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The Intrinsic Mechanism and Enhancement Pathways of Online Social Science Popularization Effectiveness

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Abstract: In recent years, social philosophy has emphasized that the popularization of social sciences is a crucial means to enhance citizens' social scientific literacy and ideological-moral standards, promoting comprehensive individual development and the progress of social civilization. As an important channel for such efforts, online social science dissemination plays a significant role in advancing its reach. However, the current effectiveness of online dissemination still faces numerous challenges. Therefore, this study analyzes the weight of factors influencing online social science popularization based on questionnaire data and identified issues. Furthermore, drawing on DeFleur's Interactive Process Model, a closed-loop framework is constructed, encompassing subject encoding, channel communication, audience decoding, and feedback regulation. This model reveals the interaction among subject control, channel algorithm optimization, and audience demand responsiveness. Based on the findings, solutions are proposed through three pathways: internal dynamics, external dynamics, and feedback regulation mechanisms. These include expanding the scope of popularization subjects via policy incentives, enabling targeted content delivery through technological empowerment, and establishing digital feedback mechanisms. The study aims to provide decision-making support for governments in optimizing resource allocation for social science popularization and setting technical standards for online dissemination, thereby contributing to rural revitalization and the improvement of citizens' scientific literacy.

Keywords: Internet; Big data; Analytic hierarchy process; Intrinsic mechanism; Pathways

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1. Introduction

According to the 50th Statistical Report on China's Internet Development by the China Internet Network Information Center (CNNIC), as of June 2022, China's Internet user base reached 1.051 billion, with an Internet penetration rate of 74.4%, including 58.8% in rural areas. The average weekly online time per user was 29.5 hours, mobile Internet usage accounted for 99.6%, and short video users numbered 962 million, representing

91.5% of the total user base, laying a robust foundation for online social science popularization. Current research indicates that advancements in information technology present both opportunities and challenges for social science dissemination: Domestic scholars highlight issues such as uneven content quality and insufficient dissemination efficiency in online platforms, while the international academic community emphasizes collaborative pathways integrating public engagement and technological empowerment, exemplified by insights from the U.S. National Academy of Sciences' evaluation framework for science communication.

Despite theoretical advancements, practical implementation faces contradictions between the proliferation of pseudo-scientific content on self-media platforms and the insufficient outreach capabilities of official channels. Enhancing the credibility of online content, optimizing algorithmic precision in information delivery, and establishing dynamic feedback mechanisms have emerged as critical strategies to strengthen the effectiveness of social science popularization.

2. Current challenges in online SSP effectiveness

2.1. Public cognitive deficits and social prioritization bias

Survey data reveal that only 10.08% of the public self-identify as "highly knowledgeable" in social sciences, while over 70% possess intermediate awareness. Structural imbalances stem from two dimensions: 56% of audiences hold educational qualifications below associate degrees, and societal prioritization skews toward STEM fields (social science activities account for <30% in many regions), with 42.86% dismissing social science knowledge as "unimportant" [1]. Deeper contradictions lie in the inadequate scientific literacy of social science practitioners, 60% of academics engage in astrology-related activities, and 30% of highly educated groups endorse its scientific validity, reflecting the marginalization of social sciences.

2.2. Dual lag in communication efficacy and governance mechanisms

Over 70% of respondents rely on online channels, yet 23.53% question their credibility. Offline engagement remains low (21.29%). Governance deficiencies manifest in fragmented regulations: no national legislation exists, while localized policies (e.g., Hunan Province's guidelines) lack coordination. 63.03% of activities rely on individual initiatives with insufficient funding. Rigid dissemination formats exacerbate supply-demand mismatches: 61.62% demand enhanced engagement, yet innovative formats cover only 14.29%, resulting in 69.47% rating outcomes as "mediocre."

2.3. Content misalignment and professional capacity gaps

While 79.83% of audiences prioritize practical knowledge, 68.35% of supplied content remains theoretical, with critical fields like legal studies (40.06%) and healthcare (52.66%) underrepresented. Rural areas face <35% coverage of economic management knowledge, and 65% of youth deem the content monotonous. Root causes include shortages of professional creators, absent demand-response mechanisms, and risk-averse content strategies constrained by ideological oversight [2]. The "scenario-based popularization" model in Yuhuan City elevated participation by 30%, demonstrating reform potential.

2.4. Urban-rural popularization divide

Urban areas monopolize >80% of resources (lectures, exhibitions), while rural residents (42.3% of the population) endure scarcity. Entertaining self-media content dominates 80% of rural online engagement, with short videos penetrating 76.5% of family chat groups. This entrenches a structural contradiction: "urban resource surplus versus rural demand deprivation."

3. Analysis of factors influencing the effectiveness of online social science popularization

Online social science popularization, serving as a critical supplement to traditional approaches, urgently requires enhanced effectiveness. To identify influencing factors, this study collected 357 valid responses through a questionnaire designed with reference to the China Public Science Literacy Survey Report and existing research frameworks, covering three dimensions: participation behaviors, attitudes, and demands. The sample predominantly comprised adolescent students (66.39%), individuals aged 18–35 (83.19%), and highly educated groups (94.68%), necessitating caution regarding the generalizability of findings due to demographic concentration. Building on Guo Liang's OLS model, which confirmed positive correlations among active learning, perceived importance, and credibility with popularization outcomes, this research further employs the analytic hierarchy process (AHP) to quantify the relative weights of these three factors and online dissemination methods on effectiveness, thereby providing empirical support for optimization strategies [3].

3.1. Indicator design

This indicator system integrates communication theory and empirical research, structured around four core dimensions—active online learning, perceived importance of social science popularization, online science communication credibility, and digital dissemination modes, which correspond to audience cognition-behavior patterns, content quality, and channel efficacy. Anchored in Lasswell's "5W" model, the meso-level indicators emphasize dissemination channels, incorporating social media platforms as mainstream conduits through survey data while bridging traditional and emerging media ecosystems [4]. Specific platform functionalities are linked to theoretical constructs: Baidu Baike's credibility underpins content quality, whereas WeChat and Weibo facilitate active learning behaviors. By synthesizing Bucchi's public engagement with science model and the NASEM channel efficacy framework, the system enhances social media's interactivity and scientific rigor in dissemination performance, ultimately forming a multidimensional, synergized framework (**Figure 1**).

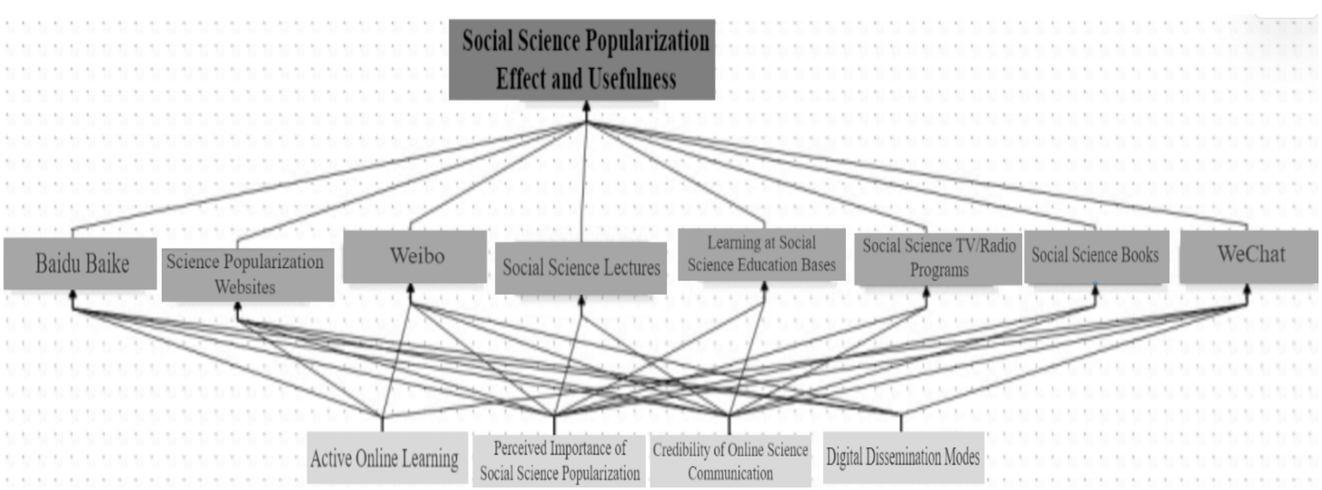

Figure 1. The relationship of the index system of the analytic hierarchy process

3.2. Construction of hierarchical structure model and judgment matrix

3.2.1. Establishing the hierarchical structure system

Based on the indicators selected in the previous section, we constructed the following hierarchical levels as shown in the table below (**Table 1**).

Table 1. Judgment system for the effect and usefulness of social science popularization

Decision-making objective	Middle layer	Relevant factors
Social Science Popularization Effect and Usefulness A	Baidu BaikeB_1	Active Online LearningC_1
	Science Popularization WebsitesB_2	Perceived Importance of Social Science PopularizationC_2
	WeiboB_3	Credibility of Online Science CommunicationC_3
	Social Science LecturesB_4	Digital Dissemination ModesC_4
	Learning at Social Science Education BasesB_5	
	Social Science TV/Radio ProgramsB_6	
	Social Science BooksB_7	
	WeChatB_8	

3.2.2. Construction of the hierarchical structure model

In the analytic hierarchy process (AHP), the authors employ the consistent matrix method to construct the judgment matrix. Specifically, rather than conducting collective comparisons of all involved factors simultaneously, this method systematically compares each pair of factors separately. This pairwise comparison approach significantly reduces computational errors that may arise from simultaneous multi-factor comparisons, thereby enhancing the precision of the results. The matrix is conventionally denoted as "A", with its specific elements represented as "a_{ij}" (**Table 2**).

Table 2. Scaling methods for judging matrices a_{ij}

Scale	Meaning
1	It indicates that the two factors are of equal importance when compared
3	It indicates that, compared with the two factors, one factor is slightly more important than the other
5	It indicates that when comparing two factors, one factor is significantly more important than the other
7	It indicates that when comparing two factors, one factor is more strongly important than the other
9	It indicates that compared with the two factors, one factor is more important than the other
2,4,6,8	The median of the above two adjacent judgments
Reciprocal	Factor $a_{ji}=1/a_{ij}$

3.3. Hierarchical sorting and consistency checking

For the maximum eigenroot λmax in the judgment matrix, the eigenvector of λmax is normalized, which means that the total result of each element in the vector is 1, and the result after normalization is marked with the W symbol. The elements of W are sorted hierarchically, that is, the ranking weight of the relative importance of the elements of the same level to a factor at the next level.

Define conformance metrics CI = $\frac{\lambda - n}{n - 1}$

Among them:

CI = 0, with complete consistency;

CI is close to 0 and has satisfactory consistency.

The larger the CI, the more serious the inconsistency.

Then, the random consistency index RI is introduced to measure the CI size.

The consistency ratio calculation formula is defined: CR = (**Table 3**). It is generally believed that when the consistency ratio CR<0.1, the degree of inconsistency of the matrix is within an acceptable range, and then the consistency test is passed. The normalized eigenvector can be used as the weight vector, otherwise, the pair comparison matrix should be reconstructed to adjust a_{ij}.

Table 3. Random consistency index RI

n	1	2	3	4	5	6	7	8
RI	0	0	0.58	0.90	1.12	1.24	1.32	1.41

3.4. Determine the indicator weight

At the beginning of the calculation, the questionnaire survey method is adopted, through the masses to distribute questionnaires, score the indicators, and then take the weighted average. After sorting out the questionnaire data, AHP software is used to calculate the data results and carry out a consistency test to obtain the relevant weights. The analysis is as follows.

The middle layer includes eight indicators: Baidu encyclopedia, popular science website, microblog, listening to social science lectures, learning in a social science base, watching social science TV and radio programs, social science books, and WeChat. Relevant results are obtained according to importance, and the judgment matrix is shown as follows (**Table 4**).

Table 4. Weights under level A of decision-making objectives

Social science popularization effect and usefulness A	Baidu baikeB_1	Science popularization websitesB_2	WeiboB_3	Social science lecturesB_4	Learning at social science education basesB_5	Social science TV/Radio programsB_6	Social science booksB_7	WeChatB_8	Wi
Baidu BaikeB_1	1	2	1/3	2	4	2	3	1/2	0.1437
Science popularization websitesB_2	1/2	1	1/2	2	2	2	3	1/3	0.1108
WeiboB_3	3	2	1	1	6	2	3	1/3	0.1735
Social science lecturesB_4	1/2	1/2	1	1	1	1/4	1/3	1/5	0.0512
Learning at social science education basesB_5	1/4	1/2	1/6	1	1	1/4	1/2	1/7	0.0379
Social science TV/ Radio programsB_6	1/2	1/2	1/2	4	4	1	3	1/3	0.1108
Social science booksB_7	1/3	1/3	1/3	3	2	1/3	1	1/4	0.0617
WeChatB_8	2	3	3	5	7	3	4	1	0.3103

The vector of the above judgment matrix is calculated, and then the vector is normalized to obtain the weight ratio of indicators at level A of the decision target, W = (0.1437 0.1108 0.1735 0.0512 0.0379 0.1108 0.0617 0.3103). According to the weight value obtained, $\lambda max=\sum_{i=1}^{n}\frac{(AW)i}{nWi}$=C*W is calculated, where C is the judgment matrix and W is the weight vector.

$$C*W=\begin{bmatrix} 1 & 2 & 1/3 & 2 & 4 & 2 & 3 & 1/2 \\ 1/2 & 1 & 1/2 & 2 & 2 & 2 & 3 & 1/3 \\ 3 & 3 & 1 & 1 & 6 & 2 & 3 & 1/3 \\ 1/2 & 1/2 & 1 & 1 & 1 & 1/4 & 1/3 & 1/5 \\ 1/4 & 1/2 & 1/6 & 1 & 1 & 1/4 & 1/2 & 1/7 \\ 1/2 & 1/2 & 1/2 & 4 & 4 & 1 & 3 & 1/3 \\ 1/3 & 1/3 & 1/3 & 3 & 2 & 1/3 & 1 & 1/4 \\ 2 & 3 & 3 & 5 & 7 & 3 & 4 & 1 \end{bmatrix} * \begin{bmatrix} 0.1437 \\ 0.1108 \\ 0.1735 \\ 0.0512 \\ 0.0379 \\ 0.1108 \\ 0.0617 \\ 0.3103 \end{bmatrix} = 8.8054$$

The above matrix calculation results in the maximum eigenroot λmax=8.8054，CI=(8.8054-8)/7=0.1151, and the value of RI can be obtained from Table 4-3, which shows that RI=1.41，CR=0.1151/1.41=0.0816,CR less than 0.1, It shows that the selection of first-level index meets the requirements of consistency test.

According to the application of analytic hierarchy Process (AHP) in the A-level indicators of decision objectives and the consistency test of the correlation matrix, the index matrix of the middle layer is constructed and the consistency test is carried out according to the construction and consistency test of the first-level indicator matrix above, and the weight of the index of the middle layer is obtained. Take the middle layer, B_1 Baidu Encyclopedia, as an example, as shown in **Table 5**.

Table 5. Weights under level B1 of the middle Layer

Baidu BaikeB_1	Active online learning	Perceived importance of social science popularization	Credibility of online science communication	Digital dissemination modes	Wi
Active online learning	1	1	1	1/2	0.2053
Perceived importance of social science popularization	1	1	2	2	0.3453
Credibility of online science communication	1	1/2	1	1	0.2053
Digital dissemination modes	2	1/2	1	1	0.2441

Weight ratio of indicators in the middle layer B1: W1 = (0.2053 0.3453 0.2053 0.2441), CR=0.0688.

Similarly, the weight ratio of indicators under the middle layer B_2 level, W_2= (0.1227 0.3085 0.4294 0.1394), can obtain CR=0.0299.

In the middle layer, the weight ratio of indicators under B_3 level, W_3= (0.2310 0.1756 0.4300 0.1634), CR=0.0768.

In the middle layer, the weight ratio of indicators under B_4 level, W_4= (0.5000 0.5000), CR=0.

In the middle layer, the weight ratio of indicators under B_5 level, W_5= (0.5000 0.5000), CR=0.

In the middle layer, the weight ratio of indicators under B_6 level, W_6= (0.6667 0.3333), CR=0.

In the middle layer, the weight ratio of indicators under B_7 level, W_7= (0.5000 0.5000), CR=0.

In the middle layer, the weight ratio of indicators under B_8 level, W_8= (0.2760 0.5055 0.0701 0.1483), CR=0.0708.

According to the above data, CR is less than 0.1, so it passes the consistency test.

Through the above calculation, the weight of relevant factors in the popularization effect and the usefulness of the social science of the decision goal are obtained (**Table 6**).

Table 6. Evaluation system index weights

Target label	Alternative plan	Weight
Social science popularization effect and usefulness A	Active online learningC_1	0.1049
	Perceived importance of social science popularizationc_2	0.3492
	Credibility of online science communicationC_3	0.4209
	Digital dissemination modesC_4	0.1249

The analysis results show that the credibility of network science popularization is the most important factor affecting the effectiveness of network science popularization, followed by the importance of social science popularization, network communication mode becomes the third important factor, and active network learning is the last.

4. The intrinsic mechanism of online social science popularization effectiveness

The preceding analysis identifies key factors influencing the effectiveness of online social science popularization and quantifies their relative weights, establishing a foundation for systematic problem diagnosis. To address existing challenges, it is imperative to elucidate the intrinsic mechanisms governing information dissemination, including the operational workflow, the roles of influencing factors across stages, and their interdependencies [5]. Guided by DeFleur's Interactive Process Model, the effectiveness of online social science popularization emerges from a dynamic closed-loop system comprising "subject-channel-audience" interactions (**Figure 2**). This framework operates through three core mechanisms:

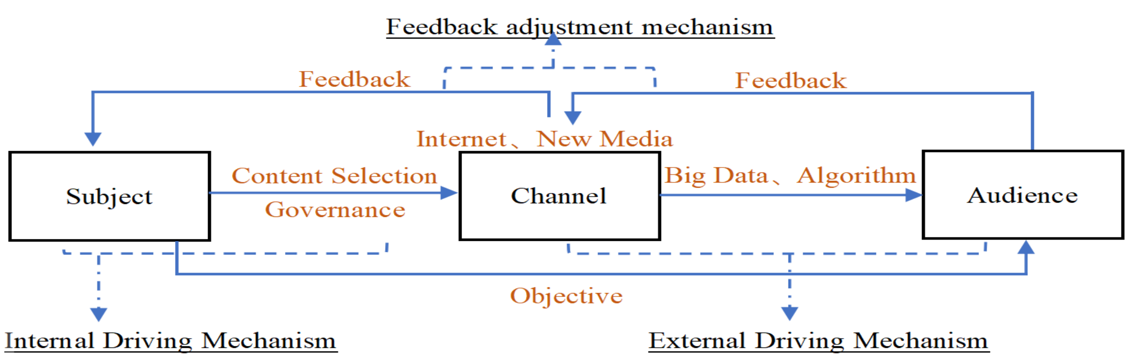

Figure 2. The internal mechanism model of the effectiveness of popularizing online social sciences

4.1. Subject encoding mechanism

Social science practitioners, as internal drivers, formulate policies and produce content. Content quality directly determines initial dissemination efficacy. Substandard content may trigger audience decoding barriers, causing communication attenuation.

4.2. Channel transmission mechanism

New media platforms (e.g., short videos, livestreams, official accounts) and algorithmic technologies serve as transmission media, governing content reach and timeliness. While big data push enhances targeting efficiency, it risks reinforcing information cocoons as systemic noise.

4.3. Audience feedback mechanism

As information decoders, audiences generate external momentum through engagement behaviors (e.g., clicks, comments). User behavior data flows back to content producers via channels, forming a dynamic regulatory loop. For instance, optimizing content push through big data analytics enables iterative improvements in dissemination efficiency.

These components create a reinforcing "production-dissemination-feedback" cycle. Channels function not only as conduits but also as critical noise filters. Ultimately, dissemination effectiveness hinges on the synergistic alignment of content quality, channel adaptability, and audience decoding capacity.

The efficacy of online social science popularization is propelled by coordinated internal and external mechanisms. Internally, the core lies in practitioners' rigorous control over content credibility, with institutional prioritization directly determining resource allocation efficacy. Externally, the mechanism generates momentum through audience self-directed learning and channel compatibility, where high-quality content stimulates engagement, while algorithm-optimized new media channels (e.g., short videos, livestreams) amplify dissemination breadth and timeliness. These dual mechanisms establish a dynamic "production-dissemination-feedback" loop. By anchoring credibility as the foundation and innovating channel strategies to expand outreach boundaries, this framework achieves systemic enhancement of popularization effectiveness.

5. Pathways to enhance the effectiveness of online social science popularization

Guided by internal-external synergy mechanisms, a three-tier optimization framework should be established.

5.1. Internal optimization

Develop a multi-stakeholder collaboration mechanism to mobilize social science talent in universities and incentivize public participation through a "Certified Science Communicator" program [6]. Strengthen policy support by refining online content review systems to regulate content production by influencers (e.g., key opinion leaders/content creators). Increase funding allocations, prioritizing investments in content creation and algorithm development. Innovate a "Centralized Coordination + Crowdsourced Creation + Intelligent Distribution" model to optimize content supply through data-driven screening.

5.2. External activation

Integrate mainstream platforms (e.g., Douyin, Bilibili) and leverage federated learning algorithms for cross-platform precision targeting. Address rural demand gaps by developing tailored content such as agricultural technique short videos and livestreams, facilitating the penetration of science popularization resources through digital channels to replace traditional urban-centric dissemination.

5.3. Feedback regulation

Establish a dedicated department to implement a "Human-AI Dual-Track Feedback System." This system captures real-time demands via user evaluation modules and big data analytics (e.g., viewing duration, preferences, occupations), enabling dynamic adjustments to content strategies. A closed-loop iterative mechanism—"Demand Identification → Precision Supply → Effectiveness Evaluation"—is thus formed to ensure continuous improvement [7].

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