquirement of pertinent data. Following the process of screening and integration, the design opportunities can be succinctly categorized into five distinct content items that are the quantification of learning quality for quantity-based users, the quantification of learning quality for time-based users, the implementation of timed reminders for work and rest intervals, instant peer messaging, and enabling the sharing of learning progress. The five solutions can be formed from the five functions: word count statistics, time recording, timed reminders, peer communication, and real-time data sharing. Furthermore, the five functions can be categorized into four different components, including data gathering, data processing, data feedback, and social system.

The process of data collecting is facilitated by the utilization of various writing tools and specific supplementary hardware. Data processing serves as a bidirectional transmission platform allowing the exchange of information between the stages of data gathering and data feedback. The transmission of data feedback primarily depends on networking or other connectivity mechanisms to relay information to external platforms where feedback is then visually displayed on mobile applications. The social system operates through using collected and analyzed data, including rankings, which foster competitiveness and motivation among users, encouraging changes in their learning attitudes and behaviors. Additionally, the system enhances communication and interaction among users. The design of the mobile

application and smart pen module originates from the aforementioned four components which serves as the foundation for the further development of the product framework and subsequent product design.

3.2. Design of Data Collection End

Based on the identification of typical user roles and the formulation of potential solution, the module of data collection consists of two modules, namely word count statistics and usage time recording.

The module for word count statistics incorporates a data collection method for periodic triaxial acceleration behavior, which can be measured and executed using an accelerometer. Jiang Bo introduced a novel approach for detecting steps using waist-mounted microelectromechanical systems (MEMS) accelerometers [9]. This algorithm combines three thresholds, including peak, zero-crossing, and valley, to assess the movement condition of pedestrians. The reduction of noise interference in the accelerometers false peak value is achieved by sequentially detecting the three thresholds. The process of writing is characterized by the generation of triaxial acceleration fluctuations and short breaks occurring between successive words, resulting in exhibiting periodic patterns akin to those observed during walking. Hence, the act of writing can be seen as a behavioral pattern characterized by periodic triaxial acceleration fluctuations, which can be identified by the utilization of a MEMS accelerometer. The calculation of the number of words written can be achieved by the analysis of the acquired image, where it can provide an indicator of the learning outcomes for quantity-based users.

In addition, the module can get usage time values by analyzing the image derived from the acceleration data. This particular value can serve as one of the foundational elements for time statistical analysis. Plus, the time recording feature can be initiated and terminated manually with the help of a time chip, which is used to quantify the learning achievements of time-based users.

3.3. Design of Data Transmission and Processing End

The data transmission and processing component is capable of evaluating and converting the acquired acceleration change data into word count and duration data. This helps the visualization and analysis of user settings gained from the data feedback component, which then transmits the information to the data collection component to aid in the completion of user settings. The processor is responsible for carrying out the data processing tasks, while the transmission function is facilitated by means of Bluetooth technology, where data can be disseminated among users in order to achieve the process of peer sharing and motivating.

The data feedback endpoint facilitates the visualization of processed data, enabling users to quantitatively assess their learning outcomes, make comparisons with other users, and gain a partial understanding of their learning progress, which has a motivational impact.

3.4. Design of Social System

Interaction and communication between users play a significant role in influencing user behavior in online communities [10]. The social system is an integral component of the incentive system, which provides users with stimulation and motivation and encourages them to set personal objectives. The primary modules of the social system are learning achievement ranking and instant messaging. Users can select a quantification approach that aligns with their preferred learning style, time-based or quantity-based. Additionally, they can exchange data with peers within the groups they participate in, and receive diverse visual virtual incentives based on their ranking outcomes. Furthermore, users have the opportunities to engage in discussions and send messages which can augment the motivational impact by interaction among peers (see Fig.3).

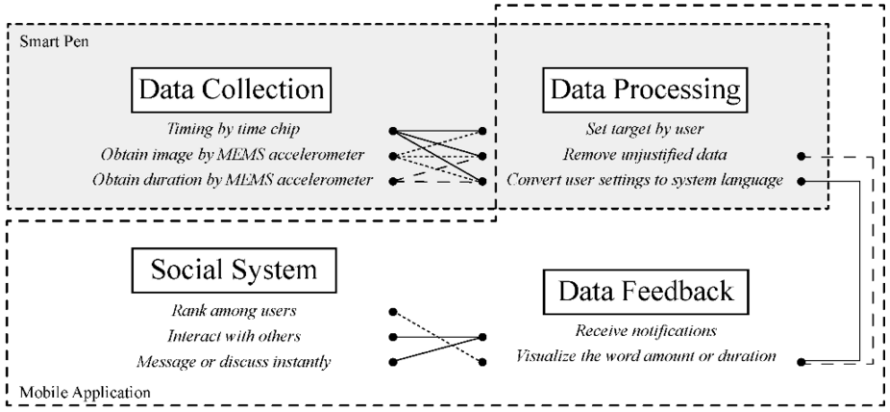

Figure 3. The structure of the product system

3.5. Design Strategy Proposal of Mobile Application

The interaction between users and products is not limited to the physical characteristics of the product, but also includes a process consisting of a series of behaviors, which is a system service platform mediated by the product [11]. Hence, it can be argued that the inclusion of digitalization holds major significance in the realm of persuasive design [12]. The utilization of a mobile application as a visual medium for representing the product system enables an illustration of the users current status, goals, and achievements.

The mobile application integrates many features outlined in the FBM model to effectively generate triggering factors for users. The main motivating factors in online communities are rewards, which include various forms of recognition, prestige, and respect. Users demonstrate a willingness to uphold their reputation and social standing by consistently making valuable contributions to the community [13]. Therefore, while the implementation of virtual incentives, showcasing user achievements, and adding interactive features could increase user motivation. Besides, users have the option to set personal targets and allocate time accordingly, taking into account their unique learning abilities and habits. Additionally, the inclusion of a conversation and communication feature, such as instant messaging,

allows users to promptly address their learning inquiries, thereby enhancing their proficiency in utilizing the platform. Furthermore, it is possible to send daily reminders at a designated time and disclose the top three outcomes of the daily rankings, which can effectively stimulate user engagement and enhance their excitement for learning, leading to an improvement in the quality of learning.

4. Design Strategy Practices

4.1. Design of Mobile Application "Track"

"Track" is one of the outputs of this product design, which is a mobile application with four primary features: word count ranking, study time ranking, timing setting, and interactive communication.

The functions "word count ranking" and "study time ranking" can be found inside the "statistics" section of the secondary function area. Through the utilization of a smart pen and the subsequent transfer of data through Bluetooth to a mobile application, users are able to access their present word count and study time data, which enables them to engage in a comparative analysis of their ranks in relation to other users, thus facilitating the attainment of a motivational effect. Furthermore, the subordinate functions provide users the ability to view historical data and form groups which provides the seamless comparison of ones quantified outcome over a specific timeframe. Additionally, it enables users to share data, engage in peer supervision, and foster motivation among friends.

The function "timing setting" can be found under the area named "Me". Users can set their own goals in the application and receive automated reminders when the designated time arrives. This feature has the potential to enhance learning motivation by setting goals and reinforcing the motivational impact of the system.

The instant messaging function is situated under the "Notification". Users can discuss and communicate with friends in various groups in real time, as well as obtain information such as likes from other users (see Fig. 4).

4.2. Design of the Smart Pen

The smart pen serves as the medium for collecting data and executing user instructions within the product. The proposed concept involves the integration of electronic component modules into stationery items, offering several benefits such as recyclability, compactness, user-friendly operation, and affordability. The users activity-related data is captured using an accelerometer and a time chip, and the specific outcomes are derived through the data processing component. In the meantime, the smart pen can send out visual reminders at the designated time set in the application "Track" (see Fig. 5).

Figure 4. The interface of mobile application "Track" in Chinese

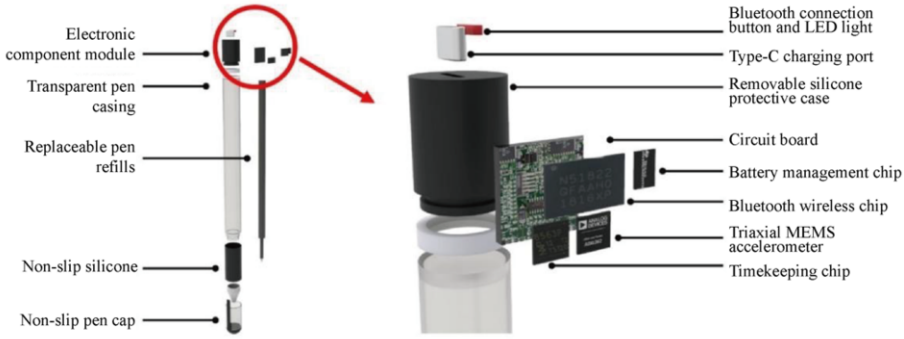

Figure 5. Exploded view of the Smart Pen

5. Conclusion

The role of education, particularly at the undergraduate level, holds enormous significance in the realm of social development. Nevertheless, due to shifts in the social milieu and alterations in students attitudes and self-perception, certain students exhibit diminished motivation for learning and a decrease in enthusiasm. Consequently, there is a deterioration of the quality of their education, which is detrimental not only to their personal development but also to the long-term progress of society and the nation. In turn, educators are currently grappling with an urgent need to address challenges related to enhancing the educational standard, revamping the learning environment, and fostering a better atmosphere for learning. Through the execution of external interventions and the facilitation of students self-transformation, the collective can be motivated towards change, hence presenting a promising avenue for exploration.

This article defines typical user roles, delineates the customary user behavior

chains and user journey maps, and scrutinizes the experimental findings. Subsequently, the study delves into the areas of discomfort and anticipated outcomes, and proceeds to develop appropriate design approaches. By making slight alterations to traditional products and integrating them with mobile devices that enable data visualization and foster community engagement, a product is developed that is underpinned by persuasive theory and user behavior. The aforementioned product acquires data from an individual user and utilizes it for the purpose of facilitating the sharing of information between group circles. Drawing upon persuasive theory, this approach facilitates the process of integrating individuals into cohesive groups, hence fostering the creation of a reconfigured environment. This study is grounded in the context of everyday life, aligning with the specific usage scenarios and social needs of individual users to achieve optimal outcomes through incremental modifications. Nonetheless, it is important to acknowledge certain limitations in the research process, such as a limited sample size and inadequate experimental design. These shortcomings should be duly considered in later stages of investigation, allowing for further refinement and iterative updates. The ultimate goal is to develop a comprehensive and representative product that fulfills its intended purpose effectively.

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