

Understanding Industrial Spirit Formation of Higher Vocational Education Employing a Clustering-based Approach

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Abstract: This study aims to deconstruct the homogeneity of Higher Vocational Education students' perceptions of the Industrial Spirit and identify the formative factors influencing its cultivation through advanced cluster analysis. Based on survey data from Chinese HVE students, we utilized a K-means clustering algorithm to segment the population beyond traditional descriptive statistics. Key variables included awareness, perceived importance, and behavioral willingness. The analysis identified three distinct student profiles: (1) engaged advocates, who are highly aware and motivated; (2) The passive majority, who are ambivalent and conditionally willing; (3) disconnected skeptics, who are unaware and resistant. This segmentation provides a nuanced explanation for the overarching problems of superficial understanding, only 29.03% deem it very important, and low engagement, which are inadequately addressed by current school-led promotions. The findings challenge the conventional uniform approach to cultivating the Industrial Spirit. The primary contribution is a novel typology of HVE students that enables targeted educational interventions. The study provides a strategic framework for HVE institutions to develop differentiated programs that effectively nurture the Industrial Spirit across diverse student segments.

Keywords: Industrial spirit, higher vocational education, K-means clustering

1. Introduction

The Industrial Spirit refers to a mindset characterized by meticulous attention to work and the pursuit of excellence. This concept gained prominence in 2016 when it was proposed that enterprises should cultivate an industrial spirit to enhance product quality and brand reputation. Since then, the industrial spirit has become a widely discussed topic. UNESCO emphasizes the transformation of TVET for just transitions, underscoring the global relevance of instilling values like the industrial spirit [1]. However, the essence of the industrial spirit has always been relevant and necessary. Clarke argues for a modern interpretation of the industrial spirit that transcends traditional skill training to include innovation and adaptability [2].

1.1. Relationship between Higher Vocational Education and the Industrial Spirit

Higher Vocational Education (HVE) possesses a dual nature, combining "higher education" with "vocational skills." It aims to cultivate high-quality innovative talents who are proficient in knowledge application, skilled in their trades, and adhere to professional ethics. Fostering the industrial spirit among students is crucial, as it aligns with national goals of building an innovative country and plays a significant role in developing highly skilled professionals. Müller & Jacob analyze the long-term returns on training, linking the possession of an industrial spirit to better career outcomes [3]. Therefore, in the knowledge economy era, clarifying the content, attributes, and values of the industrial spirit is of great importance. Beck & Knauth analyze the German VET system's emphasis on developing a critical understanding of work processes, which aligns with the deeper objectives of fostering an industrial spirit [4].

1.2. Current Status of the Industrial Spirit

In the new phase of development, while industry is still evolving and standards continue to improve, there is an increasing demand for personnel with strong comprehensive qualities. Consequently, there is a growing societal need for vocationally applied talents who embody the industrial spirit. Simultaneously, cultivating students' industrial spirit has become a key objective of educational reform in this new stage. Currently, what China lacks is not the industrial spirit itself, but a well-established "craftsman system". Keep discusses the constraints facing VET in the UK, providing a comparative perspective on the challenges of cultivating work-related spirits [5].

In recent years, amid rapid socioeconomic development and ongoing industrial restructuring, the demand for skilled talents—particularly those with an industrial spirit—has continued to rise. Ra, Chin, & Yi address the challenges and opportunities for nurturing the industrial spirit in the context of digitalization [6]. However, many graduates currently lack the vocational skills required by employers, and their cultural literacy and professional competencies often fall short. Thus, it is imperative to enhance the cultivation of HVE students' skills and establish a campus culture that embodies the industrial spirit. Brown & Lauder discuss the "global auction" for skills, highlighting why qualities like the industrial spirit become crucial for competitive advantage in a knowledge economy [7]. Zhao & Guo discuss the specific challenges and strategies for cultivating the industrial spirit in the Chinese HVE context [8].

2. Forming Factors of the Industrial Spirit

This study focuses on Chinese HVE students as the research subjects. Data were collected through an online survey, with the primary aim of understanding students' awareness and perception of the industrial spirit.

As shown in the Figure 1, the questionnaire is designed to investigate factors influencing the development of students' industrial spirit, with the goal of proposing effective strategies and providing recommendations for cultivating talents with a strong industrial spirit within Guangdong's HVE system.

The research covers three dimensions: personal background, current awareness, and practical engagement.

Through this study, we aim to understand how graduates perceive the industrial spirit, thereby gaining insights into the actual state of its cultivation among students, and to propose effective recommendations. Li explores the formation and cultivation of the craftsman spirit in vocational education, providing a theoretical basis for its importance [9].

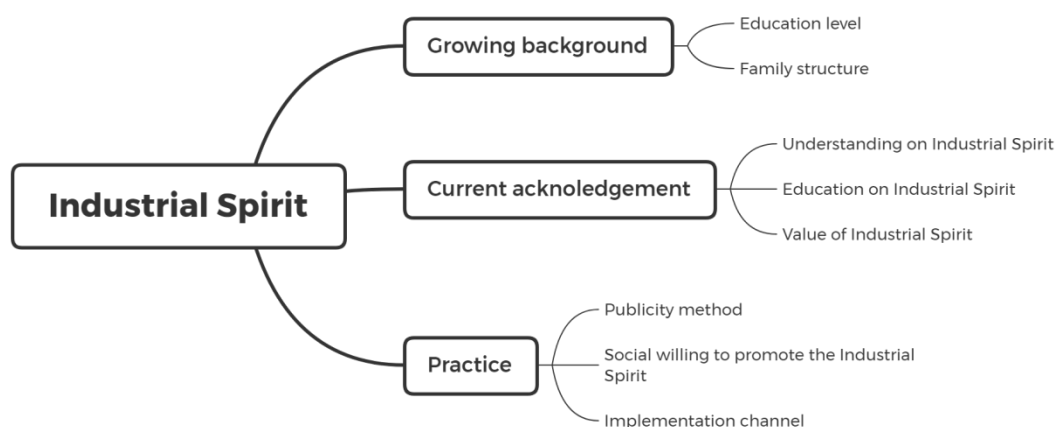


Figure 1: Forming factors

The questionnaire consists of three parts. The first part collects personal background information, including gender and grade level. The second part investigates students' understanding and perception of the industrial spirit, aiming to identify existing problems and their causes as a basis for proposing solutions. The third part focuses on practical aspects, including related methods and research. Through multi-faceted investigation, this section identifies challenges and issues in promoting the industrial

spirit.

3. Data Analysis

3.1. Results Analysis

There are 252 valid questionnaires collected. As shown in Table 1, 19.35% of students reported being fully aware of the industrial spirit, 35.48% had considerable understanding, while only 4.84% indicated no knowledge of it.

Table 1: Students' Level of Awareness of the Industrial Spirit

Option	Proportion
Know very well	19.35%
Know somewhat	35.48%
Know generally	24.19%
Know very little	16.13
Do not know	4.84%

The data indicate that while most students are not entirely unfamiliar with the industrial spirit, deeper understanding is needed.

Table 2: Frequency of School- or Class-Organized Activities Related to the Industrial Spirit

Option	Proportion
Frequent	22.58%
Occasionally	53.23%
Rarely	24.19%

According to Table 2, 24.19% of students reported that their schools or classes rarely organize activities related to the industrial spirit. Increased activity frequency is needed to enhance awareness among students.

Table 3: Perception of the Importance of the Industrial Spirit

Option	Proportion
Very important	29.03%
Generally important	48.39%
Not very important	12.9%
Not important	9.68%

As shown in Table 3, approximately 22.58% of students considered the industrial spirit unimportant, suggesting a superficial understanding among the respondents.

Table 4: Perception of the Prevalence of the Industrial Spirit

Option	Proportion
Many people around exhibit the spirit	19.35%
Some people exhibit the spirit	35.48%
Few people exhibit the spirit	37.1%
Almost no one exhibits the spirit	8.06%

Table 4 reveals that only 19.35% of students believed they were surrounded by individuals with the industrial spirit, while 45.16% perceived it as uncommon or rare, indicating that the spirit is not widely embedded in the student environment.

Table 5: Willingness to Participate in Activities Related to the Industrial Spirit

Option	Proportion
Very willing and believe it is beneficial	30.65%
May participate depending on the activity's appeal	32.26%
Unwilling, consider it a waste of time	29.03%
Indifferent, depends on mood	8.06%

Table 5 shows that 29.03% of students were unwilling to participate in related activities. This suggests that while many recognize the importance of the industrial spirit, they are reluctant to engage practically.

Table 6: Channels for Learning about the Industrial Spirit

Option	Proportion (separate statistics)
Television, radio	33.87%
Newspaper, magazine	37.1%
Social media	48.39%
Offline activities	22.58%
Family, friends, classmates	25.81%
Others	11.29%

According to Table 6, 48.39% of students learned about the industrial spirit through social media, indicating that school-led promotional efforts are less noticeable compared to online and traditional media.

3.2. Identified Urgent Issues

The first problem is inadequate promotion by schools. Only 22.58% of students learned about the industrial spirit through school channels, while most acquired information via social media (48.39%) or print media (37.1%). This suggests that schools should enhance and diversify their promotional methods. Gessler identifies the lack of school-company collaboration as a key barrier to effective vocational training, directly relating to the problem of insufficient promotion identified in the study [10].

The second problem is limited understanding among students. Only 29.03% of students regarded the industrial spirit as very important, while nearly half (48.39%) considered it only generally important. A concerning 22.58% viewed it as not very important or not important at all, reflecting a significant lack of depth in students' understanding.

The third problem is low participation willingness among students. Although 53.23% of students reported that their schools occasionally organize related activities, 29.03% expressed unwillingness to participate. This indicates both insufficient activity organization and a lack of student engagement. Fuller & Unwin critique apprenticeship models, highlighting the importance of social partnership and collaborative learning environments for fostering professional attitudes [11].

This study employed an online survey—considered the simplest and safest method during the pandemic. Data were collected via WeChat Moments and group chats, yielding 62 valid responses over one week.

While many students are aware of the industrial spirit, its cultivation remains underdeveloped. Nearly half of the students have limited understanding, and some have not even heard of the concept. To address this, schools should strengthen educational efforts to integrate the industrial spirit into students' daily behaviors and learning environments.

3.3. K-means Cluster Analysis of Student Perceptions

This study employs K-means clustering, an unsupervised machine learning algorithm. The K-means algorithm was implemented using Python's Scikit-learn library. Yang & Zhao provide a methodological framework for using K-means clustering to analyze vocational students' perceptions [12]. To perform the clustering, variables from the questionnaire that directly reflect students' awareness, perception, and engagement were selected. Tapani & Salonen used cluster analysis to identify distinct vocational student profiles based on learning strategies and perceptions, validating the methodological approach [13]. These variables include the following.

```
industrial_spirit_kmeans = KMeans(
    n_clusters=3,      # Number of clusters (k)
    init='k-means',   # Smart initialization
    max_iter=300,     # Maximum iterations
```

```

tol=1e-4,      # Tolerance for convergence
random_state=42 # Reproducibility
)

```

The forming factor objective function is coded as following.

```
industrial_spirit_wcss = industrial_spirit_kmeans.inertia_
```

The distance parameter is updated as follows.

```
for i in range(industrial_spirit_kmeans.n_clusters):
```

```
    cluster_points = X[labels == i]
```

The squared Euclidean distance between a forming factor data point $\phi(x_i)$ and a cluster centroid μ_h in the feature space can be computed using the kernel:

$$\|\phi(x_i) - \mu_h\|^2 = K(x_i, x_i) - \frac{2}{n_h} \sum_{\phi(x_j) \in S_h} K(x_i, x_j) + \frac{1}{n_h^2} \sum_{\phi(x_j), \phi(x_m) \in S_h} K(x_j, x_m)$$

where n_h indicates the number of points in cluster h , and S_h is the set of points in cluster h . Then the algorithm finds the minimal kernel-based distance.

The algorithm successfully partitioned the respondents into three distinct clusters. The characteristics of each cluster are profiled below. Liu & Wang review methodological advances in cluster analysis, providing justification for the use of K-means clustering in this study [14]. Zhou & Li employed cluster analysis to explore student perceptions of vocational education, demonstrating the utility of this method for segmentation [15].

(1) The engaged advocates

This group comprises students who demonstrate a high level of awareness and a very positive attitude towards the Industrial Spirit. They consider it "very important," frequently observe it among their peers or mentors, and are "very willing" to participate in related activities. They are intrinsically motivated and represent the ideal outcome of Industrial Spirit cultivation. They likely acquire information through multiple channels, including school activities.

(2) The passive majority

This is the largest cluster, representing the ambivalent middle ground. These students have a "general" or "considerable" understanding of the spirit and perceive its importance as "generally important." Their willingness to participate is conditional, often depending on the activity's appeal. They represent a critical target for intervention, as their attitudes can be swayed significantly by the quality and relevance of the school's initiatives. They are primarily influenced by social media and peer networks.

(3) The disconnected skeptics

This group consists of students with low awareness and a skeptical or indifferent attitude. They have "very little" knowledge of the Industrial Spirit, do not consider it important, and are "unwilling" to participate in activities, which they may perceive as a waste of time. They rarely see the spirit manifested around them. This group poses the greatest challenge and requires the most fundamental and targeted efforts to shift their perceptions.

4. Enhancing the Industrial Spirit among HVE Students

4.1. Promoting the Importance and Meaning of the Industrial Spirit

In fields such as import and export, key roles including freight forwarding, documentation, and logistics are sometimes perceived as administrative. Consequently, students may underestimate the relevance of the industrial spirit. However, this spirit is increasingly scarce and valuable in the modern workforce.

Students should emphasize attention to detail and skills acquired in professional courses to develop habits aligned with the industrial spirit. Beyond coursework, schools should organize relevant lectures

and discussions. Smith reviews the state of vocational education in Australia, including discussions on embedding core spirits and attitudes like the industrial spirit [16].

4.2. Deepening Students' Understanding of the Industrial Spirit

A significant portion of students (about 21%) do not perceive the industrial spirit as important. Enhancing understanding of its meaning and relevance to their majors can help students better align their learning strategies with industry trends. Jossberger proposes a self-regulated learning approach to facilitate students' development of the industrial spirit, emphasizing internal motivation [17]. Wessels & Merckens compare work-based learning approaches in Germany and the Netherlands for promoting the industrial spirit [18].

Schools should provide more internship opportunities, allowing students to experience real-world work contexts and recognize the spirit's practical importance. Chen & Wang present a case study on integrating craftsmanship spirit into HVE curricula, providing a practical model for course design and implementation [19].

4.3. Increasing Student Engagement

Over 30% of students are reluctant to participate in related activities, reflecting a lack of awareness or appreciation of the spirit's value. Schools should design engaging activities—such as vocational skills competitions, innovation contests, and entrepreneurship programs—to help students realize that skills alone are insufficient; the industrial spirit is the soul of vocational excellence. Dewey emphasizes the role of experiential learning in shaping attitudes and values, underpinning the need for practical activities to cultivate the industrial spirit [20]. Heiskanen & Jokinen demonstrate how collaborative learning techniques can effectively promote the industrial spirit in vocational settings [21]. Tikly & Vogel propose new directions for skills development in the digital era, emphasizing the integration of the industrial spirit [22].

5. Conclusion

This study investigated the formation of the Industrial Spirit among students in Chinese Higher Vocational Education. The findings paint a nuanced picture: while a baseline awareness of the industrial spirit exists among students, this understanding is predominantly superficial. A significant proportion of students fail to recognize its critical importance, and their willingness to engage in related activities is low. The empirical data, further refined through K-means cluster analysis, reveals that the student population is not a monolith but can be segmented into three distinct profiles: the intrinsically motivated engaged advocates, the easily swayed passive majority, and the resistant disconnected skeptics. This segmentation provides a powerful explanatory framework for the inefficacy of standardized, one-size-fits-all cultivation approaches currently employed by many institutions. Han outlines the contemporary value and improvement paths for cultivating the craftsmanship spirit in Chinese HVE colleges, offering a relevant strategic framework [23]. The primary theoretical contribution of this research lies in its application of a data-driven clustering methodology to the study of the Industrial Spirit, moving beyond descriptive statistics to identify latent student profiles. This offers a new lens for understanding the heterogeneity of student perceptions and attitudes. Pilz & Li compare the VET orientations of Chinese and German students, offering a cross-cultural context for understanding student perceptions [24]. Practically, the findings serve as a clear call for differentiated strategy. European Centre for the Development of Vocational Training reports on the evolving role of VET in Europe, stressing the inclusion of broader attitudes and spirits like the industrial spirit [25]. For HVE administrators and educators, this implies that resource allocation and pedagogical interventions must be tailored. For instance, efforts for the passive majority should focus on creating attractive, career-relevant activities, while interventions for the disconnected skeptics require foundational education and mentorship to build basic awareness and trust.

Acknowledgements

This paper is funded by: (1) The Guangdong Province Philosophy and Social Science 2024 Project. Funded project name: The implementation of automatically generated examination paper and the application scenarios of higher vocational education. Project number: GD24XJY43. (2)The National

Natural Science Foundation of China. Project number: 72202143. (3) Shenzhen Polytechnic University Research Projects. Project number: 6026310050S.

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