



K-Means and Decision Tree Models for Analysis Students Perception of Digital Marketing

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Abstract

Amid intensifying competition among educational institutions and the rapid expansion of digital platforms, schools must adopt effective digital marketing strategies to attract prospective students. This research examines students' perceptions of the implementation of digital marketing at the Global Islamic Boarding School (GIBS) in Barito Kuala Regency, South Kalimantan, Indonesia. Data were collected from 95 students using a structured questionnaire comprising 20 variables related to digital marketing and word-of-mouth communication. A hybrid analytical framework integrating K-Means Clustering and Decision Tree analysis was employed to identify perception-based segments and determine key differentiating indicators. The Elbow method indicated an optimal three-cluster solution, resulting in highly positive, negative, and moderate perception groups. Decision Tree results revealed that engaging content (B7), social media stability (B12), and invitation to attend school (C19) were the most influential variables distinguishing clusters, with satisfactory classification performance supporting the robustness of the segmentation. The findings suggest that emotionally engaging and experientially rich content plays a more decisive role in shaping student perceptions than purely technical aspects of digital media management. Accordingly, schools should optimize their digital marketing strategies by emphasizing authentic student experiences, maintaining consistent, stable online communication, and incorporating persuasive calls to action to enhance prospective students' interest. This research contributes a data-driven segmentation framework that enriches educational digital marketing research and provides practical guidance for strategy development in boarding school contexts.

Keywords: Data-Driven Insights, Digital Marketing, Educational Institutions, K-Means Clustering, Student Perception

1. INTRODUCTION

Ki Hadjar Dewantara emphasized the existence of three fundamental educational environments, known as the Three Centers of Education: formal (schools), non-formal (communities), and informal (families). Each of these pathways plays an essential role in guiding and nurturing human development toward wholeness and excellence [1]. The Global Islamic Boarding School (GIBS), a private boarding institution located in Barito Kuala Regency, South Kalimantan, integrates both the National Curriculum and its own Boarding Curriculum within its learning framework and has earned an "A" accreditation. However, despite these institutional strengths, GIBS has experienced difficulties in achieving its new student enrollment targets over the past five years, particularly among prospective students from outside Barito Kuala Regency. Previous studies have indicated that the marketing strategies implemented by GIBS, including digital marketing, have not been fully effective in reaching and influencing prospective students [2]. This condition highlights the need for further evaluation of how digital marketing practices are perceived by students as key stakeholders [2], [3].

With the advancement of digital technology, platforms such as websites, social media, and online content have become strategic tools for shaping institutional image and expanding information reach [4], [5]. Accordingly, this research focuses on analyzing students' perceptions of digital marketing implementation to identify perception patterns and key differentiating factors. Digital marketing is increasingly recognized as a key factor influencing school choice. Kholik [6] highlights that digital marketing via social media provides schools with new opportunities to connect with audiences and strengthen their brand identity. In the context of secondary education, a well-designed digital marketing strategy can play a pivotal role in shaping the



perceptions and decisions of both prospective students and their parents when selecting an educational institution [7].

The success of a digital marketing strategy is influenced not only by the frequency of media usage but also by users' perceptions and experiences when interacting with it. Positive views regarding accessibility, information clarity, and content credibility serve as key indicators of effective digital marketing efforts [8], [9]. Previous studies on school marketing and student perception have predominantly relied on conventional statistical approaches such as descriptive analysis, correlation, or regression models. While effective in measuring overall tendencies, these methods are limited in capturing heterogeneity among respondents and uncovering latent perception patterns within complex datasets.

In recent research on data-driven marketing and consumer analytics, machine learning techniques such as K-Means Clustering have been widely adopted for segmenting customer or user groups based on behavioral and perception data, enabling more targeted strategy development [10]. In addition, hybrid analytical frameworks that combine unsupervised clustering with supervised classification have been shown to enhance interpretability and actionable insights, as methods such as K-Means followed by Decision Tree classification provide both latent segment discovery and the identification of key differentiating attributes [11]. Despite the extensive use of these approaches in retail, e-commerce, and broader digital marketing research, their application in the specific context of educational digital marketing particularly within boarding school environments remains limited. Consequently, recent educational marketing studies have increasingly adopted machine learning techniques, such as K-Means Clustering and Decision Trees, as analytical alternatives to identify hidden segments and reveal key differentiating attributes among respondent groups [12].

This research seeks to examine students' perceptions of digital marketing practices at the Global Islamic Boarding School (GIBS) by integrating K-Means Clustering and Decision Tree methods to generate a segmented understanding of student perceptions and identify the key factors that most strongly influence their views. Students were selected as the primary respondents because they are the direct users of educational services and the main audience exposed to the school's digital marketing content. According to consumer behavior theory, primary users play a critical role in shaping preferences and attitudes during the information search and evaluation stages of decision-making [13], [14]. In the context of secondary and boarding education, students actively interact with digital platforms and form perceptions that influence their interest in a school. Although parents often serve as the final decision makers in school enrollment, particularly for boarding institutions, prior studies indicate that enrollment decisions frequently involve joint decision-making between parents and students, in which students' perceptions and preferences significantly influence the final choice [13], [14]. Therefore, analyzing students' perceptions provides relevant and strategic insights into the effectiveness of digital marketing initiatives.

2. MATERIALS AND METHOD

2.1. Flowchart

This research adopted an exploratory quantitative approach, utilizing data collected through a questionnaire developed by [2]. The questionnaire served as the primary instrument for collecting students' responses related to the key research variables. Prior to analysis, a data pre-processing stage was conducted, including completeness checking and consistency validation. Since the dataset contained no missing values, no imputation was required. All questionnaire responses were measured using a uniform Likert scale (1–4); therefore, normalization was not applied to preserve the original interpretability of the indicators. Additionally, no extreme outliers were detected because the data were bounded within the predefined scale range.

Following pre-processing, clustering was performed using the K-Means algorithm, with the optimal number of clusters determined via the Elbow method. Based on the selected cluster number, centroids and cluster memberships were established. Subsequently, Decision Tree analysis was applied to identify key indicators distinguishing the clusters. The final stage involved descriptive interpretation of each cluster to characterize respondents' perception profiles. The complete research workflow is illustrated in Figure 1.

2.2. Data

The dataset for this research was obtained from questionnaire responses collected from students of the GIBS. A total sampling (census) approach was employed, in which all 95 active students of GIBS form Class X and XI participated in the research. The respondents consisted of 42 male and 53 female students. The questionnaire comprised 20 variables, including 14 indicators related to digital marketing and 6 indicators associated with word-of-mouth communication. Since the entire student population was included, the dataset fully represents students' perceptions within the GIBS context. The detailed list of questions and corresponding variables is presented in Table 1.

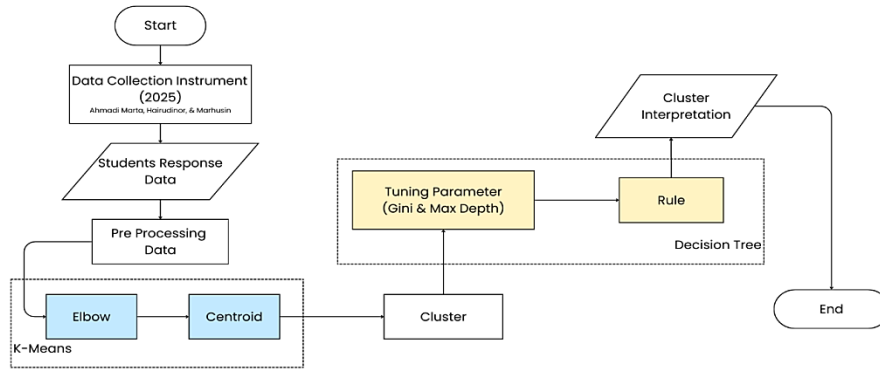


Figure 1. Flowchart

Table 1. Question Indicator

Code	Question
B1	The GIBS SMA website is easy to access
B2	GIBS SMA social media is easy to access
B3	I can do questions and answers via the GIBS SMA website
B4	I can do questions and answers via GIBS SMA social media
B5	Various content is distributed via SMA GIBS social media
B6	The content distributed helps me get information
B7	The content distributed is interesting to me
B8	The information conveyed via social media is credible for me
B9	The information conveyed via social media is specific to me
B10	The GIBS SMA website rarely experiences problems when accessed
B11	The features on the SMA GIBS website are easy to access
B12	GIBS SMA social media rarely experiences problems when accessed
B13	The information conveyed via the Website is clear to me
B14	Information conveyed on social media provides economic benefits for me
C15	I will tell other people about your experience at GIBS High School
C16	I tell other people about the quality of SMA GIBS's services
C17	I recommend GIBS SMA to others
C18	I provide information related to SMA GIBS to other people
C19	I persuaded others to attend GIBS High School
C20	I persuaded parents to send you to GIBS High School

Figure 2 illustrates the average scores for each questionnaire item (feature) obtained from the respondents. The detailed descriptions of items B1 through C20 are provided in Table 1. The questionnaire employed a 1–4 rating scale. As shown in Figure 2, the mean scores range from 1.7 to 3.4, reflecting variations in respondents’ perceptions across different statements. Items such as B10, B14, C19, and C20 recorded the highest average scores, suggesting strong agreement from respondents. In contrast, items B2, B5, and C16 received the lowest scores, indicating general disagreement. Overall, 13 items yielded an average score above 2.0, implying that respondents’ perceptions were generally positive toward most of the questionnaire indicators.

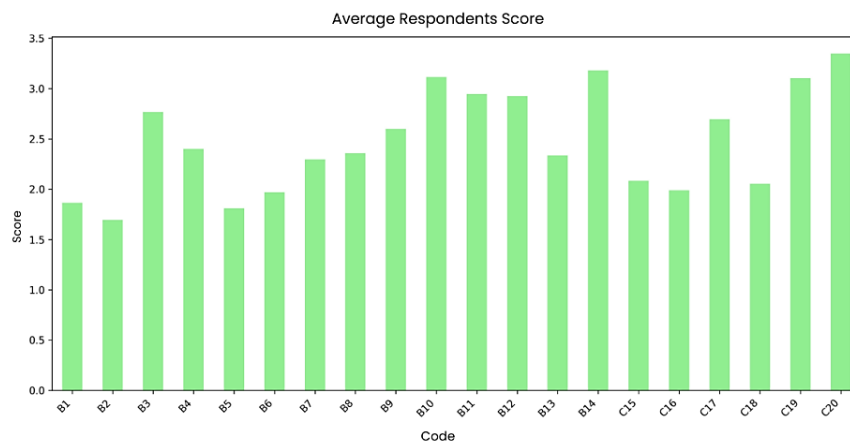


Figure 2. Average Respondents Score

2.3. Digital Marketing

Digital marketing constitutes a strategic approach that utilizes digital technologies and internet-based networks to engage consumers in a manner that is more effective, interactive, and measurable [8]. In the educational sector, digital marketing functions as a means to enhance institutional reputation, expand the dissemination of information, and strengthen the relationship between schools and prospective students [9]. As articulated [15] digital marketing encompasses a range of activities, including social media promotion, website management, and the dissemination of informative content aligned with user needs. Social media, in particular, serves as a vital medium for facilitating two-way communication, enabling users to provide immediate and meaningful feedback.

2.4. K-Means

The K-Means Clustering method is an unsupervised learning algorithm designed to partition data into multiple groups (clusters) according to the degree of similarity among the data points [12]. The algorithm operates by first specifying the number of clusters, k , and then iteratively computing the Euclidean distance K-Means Clustering is an unsupervised learning algorithm that partitions data into k clusters based on similarity among data points [16]. The algorithm iteratively calculates the Euclidean distance between each point and the cluster centroids, updating centroid positions until convergence is achieved [17].

2.5. Decision Tree

The Decision Tree is a supervised learning algorithm used for classification and regression by partitioning data based on attribute-specific [18]. Nodes represent attribute tests, and branches indicate possible outcomes. Using metrics such as Information Gain or the Gini Index, the algorithm identifies the most informative splits by minimizing node impurity [19]. Decision Trees are highly interpretable, producing intuitive "if-then" rules that clearly describe the decision-making process [20].

3. RESULTS AND DISCUSSION

A preliminary analysis was conducted to examine correlations among the questionnaire indicators. Figure 3 shows a heatmap of these correlations, where red denotes strong positive correlations and blue indicates weaker or negative correlations. Most indicator pairs exhibit moderate positive correlations ($r = 0.1 - 0.6$), suggesting generally supportive but not strong relationships. Several pairs demonstrate higher correlations above 0.6, including B6–B7 ($r = 0.72$), B11–B12 ($r = 0.69$), C15–C16 ($r = 0.74$), C17–C19 ($r = 0.72$), and C19–C20 ($r = 0.75$), indicating mutually reinforcing items. These results provide a critical basis for the clustering analysis.

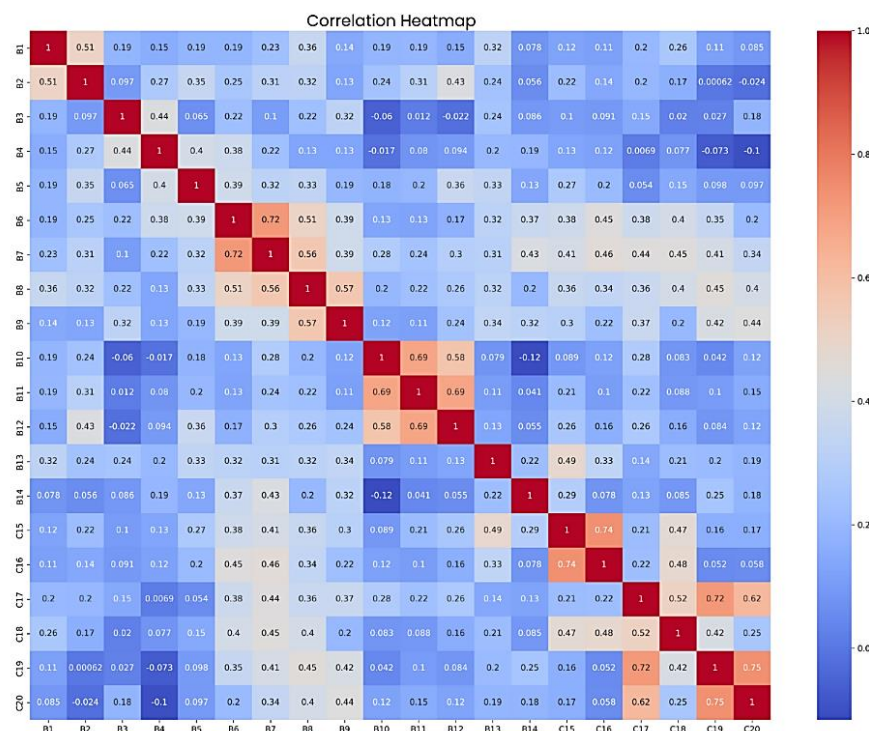


Figure 3. Correlation Heatmap

3.1. Number of Cluster

After examining the correlations among the questionnaire indicators, the next step was to determine the optimal number of clusters for grouping the respondents. The Elbow method was employed by analyzing the change in inertia relative to the number of clusters. As shown in Figure 4, a sharp decline in inertia occurs at $k = 3$, followed by a more gradual decrease, indicating that three clusters: Cluster 0, Cluster 1, and Cluster 2 represent the optimal grouping.

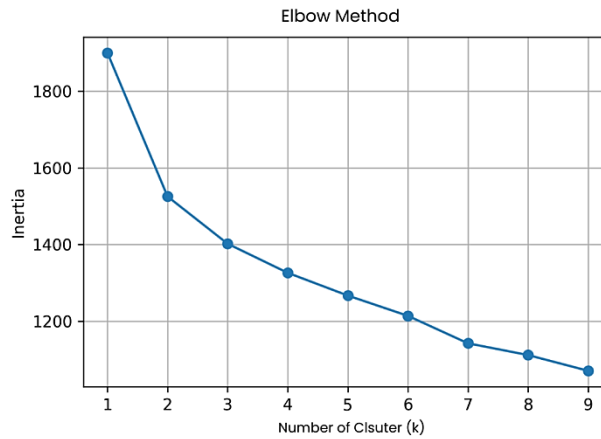


Figure 4. Elbow Method

Table 2. Cross Data Results

Cluster	Gender		Grade		Region		
	M	F	X	XI	South Kalimantan	Central Kalimantan	Others
0	16	16	15	17	22	9	1
1	16	15	15	16	15	13	3
2	10	22	16	16	14	16	2

To enrich the interpretative analysis, cluster membership was further examined across demographic variables, including gender, grade level, and region of origin. The results from Table 2 indicate that gender and grade distributions are relatively balanced across clusters, suggesting that perception differences are not strongly associated with these demographic characteristics. However, regional distribution reveals a more distinct pattern. Cluster 0 is predominantly composed of students from South Kalimantan, indicating that local students tend to exhibit more favorable views of the school’s digital marketing practices. In contrast, Cluster 1 includes a relatively higher proportion of students from outside South Kalimantan, particularly Central Kalimantan. Similarly, Cluster 2 is also more represented by non-local students. These findings suggest that geographic background may influence how digital marketing efforts are perceived, particularly among students who rely more heavily on online information when considering enrollment decisions.

3.2. Cluster Results

The application of the K-Means method with $k = 3$ produced three clusters: Cluster 0, Cluster 1, and Cluster 2. Each cluster is represented by centroids corresponding to the questionnaire indicators, serving as the cluster’s central point. Tables 3 and 4 provide an overview of all centroids and responses for each cluster. Cluster 0, comprising 32 respondents, exhibits positive centroid values ranging from 0.2 to 1.0, indicating general agreement with the questionnaire items. Cluster 1, consisting of 31 respondents, has centroid values ranging from -0.9 to -0.1, reflecting disagreement with the items. Cluster 2, the intermediate group with 32 respondents, shows centroid values between -0.4 and 0.6, suggesting a moderate perception of the questionnaire indicators.

Table 3. Centroid

Indicator	Cluster (k)		
	0	1	2
B1	0.5	-0.6	0.1
B2	0.4	-0.8	0.3
B3	0.5	-0.3	-0.2
B4	0.3	-0.5	0.2
B5	0.5	-0.6	0.0
B6	0.8	-0.5	-0.4
B7	1.0	-0.6	-0.4

Indicator	Cluster (<i>k</i>)		
	0	1	2
B8	0.9	-0.5	-0.4
B9	0.7	-0.4	-0.4
B10	0.2	-0.8	0.6
B11	0.3	-0.8	0.5
B12	0.4	-0.9	0.5
B13	0.7	-0.4	-0.4
B14	0.6	-0.2	-0.4
C15	0.7	-0.4	-0.3
C16	0.5	-0.3	0.2
C17	0.7	-0.3	0.4
C18	0.6	-0.4	-0.2
C19	0.8	-0.1	-0.7
C20	0.7	-0.1	-0.6

Table 4. Cluster Results

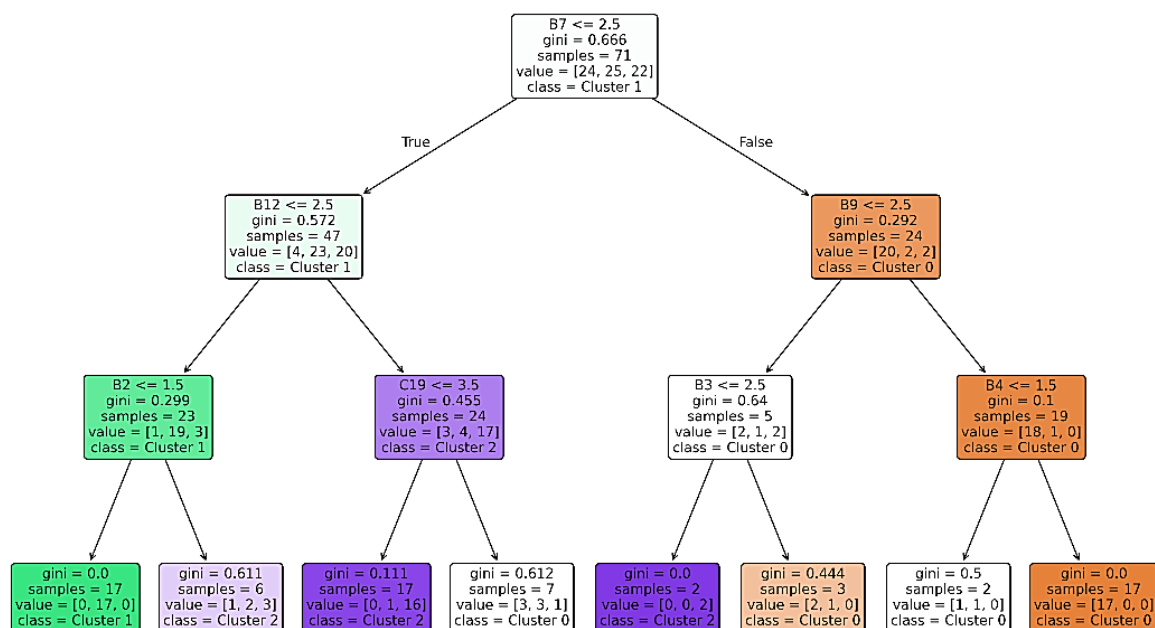
Cluster (<i>k</i>)	Response	Total
0	1, 5, 7, 9, 13, 15, 23, 24, 25, 26, 30, 31, 33, 36, 37, 41, 42, 47, 48, 50, 51, 53, 59, 63, 65, 66, 72, 79, 81, 83, 93, 94	32
1	3, 16, 18, 21, 27, 28, 38, 45, 49, 52, 55, 57, 58, 60, 61, 64, 67, 69, 70, 71, 76, 77, 78, 80, 82, 84, 88, 89, 90, 91, 92	31
2	2, 4, 6, 8, 10, 11, 12, 14, 17, 19, 20, 22, 29, 32, 34, 35, 39, 40, 43, 44, 46, 54, 56, 62, 68, 73, 74, 75, 85, 86, 87, 95	32

3.3. Decision Tree Analysis

The subsequent stage of this research involved further analysis using the Decision Tree method. This analysis aims to interpret the clustering results by identifying the key indicators that most effectively distinguish between clusters. In this process, the clusters obtained from the K-Means method serve as class labels (targets), while the questionnaire indicators function as predictor variables.

Figure 5 illustrates that question B7 is the most influential variable in the initial split, followed by B12, B9, B4, B3, C19, and B2 at subsequent levels. The interpretation of Figure 5 is as follows:

- Cluster 0** comprises respondents with $B7 > 2.5$ and $B9 \leq 2.5$, particularly when $B4 \leq 1.5$, representing a group with relatively consistent and stable responses.
- Cluster 1** includes respondents with $B7 \leq 2.5$, $B12 \leq 2.5$, and $B2 \leq 1.5$, indicating a group with comparatively higher perceptions on these indicators.
- Cluster 2** is characterized by $B12 \leq 2.5$ and $C19 > 3.5$, reflecting a group with distinct or more varied orientations and experiences.

**Figure 5.** Decision Tree Results

To evaluate the robustness of the Decision Tree model, classification performance metrics were calculated by comparing the predicted cluster labels with the original cluster assignments generated by the K-Means algorithm. The model achieved an overall accuracy of 81.05%, indicating a strong ability to reproduce the cluster structure. The macro-average precision, recall, and F1-score were 0.83, 0.81, and 0.80, respectively. Given the relatively balanced distribution of respondents across clusters, macro-averaged metrics were considered appropriate to ensure equal weighting of each perception group. These results confirm that the Decision Tree provides a reliable representation of the perception-based segmentation and supports the validity of the extracted decision rules.

3.4. Discussion

Beyond the numerical differentiation that explain in the sub section Cluster Reults and Decision Tree, the prominence of B7 (engaging content) as the primary splitting variable suggests that emotional and experiential appeal plays a central role in shaping students’ perceptions of digital marketing within a boarding school context. Unlike non-boarding schools, boarding institutions require students to imagine not only academic quality but also daily life, social interaction, and residential experience. In this setting, engaging digital content functions as a symbolic representation of the school environment, allowing students to visualize their potential future experience. Therefore, respondents who perceive the content as engaging are more likely to form positive overall impressions of the institution.

From a theoretical perspective, this finding aligns with consumer behavior and digital engagement literature, which emphasize that engagement enhances emotional connection, perceived credibility, and behavioral intention. Engaging content operates at the early and decisive stages of attention and interest formation, which may explain why B7 emerges as the primary differentiating factor across clusters. While variables such as platform stability (B12) and information clarity contribute to perception formation, they appear to function as supporting factors rather than primary drivers.

Overall, the correlation, clustering, and Decision Tree analyses form a consistent, mutually supportive pattern. Strong correlations help explain the co-occurrence of variables within clusters, K-Means provides a quantitative segmentation, and Decision Trees offer interpretable rules clarifying why respondents belong to specific clusters. Importantly, the integrated analytical approach reveals that segmentation is driven not merely by technical or structural aspects of digital marketing, but by how effectively the content resonates with students’ psychological expectations and imagined boarding school experience. This insight contributes to educational marketing literature by demonstrating that, in boarding school contexts, affective engagement may outweigh purely informational attributes in differentiating perception groups.

Table 5. Comparative Results

Ahmadi Marta [2]	Tesdiq Prigel Kaloka
DM → WOM: significant	Cluster 0: highly positive
WOM → BA: significant	Cluster 1: negative
WOM → Decision: significant	Cluster 2: moderate
BA → Decision: significant	Key differentiating indicators:
DM → BA: not significant	B7 (engaging content)
DM → Decision: not significant.	B12 (social media stability)
DM indirectly affects Decision & BA via WOM.	C19 (invitation to attend school)
	Positive correlation between strong content & stable media with favorable perceptions

The comparative results with previous research by Ahmadi [2] can be seen in Table 5. Examined the structural relationships among Digital Marketing (DM), Word of Mouth (WOM), Brand Awareness (BA), and enrollment decisions using a causal modeling approach, the present research provides a complementary perspective by focusing on perception-based segmentation. The prior findings indicated that digital marketing did not directly influence enrollment decisions but exerted an indirect effect through WOM. This suggests that the effectiveness of digital marketing depends on intermediary psychological and social processes rather than direct persuasion.

The current research extends this understanding by demonstrating that students’ perceptions of engaging content (B7) and social media stability (B12) function as primary differentiating factors across perception clusters. While the previous research explained “how” digital marketing influences decision-making structurally, this research explains “why” such influence may vary across student segments. In particular, the identification of three perception clusters (highly positive, negative, and moderate) reveals that digital marketing effectiveness is not uniform but contingent upon how students emotionally and cognitively interpret the content.

Furthermore, the dominance of engaging content (B7) supports the earlier finding that digital marketing impacts decision-making indirectly, as engaging content may stimulate interpersonal

communication and WOM processes. Therefore, this research enriches prior causal findings by uncovering the latent segmentation patterns that underlie the mediation mechanisms previously identified.

This research offers three main contributions to the educational marketing literature. First, methodologically, it integrates unsupervised clustering (K-Means) with an interpretable classification model (Decision Tree), providing a hybrid analytical framework that not only segments respondents but also explains the defining characteristics of each segment. This approach goes beyond traditional regression-based analyses by uncovering latent heterogeneity within perception data.

Second, conceptually, this research demonstrates that the effectiveness of digital marketing in educational institutions particularly boarding schools is strongly driven by affective engagement rather than solely by structural or informational attributes. The identification of engaging content (B7) as the primary differentiator suggests that emotional resonance plays a more decisive role in perception formation than previously emphasized in causal models.

Third, in contrast to prior studies that treated student perceptions as relatively homogeneous, this research reveals the existence of three distinct perception-based segments (positive, negative, and moderate), indicating that digital marketing impact varies across psychological groups. This segmentation perspective provides a deeper explanation for why digital marketing may not always show direct statistical significance in structural models, as its influence depends on how different perception clusters interpret and internalize digital content. Therefore, the present research advances existing research by bridging causal relationship analysis with perception-based segmentation, offering both theoretical enrichment and practical guidance for designing more targeted digital marketing strategies in boarding school contexts.

4. CONCLUSION

The Decision Tree analysis revealed that B7 (engaging content), B12 (social media stability), and C19 (invitation to attend the school) are the most influential indicators differentiating perception clusters. Based on these findings, several actionable recommendations can be proposed for GIBS. First, improving content engagement (B7) through visually rich posts, student-centered storytelling, and interactive formats such as short videos or testimonials may strengthen positive perceptions. Second, ensuring stable and reliable social media performance (B12), including consistent posting schedules and platform responsiveness, is essential to maintain user trust. Third, strengthening persuasive messaging (C19) by incorporating clear calls-to-action and success stories may increase students' willingness to recommend and invite others to enroll.

For Cluster 2, which exhibits moderate perceptions, targeted improvements should focus on enhancing content relevance and consistency. Students in this group may benefit from clearer informational content, such as academic program highlights, extracurricular activities, and school achievements, delivered through stable and engaging digital platforms. Addressing these aspects may help shift moderate perceptions toward more positive evaluations.

From a practical perspective, this research provides a data-driven framework for GIBS to refine its digital marketing strategy by aligning content quality, platform reliability, and persuasive communication with student perception profiles. Future research may expand the respondent population and apply additional machine learning techniques, such as Random Forests or Support Vector Machines, to further improve classification performance and deepen analytical insights.

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