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Evaluating the Effectiveness of Mobile Precision Push Services A User-Centric Behavioral Framework

Wang Peng [1], Norhayati Hussin[2]*, Masitah Ahmad[3]

[1)2)3)]*School of Information Science, College of Computing, Informatics and Media, Universiti Teknologi MARA Cawangan Selangor, Kampus Puncak perdana, Shah Alam, Selangor, Malaysia.*

[1)]wangpengguet@gmail.com, [2)]yatihussin@uitm.edu.my,[3)]masitah@uitm.edu.my

Abstract

Background: As precision push services (PPS) become increasingly embedded in mobile communication ecosystems, understanding how users perceive and respond to these services has become a pressing research concern. While prior studies have focused on technical accuracy and personalization algorithms, limited attention has been paid to how experiential and perceptual factors collectively influence user engagement and behavioral outcomes.
Objective: This study aims to construct and empirically validate a comprehensive user-centered evaluation model for precision push services. It seeks to identify which experiential dimensions most significantly influence user perception, and how these perceptions translate into behavioral responses.
Methods: A conceptual framework was developed integrating five experiential predictors—message validity and quality, non-interference with user experience, operability, user choice, and information transparency—alongside two perceptual mediators (effect and impact) and one behavioral outcome. A structured questionnaire using an eight-dimensional Likert scale was administered to 279 university students across multiple institutions. Data analysis involved reliability and validity testing, correlation analysis, ANOVA, and multiple regression to examine causal relationships and demographic influences.
Results: The results indicate that user choice is the most influential factor affecting both perceived effect and impact of PPS. Information transparency and message quality also significantly predict perceptual outcomes, while non-interference showed strong correlations but no direct causal influence. The impact of push services emerged as a stronger determinant of user behavior than perceived effectiveness. Gender and geographic differences were statistically controlled and found to have minimal effect on the primary causal pathways.
Conclusion: The study highlights the importance of user autonomy, transparency, and meaningful content delivery in designing effective PPS systems. By validating a full causal model and identifying critical user-centered variables, the research provides actionable insights for improving user engagement, trust, and behavioral response in personalized mobile push environments.

Keywords: Precision Push Service, User Perception, Causal Modeling, Personalization, Personalization

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I. INTRODUCTION

In recent years, the expansion of mobile ecosystems and algorithmic personalization has transformed how users receive, interact with, and interpret push notifications 0. While technical infrastructures such as data mining and machine learning have enabled more efficient targeting, the user-side perception of these services has not received commensurate attention . Many push systems continue to prioritize precision and automation at the expense of user autonomy, emotional relevance, and interface usability. This imbalance raises important questions regarding how users cognitively and behaviorally respond to such services [2].

Furthermore, although studies have addressed isolated dimensions—such as content quality [3] or notification timing—there is a lack of integrative models that account for the multifactorial nature of user perception. Particularly absent are frameworks that consider both experiential factors (e.g., transparency, operability) and perceptual outcomes (e.g., effectiveness, psychological impact) in a unified behavioral model. Addressing this gap, the present study proposes and empirically validates a causal framework that not only reflects how users evaluate precision push services (as shown in Figure 1 below), but also predicts how these evaluations translate into actual user behavior. This approach moves beyond system-centric metrics and places the user's experience, judgment, and preferences at the center of precision push evaluation.

* Corresponding author

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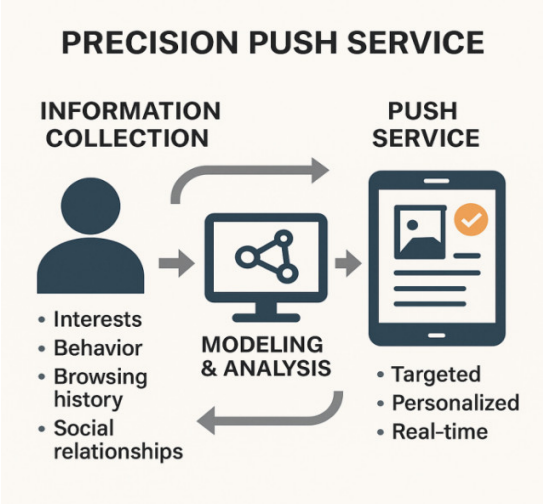

Fig. 1 Precision Push Service Working Process

This study distinguishes itself through a comprehensive, multidimensional approach to understanding user perceptions of precision push services (PPS). Theoretically, it constructs an integrated causal model that incorporates five key experiential predictors—message validity and quality, non-interference with user experience, operability, user choice, and information transparency [2]—alongside two perceptual mediators (effect and impact) and one behavioral outcome (user behavior). Unlike previous studies that address these variables in isolation, this research empirically validates their interrelationships within a unified framework.

Empirically, the study draws upon a full-sample dataset of 279 university students from six institutions across multiple regions in Guangxi, China. The sample includes diverse demographic backgrounds in terms of gender (64.9% male, 35.1% female) and place of origin, enhancing the generalizability of findings (Table 4). Methodologically, the research applies a rigorously constructed eight-dimensional questionnaire using a 5-point Likert scale, with excellent psychometric properties (Cronbach's $\alpha = 0.968$; KMO = 0.949) [2]. Advanced statistical techniques—including ANOVA, correlation analysis, and multiple regression modeling—are employed, with demographic variables statistically controlled throughout. This holistic design enables robust evaluation of both cognitive and behavioral dimensions of user perception, positioning the study as a significant contribution to user-centered mobile communication research.

Despite the expanding body of research on mobile push notification systems and personalized digital services, several critical research gaps persist. Existing studies often focus on isolated elements—such as content relevance, notification timing, or user engagement—without integrating these dimensions into a cohesive theoretical framework [2], [3]. This lack of integration hampers a comprehensive understanding of the multifaceted nature of user interaction with precision push services (PPS). Furthermore, while algorithmic precision and data-driven personalization have received considerable attention, limited focus has been placed on the subjective user experience, particularly how perceived operability [6], transparency [4], and autonomy [18] shape user attitudes toward PPS. These experiential factors, though critical in determining user satisfaction and behavior, have yet to be systematically explored in the context of personalized mobile notifications. Lastly, few studies simultaneously apply both reliability and validity testing alongside advanced multivariate statistical modeling within a single empirical framework [14], [7], thus limiting the methodological rigor of findings in the domain of personalized notification systems.

This study addresses these gaps by offering a validated, user-centered model grounded in both contextual and statistical robustness. Specifically, while previous research has explored individual aspects of PPS, this study seeks to integrate multiple experiential predictors—such as message validity and quality, non-interference with user experience, operability, user choice, and information transparency—into a unified framework. By examining these factors collectively, we aim to shed light on how they jointly influence user perceptions of PPS effectiveness and impact, which, in turn, shape behavioral outcomes.

What has been done in prior research largely pertains to analyzing isolated elements like content personalization [2] and timing [9], but without considering the interplay between these factors and their psychological effects on users. What has not been sufficiently explored, and which this research aims to address, includes the simultaneous consideration of user autonomy, transparency, and experiential satisfaction in shaping overall engagement. Moreover,

while algorithmic accuracy is well-documented [1], how these elements influence emotional resonance and cognitive engagement with PPS has been underexplored.

Future research in this domain should continue to build on the conceptual model established here by integrating more diverse user groups and expanding the empirical analysis to include longitudinal studies. These will allow for deeper insights into how user preferences evolve and how long-term engagement with PPS affects behavior. Furthermore, future work should address how personalized push strategies can be optimized by incorporating artificial intelligence and machine learning, advancing the adaptability of these systems to meet dynamic user needs [20].

The primary objective of this study is to develop and empirically validate a comprehensive model that explains how users perceive and respond to precision push notification services. Specifically, the study aims to explore the causal relationships between five key experiential dimensions—"message validity and quality", "non-interference with user experience", "operability", "user choice", and "information transparency"—and two core perceptual constructs: the "effectiveness" and "impact" of push services. These, in turn, are hypothesized to influence "user behavioral outcomes", forming an integrated eight-dimensional framework.

To achieve this objective, the study formulates and tests a set of structured hypotheses using data collected from 279 university students across diverse institutions and regions. A validated Likert-scale instrument is used to ensure measurement consistency, and statistical rigor is upheld through the use of reliability testing, exploratory factor analysis, correlation analysis, ANOVA, and multiple regression modeling [2].

This study makes several significant contributions to the field of mobile precision push services (PPS). First, it integrates multiple experiential factors into a cohesive user-centered framework, addressing a critical gap in existing research that often isolates individual aspects such as content relevance, notification timing, or user engagement. The proposed model incorporates five key experiential predictors—message validity and quality, non-interference with user experience, operability, user choice, and information transparency—alongside two perceptual mediators (effect and impact) and one behavioral outcome. By doing so, this research moves beyond previous system-centric approaches and places the user's experience, judgment, and preferences at the forefront of precision push evaluation. Second, the study advances understanding by empirically validating how these predictors interact and influence user perceptions, offering a more comprehensive view of the relationship between user experience and behavioral outcomes. Lastly, it addresses methodological gaps by applying both reliability and validity testing in conjunction with multivariate statistical modeling, ensuring robustness in the analysis. In doing so, this study provides actionable insights for system designers and developers, emphasizing the importance of user autonomy, transparency, and content relevance in optimizing PPS effectiveness.

II. Literature Review

Precision Push Service (PPS) refers to a personalized mobile internet application that leverages behavior modeling, algorithmic prediction, and user data analytics to deliver targeted content tailored to individual preferences[1][2]. While the core aim of PPS remains enhancing content delivery efficiency and personalization accuracy, its real-world effectiveness increasingly hinges on how users perceive, interpret, and respond to the push experience[12][15].

Existing research has highlighted five key experiential dimensions influencing user perception of PPS: message validity and quality, non-interference with user experience, operability, user choice, and information transparency[6][12][15]. These five factors serve as foundational variables in shaping both users' cognitive evaluations and their willingness to engage with push systems[16][18].

Message Validity and Quality ensures that users receive timely, relevant, and credible content[1][2][10]. Studies show that high-quality notifications—such as industry alerts and personal reminders—enhance trust and engagement, while irrelevant or excessive content may erode user confidence[9][15].Non-Interference relates to the perceived disruption caused by push messages. Research in human-computer interaction finds that frequent or mistimed notifications can generate user fatigue or frustration, though in certain contexts, users demonstrate tolerance when content is perceived as highly relevant[6][19]. Operability, or the system's ease of customization and control, plays a critical role in user retention[6][10]. Studies emphasize that when users can easily set preferences, silence notifications, or filter content, their overall satisfaction increases[18][19].User Choice has emerged as the most significant predictor of perceived value in PPS. When users are empowered to decide what, when, and how content is pushed, their sense of autonomy and personalization is amplified, leading to higher acceptance and behavioral response rates.Information Transparency builds trust by clearly communicating how data is used and why notifications are triggered. Openness about data processing has been linked to improved user attitudes and reduced privacy concerns[4][12].

Recent studies have called for broader, more integrated models that connect these experiential dimensions to perceptual constructs such as effectiveness and impact, and ultimately to behavioral outcomes. Kumar and Gupta

point out that even accurate content may be rejected if not perceived as meaningful or timely, underscoring the gap between algorithmic precision and human receptivity. Moreover, researchers note that user perception—rather than system logic—ultimately determines whether push content drives behavioral engagement[15][18].

Although prior research has employed quantitative tools such as surveys and structural modeling, few studies comprehensively examine the full causal chain linking experiential inputs, perceptual mediators, and behavioral responses. In addition, prior work often overlooks systematic control for demographic diversity, limiting generalizability. This study addresses those gaps by constructing a validated eight-dimensional model—including user behavior—and applying full-sample statistical tests (e.g., reliability, correlation, ANOVA, regression) on a diverse university student population[3][5][7][8][14].

In sum, the literature provides strong theoretical foundations for understanding PPS, but lacks integrative models that bridge experience, perception, and action. This study builds on and extends that foundation by empirically validating the causal pathways and clarifying which factors most strongly shape users' behavioral outcomes[7][8].

III. Methods

A. Research model determination

Through research and analysis of the perception of precision push services, a conceptual framework for evaluating precision push perceptions has been developed[2], as shown in Figure 2 below [2],[3].

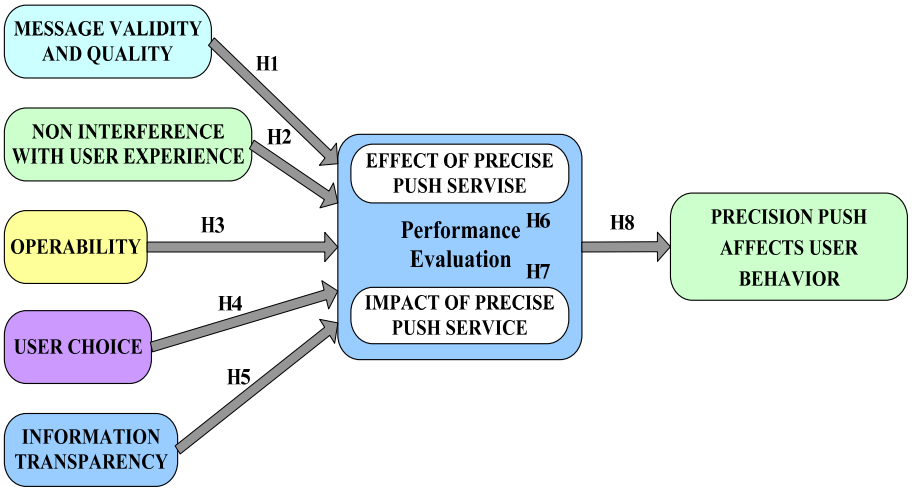

Fig. 2 Conceptual Framework For Evaluating Precision Push Perceptions [2],[3]

This study proposes a comprehensive conceptual framework to evaluate user perceptions and behavioral responses to precision push notification services, integrating five hypothesized experience dimensions. The model is constructed based on established literature in user experience, personalized messaging, and behavioral targeting systems, with theoretical grounding from studies by previous research [9], [10].

The model is visually represented in Figure 2, illustrating the multi-stage causal structure:Five experiential predictors influence two core constructs of performance evaluation—namely, the effect and impact of the push service—which subsequently affect user behavior.

The eight hypothesized predictors are described as follows:

H1: Message Validity and Quality:It is posited that the accuracy, clarity, and timeliness of push notifications directly influence users' initial satisfaction and perceived usefulness. High-quality content fosters engagement and reduces cognitive dissonance, making it more likely that users will accept or respond to the message [9], [10].

H2: Non-Interference with User Experience:Push services should avoid disrupting users' routine digital interactions. Non-intrusive delivery modes help maintain a positive user experience, thereby influencing overall satisfaction and tolerance toward push content [2].

H3: Operability:Ease of use in managing push settings—such as the ability to mute, delay, or categorize notifications—is proposed to enhance user autonomy and reduce resistance to the push service [9].

H4: User Choice:The ability to customize notification content, frequency, and delivery channels is hypothesized to be a dominant factor influencing users' perception of control and personalization. This dimension serves as a cornerstone for perceived relevance and user trust [10].

H5: Information Transparency:Transparency regarding the origin, intent, and logic behind push messages (e.g., why it is shown, when, and by whom) enhances system accountability and fosters trust. Lack of transparency can lead to user skepticism and disengagement [4].

As shown in the diagram, the five independent variables simultaneously influence two key evaluative constructs:

H6:Effect of Precision Push Service (e.g., usefulness, efficiency, match with user needs).H6 examines the effectiveness of precision push services, focusing on how usefulness, efficiency, and the match with user needs influence user behavior. This hypothesis suggests that when push notifications align closely with user needs and preferences, they are more likely to be perceived as useful and efficient, leading to increased user acceptance and engagement. The higher the relevance and utility of the content, the more likely it is that users will respond positively by engaging with the service (e.g., clicking, replying, or sharing) [9], [10].

H7:Impact of Precision Push Service (e.g., psychological influence, behavioral intention, cognitive response).H7 focuses on the psychological impact of precision push services, examining how push notifications influence users' psychological state, behavioral intentions, and cognitive responses. This hypothesis suggests that emotional resonance and cognitive engagement with the content of the push notifications play a more significant role in driving behavioral outcomes than the perceived utility alone. If users feel emotionally connected or cognitively engaged with the content, they are more likely to change their behavior in response to the push notification, such as increasing engagement, sharing, or making a purchase [9], [10].

These two constructs form the mediating layer labeled Performance Evaluation. Their role is crucial in explaining how experiential dimensions are internalized and translated into behavioral outcomes.Finally, both the perceived effect and impact are proposed to jointly determine user behavior, such as whether users click, engage with, or respond to the push notification. Prior studies suggest that impact perception (emotional/cognitive resonance) often plays a stronger role than rational evaluation (effectiveness) in shaping behavior.

H8: Precision Push Affects User Behavior.H8 proposes that precision push services significantly influence user behavior, specifically how users engage with the push notifications, such as whether they click, share, make a purchase, or take some other action in response to the notification. This hypothesis asserts that the effectiveness and impact of the push notification—driven by the alignment of content, timing, and user preferences—ultimately determine users' behavioral responses. The core idea is that precise push notifications, which are personalized and contextually relevant, lead to measurable changes in user actions, such as increased interaction or conversion rates [3], [4], [9], [10].

TABLE 1
CORRESPONDING RESEARCH QUESTIONS FOR EACH HYPOTHESIS

Variable		Items	References
Message Validity And Quality	H1	How does the validity and quality of push messages influence users' satisfaction and engagement?	[9], [10]
Non Interference With User Excellence	H2	To what extent does non-interference in user experience affect the acceptance and perceived effectiveness of push notifications?	[2]
Operability	H3	How does the ease of customization and operability of push notifications impact user engagement and perception?	[9]
User Choice	H4	How does user autonomy in choosing push content, timing, and delivery method affect user behavior and engagement with the service?	[10]
Information Transparency	H5	How does the transparency of information regarding the push notification origin and logic influence user trust and interaction?	[4]
Effect Of Precise Push Servise	H6	How does the perceived usefulness, efficiency, and match of push notifications with user needs affect user behavior?	[9], [10]
Impact Of Precise Push Service	H7	How does the emotional and cognitive impact of push notifications affect users' behavioral intentions and actions?	[9], [10]
Precision Push Affects User Behavior	H8	How do the effectiveness and impact of precision push services together influence user behavior and engagement with the content?	[3], [4], [9], [10]

The table above outlines the Research Questions corresponding to each of the eight hypotheses presented in the study. These research questions are designed to guide the investigation into how different experiential dimensions of precision push services—such as message validity, user choice, and information transparency—affect user satisfaction, engagement, and behavior. Each question is linked to a specific hypothesis, and together they aim to provide a comprehensive understanding of the causal relationships between user perception and behavioral outcomes

in the context of mobile push notifications. This table serves as a foundation for the study's analytical framework and provides clarity on the key areas of investigation within the research [2].

B. Data Collection

This study targeted a clearly defined finite population consisting of 279 undergraduate students drawn from multiple universities across Guangxi, including Guilin University of Electronic Technology, Liuzhou Polytechnic University, and Guangxi University for Nationalities. The research focused on students enrolled in communication-related and digital media programs, who were considered to have relevant exposure to mobile applications and digital push technologies. The primary objective was to empirically validate a conceptual model of precision push services by examining users' perceptual dimensions, performance evaluations, and behavioral outcomes.

To ensure both representativeness and analytical rigor, the study employed a full-sample survey strategy, collecting valid responses from all 279 participants. The sample composition accounted for demographic diversity across gender, institutional affiliation, and regional background, thereby enhancing external validity and generalizability. Given the exploratory nature of this phase and the intended use of structural modeling techniques, the sample size exceeded the recommended minimum thresholds for multivariate regression and SEM analysis [2], and proved adequate for hypothesis testing and reliability validation.

C. Instrument Development

Quantitative research methods, specifically structured questionnaire surveys, were adopted in this study to systematically analyze users' perceptions of precision push services. Prior to questionnaire development, the research framework was clearly defined, encompassing five experiential predictor variables, two core perceptual constructs—"effectiveness" and "impact"—as well as the final outcome variable, "user behavior". Together, these eight dimensions form the conceptual basis for understanding how users evaluate and respond to precision push notifications.

The finalized questionnaire was organized around these eight dimensions, with each dimension comprising 4 to 8 quantitative, single-choice items. The instrument was distributed via Tencent Questionnaire [2], a widely used online platform, enabling efficient, low-cost data collection while maximizing accessibility among the target population .

University students were selected as the primary sample group due to their high engagement with mobile technologies, digital content, and push-based services. This demographic is particularly suited for assessing the reception and behavioral influence of personalized notification systems, given their digital fluency and routine interaction with mobile platforms.

IV. RESULTS

This study focuses on precision push services, utilizing questionnaires designed with a Likert scale to measure five experiential dimensions of precision push as independent variables: information transparency, message validity and quality, non-interference with user experience, user choice, and operability. These dimensions were analyzed to understand their impact on two dependent experiential factors: the effect of precise push service and the impact of precise push service. Furthermore, these two experiential dimensions served as mediating variables to evaluate their influence on the ultimate effectiveness of precision push in shaping user behavior. A total of 279 valid questionnaires were collected from university students. To ensure data diversity and representativeness, the sampling carefully considered respondents from different universities and regions, thereby enhancing the objectivity and validity of the study's conclusions.The results of the demographic analysis of the questionnaire are shown in Table 2.

TABLE 2
ANALYSIS OF SAMPLE DEMOGRAPHIC CHARACTERISTICS

Variable	Options	Frequency	Percentage	Standard Deviation
Gender	Male	181	64.9%	0.478
	Female	98	35.1%	
School	Guilin University of Electronic Technology	37	13.3%	1.749
	Beihai Campus of Guilin University of Electronic Technology	89	31.9%	
	Liuzhou Polytechnic University	27	9.7%	
	Guilin Institute of Information Technology	30	10.8%	
	Guangxi University for Nationalities	48	17.2%	
	Others	48	17.2%	
Place of Origin	Other Cities in Guangxi	86	30.8%	0.834
	Nanning, Guilin, Liuzhou, Beihai in Guangxi	161	57.7%	
	Capital cities of provinces other than Guangxi	6	2.2%	
	Non-provincial capital cities in provinces other than Guangxi	26	9.3%	

The sample for this study primarily consisted of university students, a group characterized by strong mobile application skills and exploratory tendencies, making them particularly sensitive to the experience and perception of precision push services. Moreover, the data collection process deliberately included students from various universities and regions, taking into account their diverse living backgrounds. This ensured a broad and diverse sample, enhancing the representativeness and generalizability of the research findings.

A. Analysis of reliability and validity

Cronbach's alpha coefficient is a method used to assess the internal consistency reliability of a questionnaire or test. This coefficient reflects the average correlation between the items in the questionnaire and is used to measure whether different items collectively assess the same concept. The value of Cronbach's alpha ranges between 0 and 1, with higher values indicating better internal consistency, meaning a stronger correlation between the items. The reliability statistics for each dimension are shown in Table 3 .

TABLE 3
THE RELIABILITY TEST RESULTS BETWEEN THE VARIABLES

Different Variables	Reliability Of Each Variable	Total Reliability
Message Validity And Quality	0.888	0.968
Non Interference With User Excellence	0.706	
Operability	0.856	
User Choice	0.911	
Information Transparency	0.861	
Effect Of Precise Push Servise	0.875	
Impact Of Precise Push Service	0.895	
Precision Push Affects User Behavior	0.863	

According to the reliability statistics presented in Table 2, the overall reliability of the questionnaire is excellent, with a total Cronbach's alpha of 0.968, indicating a high level of internal consistency across all variables. Most individual variables also exhibit strong reliability, with alpha coefficients exceeding 0.85. Notably, variables such as User Choice (0.911), Impact of Precise Push Service (0.895), and Effect of Precise Push Service (0.875) demonstrate excellent reliability.

The variable "Non Interference With User Excellence" showed relatively lower reliability (0.706), primarily due to inconsistencies among items. The items cover diverse sub-variables—such as source identification, content attitude, and advertising recognition—which dilute internal coherence. Additionally, variations in item wording (abstract vs. concrete), differences in cognitive difficulty, and uneven response distributions contributed to weakened item alignment. These factors suggest structural looseness and conceptual dispersion, leading to reduced internal consistency within this variable.

The questionnaire results were further tested for validity using the Kaiser-Meyer-Olkin (KMO) measure and Bartlett's test of sphericity. A KMO value closer to 1 indicates stronger partial correlations among variables and greater suitability for factor analysis. According to established standards, a KMO value above 0.9 is considered excellent. As shown in the results, the KMO value is 0.949, which reflects an excellent level of sampling adequacy and indicates strong correlations among the items.

Furthermore, Bartlett's test of sphericity yields a chi-square approximation of 9856.124 with 1225 degrees of freedom, and a significance level of 0.000, which is well below the conventional threshold of 0.05. This allows us to reject the null hypothesis that the correlation matrix is an identity matrix, confirming that significant correlations exist among variables. Therefore, both indicators strongly support the appropriateness of applying factor analysis to this dataset and affirm the structural validity of the questionnaire.

B. Analysis Of Differences

Gender difference analysis was conducted across all measured dimensions, and the results are presented in the table 4. Independent samples t-tests were used to compare the mean scores between male and female respondents. Across all eight dimensions no statistically significant gender differences were found. All p-values (Sig. 2-tailed) were greater than the standard significance level of 0.05, indicating that gender does not significantly influence perceptions or evaluations in any of the measured dimensions[2]. Although females generally showed slightly higher mean scores in most dimensions, these differences were minor and not statistically meaningful. Therefore, it can be concluded that gender does not play a significant role in shaping participants' responses to the various aspects of the precision push service.

TABLE 4
ANALYSIS OF DIFFERENCES BETWEEN DIFFERENT GENDERS

Different variables	gender	N	Mean	Std.Deviation	t-test for Equality of Means	Sig.(2-tailed)
Message Validity And Quality	Male	181	2.3278	0.81855	0.029	0.977
	Female	98	2.3248	0.78589		
Non Interference With User Excellence	Male	181	2.3007	0.55727	-1.201	0.231
	Female	98	2.3863	0.58748		
Operability	Male	181	2.663	0.80966	-1.345	0.18
	Female	98	2.8027	0.86133		
User Choice	Male	181	2.7986	0.96665	-0.503	0.615
	Female	98	2.8583	0.90292		
Information Transparency	Male	181	2.6114	0.87207	-0.963	0.336
	Female	98	2.716	0.85394		
Effect Of Precise Push Servise	Male	181	2.6519	0.82426	-0.095	0.924
	Female	98	2.6616	0.77786		
Impact Of Precise Push Service	Male	181	2.7768	0.90192	-0.387	0.699
	Female	98	2.8204	0.89465		
Precision Push Affects User Behavior	Male	181	2.9481	0.98238	-0.789	0.431
	Female	98	3.0449	0.97284		

Based on the results of the descriptive statistics, homogeneity tests, ANOVA, and post hoc analyses, this study examined whether participants from different schools and regions demonstrated significant differences in their evaluations of precision push service dimensions. As shown in Table 5.

Firstly, the descriptive statistics (Sheet 1) revealed overall trends in the data. For instance, in the dimension of Message Validity and Quality, students from Liuzhou Polytechnic University reported the highest mean score (M = 2.49), followed by Guilin University of Electronic Technology (M = 2.38), with Beihai Campus scoring the lowest (M = 2.32). However, the differences between groups were relatively small (less than 0.2), requiring further statistical testing.

Levene's test of homogeneity of variances (Sheet 2) indicated that most variables met the assumption of equal variances ($p > 0.05$), justifying the use of one-way ANOVA. Specifically, the p-value for Message Validity and Quality was 0.053, which is slightly above the 0.05 threshold, thus still supporting the application of ANOVA [18].

According to the ANOVA results (Sheet 3), only the dimension of Operability showed a statistically significant difference among schools ($F = 2.457$, $p = 0.034$). No significant differences were found in other dimensions such as Message Validity and Quality, Non-Interference with User Experience, User Choice, or Information Transparency.

Further post hoc LSD analysis (Sheet 4) for the significant dimension (Operability) did not detect any statistically significant pairwise differences between individual schools ($p > 0.05$). Although the overall F-test suggested a difference, the lack of significance in pairwise comparisons implies that the group differences were relatively diffuse and possibly due to the cumulative effect of small differences across multiple schools.

From a practical perspective, students from Liuzhou Polytechnic University rated Operability highest (M = 3.83), suggesting they found push messages to be more readable and user-friendly. Guilin Institute of Information Technology and Beihai Campus followed closely behind (M = 3.57 and M = 3.83, respectively), while Guilin University of Electronic Technology scored the lowest (M = 3.32), indicating potential dissatisfaction with the clarity, structure, or interface design of the push content. Other schools such as Guangxi University for Nationalities and "Others" fell in the mid-range (M = 3.3–3.6).

In summary, the analysis indicates that school background had a statistically significant effect on students' perception of Operability, though specific pairwise differences were not evident. This suggests that while regional and institutional differences exist, they may be relatively subtle or affected by sample size limitations. Future studies may benefit from expanding the sample and employing more sensitive statistical methods to better detect localized differences.

A. Correlation Analysis

Based on the correlation analysis results presented in Table 6 and in alignment with the research framework, the following insights can be drawn regarding the relationships among the variables. The upper triangle of the matrix shows Pearson correlation coefficients, while the lower triangle displays Spearman correlation coefficients, both commonly used to assess linear and rank-order relationships between variables, respectively.

The correlation analysis results demonstrate strong and statistically significant relationships among all measured dimensions, supporting the structural assumptions of the research model. The five experiential dimensions—message validity and quality, non-interference with user experience, operability, user choice, and information transparency—are all positively associated with the two mediating variables: effect and impact of precise push service. Among them,

user choice, information transparency, and operability exhibit particularly strong correlations, indicating their central role in shaping user perceptions of service effectiveness.

TABLE 5
ANALYSIS OF DIFFERENCES IN REGIONAL FACTORS IN VARIOUS VARIABLES

Different variables	Different regions	N	Mean	Std. Deviation	F	Sig.
Message Validity And Quality	Guilin University of Electronic Technology	37	2.3829	0.66767	0.899	0.482
	Beihai Campus of Guilin University of Electronic Technology	89	2.3202	0.65963		
	Liuzhou Polytechnic University	27	2.4877	0.83196		
	Guilin Institute of Information Technology	30	2.0722	0.72276		
	Guangxi University for Nationalities	48	2.3819	1.06133		
	Others	48	2.309	0.88925		
Non Interference With User Excellence	Guilin University of Electronic Technology	37	2.3938	0.54648	0.797	0.553
	Beihai Campus of Guilin University of Electronic Technology	89	2.2809	0.48753		
	Liuzhou Polytechnic University	27	2.328	0.33106		
	Guilin Institute of Information Technology	30	2.2429	0.55538		
	Guangxi University for Nationalities	48	2.4494	0.76959		
	Others	48	2.3125	0.60585		
Operability	Guilin University of Electronic Technology	37	2.8604	0.70219	2.331	0.043
	Beihai Campus of Guilin University of Electronic Technology	89	2.8277	0.78594		
	Liuzhou Polytechnic University	27	2.8889	0.53309		
	Guilin Institute of Information Technology	30	2.5444	0.87858		
	Guangxi University for Nationalities	48	2.6806	0.98321		
	Others	48	2.4201	0.87586		
User Choice	Guilin University of Electronic Technology	37	2.7357	0.73299	1.116	0.352
	Beihai Campus of Guilin University of Electronic Technology	89	2.794	0.84446		
	Liuzhou Polytechnic University	27	3.0823	0.80454		
	Guilin Institute of Information Technology	30	2.8407	0.97377		
	Guangxi University for Nationalities	48	2.963	1.16113		
	Others	48	2.6273	1.05943		
Information Transparency	Guilin University of Electronic Technology	37	2.8063	0.70984	1.124	0.348
	Beihai Campus of Guilin University of Electronic Technology	89	2.5787	0.7671		
	Liuzhou Polytechnic University	27	2.8148	0.64439		
	Guilin Institute of Information Technology	30	2.6778	0.9315		
	Guangxi University for Nationalities	48	2.7326	1.13182		
	Others	48	2.4583	0.8995		
Effect Of Precise Push Servise	Guilin University of Electronic Technology	37	2.7477	0.64024	1.021	0.405
	Beihai Campus of Guilin University of Electronic Technology	89	2.6386	0.71564		
	Liuzhou Polytechnic University	27	2.7531	0.50079		
	Guilin Institute of Information Technology	30	2.6833	0.88012		
	Guangxi University for Nationalities	48	2.7569	1.08119		
	Others	48	2.441	0.84948		
Impact Of Precise Push Service	Guilin University of Electronic Technology	37	2.9243	0.75917	0.786	0.561
	Beihai Campus of Guilin University of Electronic Technology	89	2.7865	0.86329		
	Liuzhou Polytechnic University	27	2.9407	0.71213		
	Guilin Institute of Information Technology	30	2.7667	0.94407		
	Guangxi University for Nationalities	48	2.8292	1.02146		
	Others	48	2.5958	0.99573		
Precision Push Affects User Behavior	Guilin University of Electronic Technology	37	2.9243	0.90351	0.502	0.775
	Beihai Campus of Guilin University of Electronic Technology	89	2.9326	0.85915		
	Liuzhou Polytechnic University	27	3.2074	0.78148		
	Guilin Institute of Information Technology	30	3	1.02251		
	Guangxi University for Nationalities	48	3.0667	1.2066		
	Others	48	2.8958	1.079		

The two mediating variables are themselves highly correlated, suggesting that perceived effectiveness and influence of precision push services are closely intertwined in the user's evaluation process. These findings align well with the conceptual model, confirming that experiential quality significantly contributes to overall performance evaluation, which ultimately affects user behavior. The high inter-correlations among mediating variables and their strong links to core experience dimensions underscore the robustness of the performance evaluation construct. The results provide a solid statistical foundation for further causal modeling, such as regression or structural equation analysis.

Similarly, the two mediating variables—Effect of Precise Push Service and Impact of Precise Push Service—also show strong correlations with the final outcome variable, Precision Push Affects User Behavior, as presented in Table 7. This indicates that users' perceptions of the service's effectiveness and influence play a crucial role in shaping their behavioral responses. The strong associations further validate the theoretical path from user experience dimensions,

through mediating evaluations, to behavioral outcomes, reinforcing the overall coherence and robustness of the research model.

TABLE 6
CORRELATION ANALYSIS BETWEEN VARIOUS DIMENSIONS

Different dimensions	Effect of precise push servise	Impact of precise push service	Message validity and quality	Non interference with user excellence	Operability	User choice	Information transparency
Effect of precise push servise	1						
Impact of precise push service	.803** .772**	1					
Message validity and quality	.608** .609**	.616** .612**	1				
Non interference with user excellence	.562** .505**	.577** .508**	.652** .590**	1			
Operability	.659** .657**	.685** .652**	.724** .688**	.659** .546**	1		
User choice	.778** .738**	.785** .748**	.613** .564**	.640** .561**	.725** .657**	1	
Information transparency	.726** .646**	.672** .616**	.555** .543**	.575** .496**	.652** .583**	.720** .644**	1

TABLE 7
CORRELATION ANALYSIS BETWEEN VARIOUS DIMENSIONS

Different dimensions	Precision push affects user behavior	Effect of precise push servise	Impact of precise push service
Precision push affects user behavior	1		
Effect of precise push servise	.724** .714**	1	
Impact of precise push service	.827** .793**	.803** .772**	1

B. Causal Analysis

This study employed multiple linear regression analysis to examine the causal relationships among user experience dimensions, perceived performance evaluations, and behavioral outcomes related to precision push services. Based on empirical data collected through structured questionnaires, five experiential dimensions—message validity and quality, non-interference with user experience, operability, user choice, and information transparency—were included as independent variables. Two mediating variables—effect and impact of the precision push service—were examined as performance evaluation outcomes, while user behavior served as the final dependent variable. The analysis results are shown in Table 8, and detailed interpretations are as follows [2].

In the regression model where Effect of Precision Push Service served as the dependent variable, the model showed strong explanatory power ($F = 114.692$, $p < 0.001$; Adjusted $R^2 = 0.672$), indicating that the five independent variables explained 67.2% of the variance.

Among the predictors, User Choice had the strongest effect ($\beta = 0.458$, $p < 0.001$), suggesting that greater user control over information significantly improves the perceived precision and usefulness of the service . Information Transparency ($\beta = 0.304$, $p < 0.001$) and Message Validity and Quality ($\beta = 0.149$, $p = 0.006$) also showed significant positive impacts. However, Operability ($\beta = 0.040$, $p = 0.508$) and Non-interference with User Experience ($\beta = -0.030$, $p = 0.560$) were not significant, indicating these factors were less influential in how users evaluated service effectiveness.

In the model predicting Impact of Precision Push Service[2], the model was also robust ($F = 108.452$, $p < 0.001$; Adjusted $R^2 = 0.659$). Once again, User Choice emerged as the most influential predictor ($\beta = 0.501$, $p < 0.001$), indicating that when users have control or filtering abilities, they are more likely to perceive the push service as impactful. Other significant predictors included Information Transparency ($\beta = 0.159$, $p = 0.003$), Message Validity and Quality ($\beta = 0.134$, $p = 0.014$), and Operability ($\beta = 0.124$, $p = 0.044$), suggesting that content clarity and ease of use also enhance users' subjective perception of influence. However, Non-interference with User Experience remained insignificant ($\beta = -0.004$, $p = 0.936$), implying that even if push notifications are slightly intrusive, users do not necessarily consider this a major factor in being influenced.

In the final stage, the two mediating variables (Effect and Impact of Precision Push Service) were used to predict the final dependent variable: Precision Push Affects User Behavior. The model demonstrated excellent fit ($F = 313.746$, $p < 0.001$; Adjusted $R^2 = 0.692$). The results revealed that Impact was a much stronger predictor ($\beta = 0.693$, $p < 0.001$) compared to Effect ($\beta = 0.168$, $p = 0.003$), indicating that users' behavioral changes are driven more by the subjective influence of the push content rather than by their evaluation of technical effectiveness.

TABLE 8
CORRELATION ANALYSIS BETWEEN VARIOUS DIMENSIONS

Dependent Variable	Predictor	B	Beta	t	p	Std. Error	95.0% confidence interval		F	Significance	Adjusted R^2
							Upper limit	Lower limit			
Effect of Precise Push Service	Message validity and quality	0.149	0.149	2.796	0.006	0.053	0.044	0.254	114.692	.000b	0.672
	Non interference with user excellence	-0.042	-0.03	-0.583	0.56	0.072	-0.184	0.1			
	Operability	0.039	0.04	0.663	0.508	0.059	-0.076	0.154			
	User choice	0.392	0.458	7.865	0	0.05	0.294	0.49			
	Information transparency	0.283	0.304	5.856	0	0.048	0.188	0.379			
Impact of Precise Push Service	Message validity and quality	0.149	0.134	2.472	0.014	0.06	0.03	0.268	108.452	.000b	0.659
	Non interference with user excellence	-0.007	-0.004	-0.081	0.936	0.082	-0.167	0.154			
	Operability	0.134	0.124	2.024	0.044	0.066	0.004	0.265			
	User choice	0.477	0.501	8.436	0	0.057	0.365	0.588			
	Information transparency	0.165	0.159	3.003	0.003	0.055	0.057	0.273			
Precision push affects user behavior	Effect of Precise Push Service	0.203	0.168	3.006	0.003	0.068	0.07	0.337	313.746	.000b	0.692
	Impact of Precise Push Service	0.755	0.693	12.409	0	0.061	0.635	0.874			

In other words, how much the push message resonates, triggers thought, or elicits action plays a more decisive role in behavior change than technical precision alone. In summary, this study confirms that the experiential dimensions of precision push services significantly affect both perceived effectiveness and influence, especially User Choice, Information Transparency, and Message Validity and Quality. Furthermore, Impact is shown to be the key driver of user behavior change[2], more so than technical effectiveness. These findings suggest that in designing precision push strategies, developers should enhance user autonomy, increase transparency and message quality, and focus on emotional relevance and scenario-based design to achieve greater behavioral influence.

V. DISCUSSION

After controlling for gender, school affiliation, and regional background, this study systematically examined the causal relationships among user experience dimensions, perceived performance evaluations, and user behavioral responses in the context of precision push services. The findings strongly support the hypothesized model proposed by the author. In particular, User Choice emerged as the most influential factor, confirming the centrality of user autonomy in shaping perceptions of push-based information systems.

Across both models—Effect of Precision Push Service and Impact of Precision Push Service—User Choice consistently exhibited the strongest standardized regression coefficients ($\beta = 0.458$ and $\beta = 0.501$, both $p < 0.001$), indicating both statistical significance and model stability [2]. This result suggests that the degree to which users can control, customize, or reject push content directly influences how they perceive the quality, value, and trustworthiness of the service. More importantly, User Choice plays a foundational role in the full causal chain. It first shapes users' perceptions of both the effectiveness and the impact of the push service, which then mediates the final behavioral outcome. In this way, user choice acts as both a cognitive driver and the psychological starting point of behavioral transformation.

Beyond user choice, both Information Transparency and Message Validity and Quality also demonstrated stable and significant effects across both mediating models. Specifically, Information Transparency showed β values of

0.304 and 0.159 in the respective models, suggesting that clarity about information sources and delivery enhances user trust and receptivity. Likewise, high-quality, credible, and well-structured content contributes positively to how users assess the service [2].

It is also worth noting that while Operability did not show a significant effect in the Effect model ($p = 0.508$), it did reach marginal significance in the Impact model ($p = 0.044$). This suggests that the ease of interacting with the service may be more important in influencing users' sense of being impacted, rather than their perception of technical effectiveness.

An interesting observation is that Non-Interference with User Experience did not demonstrate significant causal effects in either regression model ($p > 0.5$), deviating from initial expectations. However, correlation analysis revealed strong associations between this variable and both mediators (e.g., Pearson $r = 0.562^{**}$ with Effect), suggesting it still plays a role in the user's broader perceptual schema. This "correlated-but-not-causal" pattern may be explained by several factors. First, user tolerance toward interruption varies, resulting in less consistent cognitive evaluations [8]. Second, non-interference may function as a baseline expectation—once satisfied, it no longer contributes directly to perceived value. Third, some users may be accustomed to interruptions and thus do not consider them problematic. Therefore, although not a primary causal factor, non-interference should still be viewed as part of the overall user experience environment.

In the final model predicting User Behavior, Impact of Precision Push Service demonstrated a far stronger effect ($\beta = 0.693$, $p < 0.001$) compared to Effect of Precision Push Service ($\beta = 0.168$, $p = 0.003$). This result indicates that behavioral responses are not simply driven by perceived effectiveness (e.g., accuracy, relevance), but more strongly by subjective perceptions of influence—such as whether the message resonates emotionally or prompts action. This finding highlights the importance of moving beyond technical precision toward psychological precision. Successful push strategies should not only deliver the right content but do so in a way that connects with users' emotions, intentions, and contexts.

This causal analysis provides strong empirical support for the proposed precision push model, particularly underscoring User Choice as the most influential variable throughout the pathway. Information Transparency, Message Validity and Quality, and Operability also contribute meaningfully to performance evaluations. Although certain variables like Non-Interference did not demonstrate direct causal effects, their significant correlations suggest an underlying role in shaping the perceptual environment. Overall, the study affirms that precision push systems are not just technical matching tools, but user-centered ecosystems where autonomy, transparency, and emotional relevance collectively determine behavioral outcomes.

While this study provides valuable insights into the effectiveness of precision push services and their impact on user behavior, several limitations must be acknowledged. First, the sample used in this study was drawn exclusively from university students across several institutions in Guangxi, China. This limits the generalizability of the findings to other demographics, particularly non-student populations or individuals from different cultural or geographical backgrounds. Future research could benefit from expanding the sample to include diverse age groups, professional backgrounds, and international participants to enhance external validity.Second, the study's reliance on self-reported data may introduce response biases, such as social desirability bias or recall bias. Participants may have been inclined to provide responses that they perceived as socially acceptable or that aligned with their expectations of what was being tested. To mitigate this, future studies could incorporate behavioral data, such as actual usage patterns or engagement metrics, to complement self-reported surveys and provide more objective insights into user behavior.Third, while the study included multiple variables, the measurement of operability and non-interference with user experience was somewhat limited. These constructs were assessed through self-reported surveys, which may not capture the full complexity of users' subjective experiences with push notifications. Incorporating experimental designs or field studies could provide a more nuanced understanding of how these factors influence user behavior in real-world settings.

Lastly, the study employed cross-sectional data, meaning that causal relationships were inferred from observed correlations rather than being definitively established over time. A longitudinal approach would allow for a deeper examination of how user perceptions and behaviors evolve in response to long-term exposure to precision push services. Furthermore, this study did not fully address potential moderating factors, such as individual differences in technological affinity, personality traits, or previous experiences with push notifications, which may influence the way users respond to personalized content.

Despite these limitations, the study offers important contributions to understanding how user-centered design elements—such as user choice, information transparency, and message quality—shape user engagement with precision push services. Future research addressing these limitations could further refine the understanding of the dynamics between users and mobile push systems, leading to more effective and personalized digital communication strategies.

VI. CONCLUSIONS

This study developed and empirically validated a comprehensive eight-dimensional model to assess user perception and behavior in response to precision push services (PPS). By integrating five experiential predictor variables—message validity and quality, non-interference with user experience, operability, user choice, and information transparency—with two perceptual mediators (effect and impact) and one behavioral outcome, the study offers a robust framework for understanding how users cognitively and behaviorally engage with mobile push systems [2].

Based on a full-sample quantitative survey of 279 university students from diverse institutions and regions, the study found that User Choice emerged as the strongest predictor of both perceived service effect and impact, underscoring the central role of autonomy in shaping user evaluations. Information Transparency and Message Validity and Quality also significantly influenced users' perceptions, while Operability showed marginal influence in shaping perceived impact. Interestingly, Non-Interference with User Experience, though strongly correlated with perception variables, did not yield significant causal effects, suggesting its role may be more foundational than functional.

The findings also reveal that Impact of Precision Push Service is a far stronger predictor of User Behavior than the perceived technical Effect, highlighting the importance of psychological and emotional resonance in driving engagement. This suggests that effective push strategies must not only achieve technical relevance but also foster meaningful, emotionally aligned experiences for users.

This research makes four key contributions:It presents a theoretically grounded, empirically tested causal model of PPS perception and behavior;It confirms the dominant role of user autonomy in service acceptance; It identifies transparency and content quality as critical drivers of trust and receptivity; It demonstrates the relative importance of perceptual "impact" over mere effectiveness in shaping behavioral outcomes.

These insights offer practical guidance for system designers, marketers, and platform developers seeking to improve the relevance, usability, and behavioral impact of push notification systems. Future research should explore cross-cultural generalizability, include longitudinal tracking of behavioral shifts, and investigate the ethical boundaries of personalized content delivery in relation to user consent and cognitive load. By centering user perception within the design and evaluation of PPS, this study contributes to a more user-informed, psychologically attuned approach to mobile content personalization.

Future research could explore the cross-cultural applicability of precision push services, examining how cultural differences impact user behavior. Additionally, the integration of artificial intelligence (AI) and machine learning in push notifications could enhance personalization and targeting accuracy, warranting further investigation. Longitudinal studies are needed to assess the long-term effects of precision push services on user behavior, offering insights into sustained engagement. Lastly, exploring individual differences, such as personality traits and technological affinity, could help refine push strategies to better align with diverse user preferences.

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ORCID:
Wang Peng: https://orcid.org/0009-0009-7995-749X
Norhayati Hussin: https://orcid.org/0000-0002-3818-1105
Masitah Ahmad: -

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