

Research on Influencing Factors of User Stickiness of Educational Robot Products

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Abstract:

With the rapid development of artificial intelligence technology, educational robots have been widely applied in basic and quality education as intelligent learning tools. However, the low user retention rate has become a critical issue restricting their sustainable development. User stickiness not only relates to the market performance of educational robot products but also directly affects the realization of their educational value. Addressing the limitations of existing research, which mostly explores user behavior from a single perspective and lacks systematic causal analysis, this paper constructs a comprehensive analysis framework integrating Pearson correlation analysis, the DEMATEL method, and the ISM model to systematically study the formation mechanism of user stickiness in educational robots. Based on survey data from 31 industry experts, the study first identifies and verifies 14 key factors influencing user stickiness. Secondly, it delineates the causal relationships and hierarchical structure among these factors. The results indicate that the formation of user stickiness in educational robots presents a hierarchical path of “Technology Drive — Experience Transmission — Value Perception.” Specifically, technological advancement and big data personalization are the fundamental drivers of the system; user experience factors play a key mediating role; while educational quality, content timeliness, and customer service manifest as final result variables. The conclusions provide empirical evidence for the technological optimization and operational decision-making of educational robot products.

Keywords:

Educational Robot, User Stickiness, DEMATEL, ISM, Influencing Factors

1. Introduction

1.1. Research Background and Significance

The rapid development of artificial intelligence, the Internet of Things (IoT), and big data technologies is profoundly reshaping the form of education. As an important carrier of intelligent education, educational robots have demonstrated unique advantages in learning companionship, personalized tutoring, and interactive teaching, gradually becoming a significant component of the intelligent education sector. [1] pointed out that by integrating perception, decision-making, and interaction capabilities, educational robots help expand learning contexts and enhance the learning experience. However, in market practice, educational robot products generally face the problem of “high initial usage rates but low continuous usage rates.”

Insufficient user stickiness has become a key bottleneck restricting industry development.

User stickiness is an important indicator for measuring the success of information systems and digital products, reflecting users' willingness to continue use and the stability of their behavior [2,3]. In the educational context, user stickiness relates not only to the commercial value of the product but also directly impacts learning outcomes and the realization of educational goals. Although existing studies have explored the usage of educational technology products from the perspectives of educational content, teaching effectiveness, or technology acceptance, they generally prioritize single-factor analysis and lack a systematic revelation of multi-factor coupling relationships and their action paths. Therefore, it is necessary to conduct an in-depth analysis of the influencing mechanism of educational robot user stickiness from a systems perspective.

1.2. Research Questions and Objectives

Focusing on the practical problem of insufficient user stickiness in educational robots, this paper addresses the following research questions: (1) What are the key factors influencing the user stickiness of educational robot products? (2) What causal relationships and interaction mechanisms exist among these factors? (3) At what hierarchical levels are different factors located during the formation of user stickiness, and which factors play a fundamental driving role?

1.3. Research Innovations

The main innovations of this paper are reflected in three aspects. First, methodologically, it integrates Pearson correlation analysis, DEMATEL, and ISM methods to construct a comprehensive analysis framework of "Correlation Identification — Causal Analysis — Hierarchical Structure Modeling." Second, empirically, based on expert survey data, it systematically reveals the multi-factor mechanism of educational robot user stickiness. Third, theoretically, it enriches the research on educational robots and user stickiness from a systems perspective, providing new analytical ideas for related fields.

2. Theoretical Basis and Research Framework

2.1. User Stickiness Theory

User stickiness originated in the fields of information systems and e-commerce research, emphasizing users' continuous usage behavior toward a specific system or service [2]. Lin [3] noted that user stickiness depends not only on functional value but is also influenced by usage experience and emotional factors. Theoretically, Expectation-Confirmation Theory (ECT) suggests that the result of a user's comparison between actual experience and initial expectation after using a product directly affects their willingness to continue using it [4]. The Technology Acceptance Model (TAM) emphasizes the core roles of perceived usefulness and perceived ease of use in technology adoption [5,6].

Combining this with the application context of educational robots, technological advancement and educational quality can be viewed as the main sources of perceived usefulness; interface design and system fluency influence perceived ease of use; while

social interaction and incentive mechanisms help enhance the immersive experience, thereby collectively contributing to the formation of user stickiness.

2.2. Identification and Classification of Influencing Factors

Based on relevant literature and expert interviews, this paper identifies 14 key factors influencing educational robot user stickiness from four dimensions: Software, Hardware, Social-Incentive, and Brand Service. The system of influencing factors is constructed as follows (see Table 1).

Table 1. System of Influencing Factors for User Stickiness of Educational Robots.

Dimension	Factor	Name	Description (Optimized)
Software	F1	Educational Quality	Efficiency and accuracy in assisting specific learning tasks.
	F2	Interface Design	Aesthetic appeal and clarity of information architecture.
	F3	Content Timeliness	Regular iteration based on curriculum and knowledge updates.
	F4	Big Data Personalization	Precise content recommendation and path planning based on user data.
Hardware	F5	Interaction Design	Intuitiveness and simplicity of operation methods.
	F6	Tech Advancement	Intelligence level of AI algorithms and motion control precision.
	F7	Fluency	Timeliness of response and smoothness of operation.
	F8	Multi-modal Interaction	Integration of voice, gesture, touch, and other inputs.
Social-Incentive	F9	Social Interaction	Support for user communication, sharing, and collaboration.
	F10	Social Opinion	Media reports, expert reviews, and peer recommendations.
	F11	Incentive Mechanism	Gamification elements (e.g., points, badges) to motivate learning.
Brand	F12	Brand Awareness	Market recognition, user reputation, and brand credibility.
	F13	Market Promotion	Marketing intensity, channel coverage, and pricing strategies.
	F14	Customer Service	Effectiveness of pre-sales consultation and technical support.

3. Research Methodology

3.1. Data Source and Sample Characteristics

Data was obtained through a questionnaire survey. The respondents were industry experts in the fields of educational technology, artificial intelligence, and educational products. A total of 31 valid questionnaires were recovered. The questionnaire utilized a 5-point Likert scale to evaluate the importance of each influencing factor.

Table 2. Descriptive Statistics of the Sample.

Factor	Mean	Std. Deviation	Min	Max
F1	3.968	0.795	3	5
F2	3.903	0.908	2	5
F3	4.129	0.806	3	5
F4	4.065	0.998	1	5

F5	4.032	0.875	2	5
F6	4.161	0.969	2	5
F7	4.194	0.910	2	5
F8	3.903	1.044	2	5
F9	3.548	1.028	1	5
F10	3.742	0.965	2	5
F11	3.710	0.973	1	5
F12	3.806	0.873	2	5
F13	3.903	0.790	2	5
F14	4.129	0.885	2	5

3.2. Pearson Correlation Coefficient

The Pearson correlation coefficient analysis method was used to test the correlation between the 14 influencing factors to identify the strength of associations, providing a basis for subsequent causal analysis. The correlation coefficient is calculated as:

$$r_{xy} = \frac{\sum_{i=1}^n (x_i - \bar{x})(y_i - \bar{y})}{\sqrt{\sum_{i=1}^n (x_i - \bar{x})^2} \sqrt{\sum_{i=1}^n (y_i - \bar{y})^2}}$$

Where r_{xy} represents the correlation coefficient between factor x and factor y, x_i and y_i represent the observed values of the i-th sample, and $\bar{x}$ and $\bar{y}$ represent the means of the two factors.

3.3. DEMATEL Method

The DEMATEL (Decision Making Trial and Evaluation Laboratory) method is used to characterize the causal relationships among factors in a complex system. By constructing the direct relation matrix, normalized matrix, and total relation matrix, the Influence Degree (D), Effect Degree (C), Centrality (M), and Cause Degree (R) of each factor are calculated to distinguish between cause factors and result factors [9].

(1). Method Steps

Step 1: Construct the Direct Relation Matrix Based on the Pearson correlation coefficient matrix, the direct relation matrix D is constructed. The elements d_{ij} in the matrix represent the direct influence degree of factor i on factor j.

Step 2: Calculate the Normalized Direct Relation Matrix The direct relation matrix D is normalized to obtain the normalized matrix N:

$$N = \frac{D}{s}$$

Where s is calculated as:

$$s = \max_{1 \leq i \leq n} \sum_{j=1}^n d_{ij}$$

Step 3: Calculate the Total Relation Matrix The total relation matrix T is calculated using the following formula:

$$T = N(I - N)^{-1}$$

Influence Degree (D_i): $D_i = \sum_{j=1}^n t_{ij}$

Effect Degree (C_j): $C_j = \sum_{i=1}^n t_{ij}$

Centrality (M_i): $M_i = D_i + C_i$

Cause Degree (R_i): $R_i = D_i - C_i$

(2). DEMATEL Analysis Results

Table 3. DEMATEL Analysis Results.

Rank	Factor	Name	Influence (D)	Effect (C)	Centrality (M)	Cause Degree (R)	Type
1	F6	Tech Advancement	2.191	1.076	3.267	1.114	Cause
2	F4	Big Data Personalization	2.090	1.067	3.157	1.023	Cause
3	F9	Social Interaction	1.257	1.022	2.279	0.234	Cause
4	F5	Interaction Design	1.239	1.012	2.252	0.227	Cause
5	F14	Customer Service	0.910	1.252	2.162	-0.342	Result
6	F7	Fluency	1.192	0.949	2.141	0.243	Cause
7	F13	Market Promotion	0.908	1.195	2.103	-0.287	Result
8	F2	Interface Design	1.134	0.928	2.062	0.206	Cause
9	F11	Incentive Mechanism	0.866	1.117	1.983	-0.250	Result
10	F3	Content Timeliness	0.682	1.291	1.973	-0.609	Result

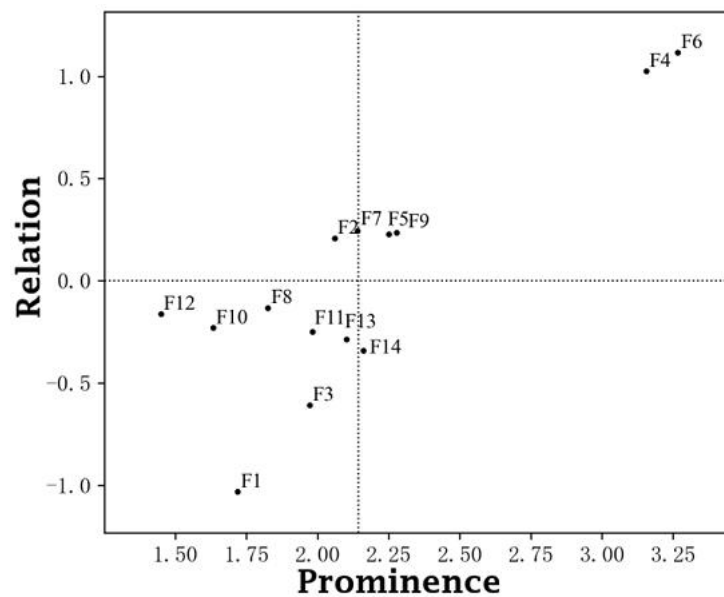


Figure 1. Prominence–Relation map of factors.

3.4. ISM Model

Based on the DEMATEL results, the Interpretive Structural Modeling (ISM) method is introduced to stratify the factors. By constructing a reachability matrix and performing hierarchical decomposition, the structural position of each factor in the system is clarified [10].

(1) Construct Reachability Matrix: Based on the total relation matrix T and a threshold λ (taken as the mean of all elements in T , $\lambda = 0.15$ to filter weak associations), the reachability matrix K is constructed.

(2) Determine Hierarchical Relationships: Using the standard decomposition method of the reachability matrix, combined with the Cause Degree ($R > 0$) to determine bottom-layer driving forces, the hierarchical structure is determined.

Table 4. ISM Hierarchical Structure Analysis Results.

Level	Level Name	Code	Factor Name	Centrality	Cause Degree	Attribute
Level 1	Top (Result Layer)	F1	Educational Quality	1.720	-1.032	Final Result
		F3	Content Timeliness	1.973	-0.609	Final Result
		F13	Market Promotion	2.103	-0.287	Final Result
		F14	Customer Service	2.162	-0.342	Final Result
Level 2	Middle (Direct Exp.)	F11	Incentive Mechanism	1.983	-0.250	Transitional
		F12	Brand Awareness	1.451	-0.163	Transitional
		F10	Social Opinion	1.634	-0.231	Transitional
Level 3	Middle (Interaction)	F2	Interface Design	2.062	0.206	Key Mediator
		F9	Social Interaction	2.279	0.234	Key Mediator
		F5	Interaction Design	2.252	0.227	Key Mediator
		F7	Fluency	2.141	0.243	Key Mediator
		F8	Multi-modal Interaction	1.826	-0.134	Key Mediator
Level 4	Bottom (Root Layer)	F6	Technological Advancement	3.267	1.114	Fundamental Drive
		F4	Big Data Personalization	3.157	1.024	Fundamental Drive

4. Research Results and Discussion

4.1. Identification of Key Factors

Based on the DEMATEL analysis results (Table 3), the influencing factors of educational robot user stickiness exhibit distinct characteristics within the system.

From the Influence Degree (D) perspective, Technological Advancement (F6) and Big Data Personalization (F4) rank highest, indicating a strong capability to directly affect other factors. This suggests that AI algorithm capabilities and personalized recommendation mechanisms are the foundation for driving the system.

From the Effect Degree (C) perspective, Educational Quality (F1), Content Timeliness (F3), and Customer Service (F14) have relatively high values, indicating they are easily influenced by the combined action of other factors. These factors reflect the overall evaluation formed by users over long-term use.

4.2. Centrality and Cause Degree Analysis

Centrality (M) reflects the comprehensive importance of a factor in the system. F6 and F4 have the highest centrality, serving as pivotal nodes.

Cause Degree (R) distinguishes causal attributes. F6 and F4 have positive and high cause degrees, identifying them as primary driving forces. Conversely, F1, F3, and F14 have negative cause degrees, characterizing them as result variables. Factors such as Interaction Design (F5) and Fluency (F7) fall in the middle, functioning as connecting mediators between the technology layer and the result layer.

4.3. ISM Hierarchical Structure Analysis

The ISM analysis reveals a clear four-layer hierarchical structure (Table 4), demonstrating a “Fundamental Drive -> Result Feedback” evolution:

(1). Root Layer (Level 4): Technological Advancement (F6) and Big Data Personalization (F4). These are the logical starting points of the system. Without stable and advanced technical support, other levels cannot function effectively.

(2). Interaction Layer (Level 3): Includes factors like Interaction Design (F5) and Fluency (F7). This layer acts as a mediator, transforming “technical capabilities” into “user experience.”

(3). Transitional Layer (Level 2): Includes Social Opinion (F10) and Incentive Mechanisms (F11). These factors amplify user motivation and emotional identification.

(4). Top Layer (Level 1): Educational Quality (F1), Content Timeliness (F3), and Customer Service (F14). These are result feedbacks formed after the combined action of technology and experience.

5. Conclusions

Based on survey data from 31 industry experts, this paper constructed and verified a comprehensive analysis framework to systematically analyze the influencing factors of user stickiness in educational robot products. The main conclusions are as follows:

First, from the perspective of the overall system structure, user stickiness is a complex system determined by the interaction of multiple factors. Technological Advancement and Big Data Personalization are the fundamental factors driving the formation of user stickiness, verifying the core role of “perceived usefulness” in the Technology Acceptance Model.

Second, regarding action paths, user experience factors play a key mediating role. Interaction design, system fluency, and social interaction convert underlying technical capabilities into perceptible user experiences. Technical advantages alone are insufficient; they must be externalized through good HCI design to effectively promote continuous usage.

Third, regarding result feedback, factors such as Educational Quality and Customer Service act as result variables. This indicates that educational quality is not the starting point of stickiness but a perceived result of technical capability and usage experience. Consequently, relying solely on marketing or service optimization without technical support is unlikely to achieve sustainable user retention.

In summary, the formation of user stickiness follows a hierarchical logic of “Technology Drive — Experience Transmission — Value Perception.” Enterprises should prioritize solidifying underlying technical capabilities, then optimize interaction experiences, to naturally enhance user recognition of educational quality and value.

6. Limitations

This study is based on expert survey data with a limited sample size. Future research could combine large-scale user behavioral data or longitudinal tracking data to further verify and expand the model results.

Conflicts of Interest

The author declares that there is no conflict of interest regarding the publication of this article.

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