

Career Planning Challenges and Strategies for Quantum Science Students Based on a Clustering Analysis

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Abstract: This study presents a contemporary analysis of career planning among quantum-related disciplines graduates in China. It aims to investigate their self-awareness, career orientation, and post-graduation plans, thereby identifying key challenges and informing targeted support strategies. An empirical study was conducted through a questionnaire survey administered to students enrolled in quantum-related programs in China. An empirical study was conducted through a questionnaire survey, which was designed with a logical structure focusing on personal, environmental, and solution factors. Data were analyzed using a K-means clustering analysis in Python to identify distinct graduate profiles. The results reveal a critical paradox: while an overwhelming majority acknowledge the importance of career planning, more than half exhibit insufficient self-recognition and unclear career direction. Post-graduation plans are evenly split between further studies and employment. A clustering analysis segmented respondents into three groups: proactive planners, uncertain explorers, and pragmatic undecided, validating the prevalence of vague self-positioning and unclear development trajectories. Students expressed a strong desire for more robust institutional support, including better access to corporate information and career guidance.

Keywords: Graduates of quantum-related programs in China; career planning; employment

1. Background

In recent years, the expansion of university enrollment has led to significant employment pressure nationwide in China, creating an unprecedented challenge for graduates. Some quantum related course graduates lack necessary self-confidence, appearing "needy" during job searches, while others maintain an unrealistic sense of entitlement, approaching employment from a perceived position of privilege. Both tendencies can reduce employment success rates. In response, educational institutions and society have encouraged graduates to "secure employment first, then refine career choices" to alleviate overall pressure. A significant skills mismatch is reported by employers, indicating a need for closer dialogue between academia and industry regarding graduate preparation [1]. Therefore, it is imperative for each student to begin career planning as early as possible. By analyzing, summarizing, and determining the relevant subjective and objective factors influencing their career, and by setting clear goals, students can better position themselves in the highly competitive employment landscape.

2. Introduction of Research

2.1. Purpose

Modern employability frameworks extend beyond simple employment rates to include metrics such as job-education alignment, career progression speed, and capacity for lifelong learning [2]. The purposes of this research are: first, to provide a contemporary analysis of career planning development for students majoring in quantum-related disciplines; second, to help regulate the supply-demand relationship between employers and graduates through investigating employment factors specific to these majors; and third, to assist quantum majors in gaining self-awareness sooner. Universities can utilize these findings to provide targeted employment guidance, helping students pursue their ideal careers.

2.2. Method

This study employed a questionnaire survey, administered via mobile devices to 265 Chinese students majoring in quantum-related fields. The sample consisted of 60% juniors and 29.23% sophomores. The questionnaire achieved a 100% response rate, yielding 265 valid responses for a 100% validity rate. Data were processed using SPSS 10.0 software.

2.3. Logic of Questionnaires

The questionnaire was designed based on the research objectives. As shown in Figure 1, it is divided into three modules: Personal Factors, Environmental Factors, and Solutions.

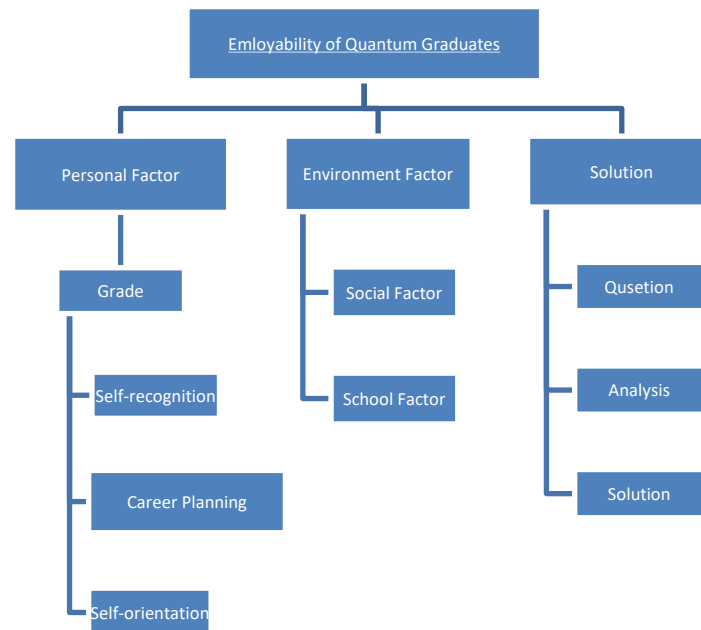


Figure 1: Influencing factors of employability

1) As personal factors is the core theme, it is essential first to understand students' self-perception and their need for planning.

2) Environmental factors. Career planning is vital for students, guiding their future career paths. Schools and society often provide relevant courses and online resources.

3) The solution module explores how students navigate post-graduation decisions, such as job hunting versus further study.

This structured approach allows researchers to understand students' perspectives progressively, helping them self-assess, find their positioning, clarify career aspirations, and identify solutions to challenges. Thus, the questionnaire design is logically sound.

3. Results Analysis

3.1. Self-recognition

Self-awareness, encompassing abilities, strengths, interests, values, and goals, is a prerequisite for effective career planning. According to the Table 1, 56.92% of students reported an inability to accurately assess their own abilities and strengths, indicating insufficient self-understanding. In contrast, 38.46% believed they had a good grasp of their strengths and interests, enabling them to leverage their advantages for self-development. These findings suggest that a majority of quantum majors lack deep self-knowledge, leading to vague career goals and planning. Students with higher levels of self-efficacy regarding their technical abilities demonstrated clearer career goals and engaged in more proactive job search strategies [3].

Table 1: Clear Understanding of Your Strengths and Weaknesses.

Option	Proportion
Yes	38.46%
Uncertain	56.92%
No	1.54%
No Idea	3.08%

3.2. Awareness of Employment Prospects

The Table 2 shows that 55.38% of quantum graduates were unclear about their future employment direction, suggesting limited concern for their career prospects. Only 32.31% had a clear understanding. Furthermore, 49.23% were uncertain about how their major would impact their future employment, while only 41.54% could clearly articulate this relationship, as shown in the Table 3. This indicates a significant disconnect between academic training and career vision for many students.

Table 2: Clear career direction related to the quantum industry.

Option	Proportion
Yes	32.31%
No	55.38%
No Idea	12.31%

Table 3: How quantum course influences career choices.

Option	Proportion
Yes	41.54%
Uncertain	49.23%
No	4.62%
No Idea	4.62%

3.3. Understanding of Career Planning

An overwhelming majority, 93.85% of quantum graduates as shown in the Table 4, recognized the importance of career planning for their employment, indicating successful awareness-raising, likely through university guidance. Only 1.54% did not appreciate its importance. Early and systematic career planning is strongly associated with higher job satisfaction and better salary outcomes, underscoring the need for integrated career guidance from the initial stages of university education [4].

Table 4: Importance of Career Planning.

Option	Proportion
Yes	93.85%
No	1.54%
No Idea	4.62%

3.4. Post-Graduation Plans

The Table 5 reveals an equal proportion of 43.08% of quantum students planning to pursue further studies versus those seeking employment directly after graduation. Only 7.69% considered entrepreneurship, indicating that most students favor traditional paths of advanced education or immediate employment over starting their own businesses.

Table 5: Planning after Graduation.

Option	Proportion
Keep Studying to Improve Degree	43.08%
Employment	43.08%
Set up Business	7.69%
Others	6.15%

3.5. Employment Orientation

According to the Table 6, in initial employment, 38.46% of students prioritized finding a job they liked, aligning work with personal interest. Meanwhile, 36.92% adhered to the "employment first, career second" approach, indicating uncertainty. Another 21.54% planned to seek jobs directly related to quantum major. When facing career confusion, a large proportion sought help from parents and teachers, highlighting a reliance on external guidance due to their own uncertainties.

Table 6: Drivers to choose a quantum job.

Option	Proportion
Base on Interest	38.46%
Based on Major	21.54%
Work first then Choose	36.92%
Don't Care	3.08%

The Table 7 shows that students look for helps from different parties. Parents, teachers and classmates are the favourite parties that students prefer to ask help from.

Table 7: Seeking helps in job hunting confusion from.

Option	Proportion
Parent	49.23%
Teacher	26.92%
Classmate	11.62%
Professional Agencies	10.92%
Self	1.33%

3.6. Factors Considered in Job Hunting

The Table 8 demonstrates that the most critical factors were alignment with personal interests and hobbies (86.15%) and specialties (80.00%). Salary level (70.77%) and company reputation were also significant. This shows that students weigh multiple factors, with personal interest and specialty fit being paramount.

Table 8: Important factors to keep in working in the quantum industry.

Option	Proportion
Interests	86.15%
Strengthens	80%
Popularity	52.31%
Position	38.46%
Payment	70.77%
Profession	29.23%
Others	9.23%

3.7. Desired Employment Support

When facing social pressure, students most desired access to information about companies and their recruitment standards (73.85%) as shown in the Table 9. Career planning guidance from schools (70.77%), increased employment opportunities from companies (69.23%), and opportunities to improve professional and English skills (60.00%) were also highly valued. This indicates a need for better information dissemination and skill development support from both educational institutions and employers.

Table 9: What helps are needed for quantum graduates in the first stage of career.

Option	Proportion
Guidance of Career Planning	70.77%
Increase Chances	69.23%
Knowing of Enterprise Information and Standard	73.85%
Psychological Guidance	50.77%
Improve English and Profession Ability	60%
Choose between Well-known Enterprises and Profession Development	56.92%

3.8. K-means Clustering Analysis of Graduate Profiles

To move beyond descriptive statistics and identify distinct subgroups within the quantum program graduates, a K-means clustering analysis was performed, which helps segment the students based on their responses to key career planning variables, providing deeper insights for targeted university support and guidance.

This paper uses the scikit-learn library in Python for the objective segmentation of students into distinct groups based on their career planning profiles, providing a more nuanced understanding for targeted intervention strategies. Data are encoded and standardized in Python. The elbow method is employed to find out the best number of clusters $K=3$.

```
career_planning_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 objective function of career planning data is coded as following.

```
career_planning_wcss = career_planning_kmeans.inertia_
```

The distance update function is implemented as follows.

for i in range(career_planning_kmeans.n_clusters):

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

The squared Euclidean distance between a career planning 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 presents the number of points in cluster h , and S_h is the set of points in cluster h . The program is executed to find the minimal kernel-based distance.

The characteristics of each cluster were interpreted by examining the mean values of the original features for the students within each group.

(1) The proactive planners

These students are self-aware, recognize the value of planning, and have a relatively clear career vision. They are likely to be the most prepared for the job market. This group is almost evenly split between pursuing employment and further study, indicating confident and deliberate decision-making.

(2) The uncertain explorers

This group shows significant ambiguity about their skills and future path, despite a moderate acknowledgment of career planning's importance. They represent the primary target for foundational university support. It shows a slight preference for further study, potentially as a mechanism to defer definitive career choices.

(3) The pragmatic undecided

This smaller cluster shows that students who understand their abilities but have not yet connected them to a specific career within the quantum field. They highly value planning but lack a clear direction. It shows the most varied intentions, with a notably higher interest in entrepreneurship compared to other clusters, supporting their profile as explorers seeking alternative paths.

4. Identified Issues

4.1. Lack of Self-Positioning

A significant number of graduates lack a clear understanding of their own positioning, including the values of quantum major, their interests, abilities, and skills. While a strong GPA is beneficial for initial screening, its correlation with long-term career success is modest, with employers placing greater emphasis on practical portfolios [5]. A significant perception gap exists where graduates often

overestimate their preparedness in emerging technologies, while employers prioritize demonstrated problem-solving abilities and proven experience [6]. This hinders their ability to find suitable jobs. Dissatisfaction often stems from misalignment between job roles, salary expectations, and personal preferences, or from perceived high corporate standards. The core challenge is not finding a job, but finding the right job.

4.2. Unclear Future Development Direction

Many quantum majors have vague notions about their future career paths. This stems partly from insufficient career guidance provided by universities and partly from the students' own lack of accurate self-assessment and awareness of the job market, having been relatively sheltered within the academic environment.

4.3. Lack of Internship Experience and Career Planning

Intense talent competition necessitates high skill levels. However, students often lack practical internship experience and concrete career plans, making their initial entry into the workforce challenging. Internships that offer meaningful project ownership and mentorship are linked to faster promotion rates and higher retention within the first three years of professional employment [7]. Structured internships and project-based learning are correlated with a significantly higher employment rate in the field, demonstrating the critical role of practical experience in translating academic knowledge into job readiness [8]. Longitudinal data confirms that core competence remains one of the strongest predictors of positive initial employment outcomes for graduates [9].

Furthermore, as enterprises raise their recruitment standards, students must learn to analyze talent market trends and seek relevant practical experiences to bridge the gap between academia and quantum industry demands.

5. Proposed Solutions

5.1. Develop Realistic Self-Positioning

Universities should improve the curriculum quality to help students to understand the industrial job market. Curriculum design for cutting-edge fields must be agile, incorporating feedback from both industry and research frontiers to remain relevant and effective [10]. A persistent gap exists between core academic curricula and the evolving skill demands of the technology sector, necessitating a more dynamic and responsive approach to curriculum design that incorporates industry feedback [11]. The integration of advanced technologies is creating new, hybrid roles that demand graduates possess not only deep technical skills but also domain-specific knowledge [12].

Students must realistically analyze their situations. Many harbor unrealistic expectations about high-paying jobs immediately after graduation. Given their typical lack of social experience, it is crucial to adjust expectations, engage in correct self-assessment, conduct serious career planning, and maintain a humble attitude to facilitate better employment outcomes. Simulate real-world industry workflows significantly improve graduates' capabilities in technical communication, project management, and the application of theoretical knowledge [13]. Universities should increase the simulation content in these courses.

5.2. Avoid Underestimating Oneself

Students should not underestimate their abilities. It is important to cultivate a correct and reasonable self-view, develop good professional habits, and enhance vocational skills. While technical proficiency is a prerequisite for entry-level positions, long-term career advancement in technology fields is increasingly determined by soft skills such as communication, teamwork, and adaptability [14]. Leveraging individual strengths is key. Conducting career planning before entering the workforce is essential for improving work efficiency. Continuous effort and practice are necessary. Mentorship from industry professionals significantly smoothes the school-to-work transition and aids in the formation of a professional identity for new graduates [15]. Therefore, university mentorship is helpful to graduates in improving their job hunting ability. Participation in hackathons and open-source projects is highly valued by employers as evidence of initiative and practical ability beyond the formal curriculum [16].

Therefore, students are recommended to participate quantum computing competitions during their study.

5.3. Engage in Reality-Based Future Planning

In fast-evolving fields like quantum technology, commitment to continuous learning is essential for sustaining long-term employability [17]. Students should create career plans based on their actual circumstances and current market demands. The quantum industry seeks talent with a strong foundation in computer science, physics, and mathematics, highlighting the critical need for interdisciplinary educational approaches [18]. This involves choosing suitable jobs, setting clear goals, and creating detailed plans broken down into actionable steps. Goals should be grounded in reality, with consideration for future development to enrich the career planning process. Cooperative education programs, industry-sponsored projects, and joint research initiatives are proven mechanisms for enhancing the job-market readiness of graduates by providing authentic context for academic learning [19]. Additionally, personal job hunting ability is also important. Personalized career counseling, including resume reviews and mock interviews tailored to the tech industry, was rated as the most beneficial service by graduates who secured their desired positions [20]. Emotional intelligence, particularly empathy and conflict management, is a strong predictor of effective collaboration in technology teams [21].

6. Conclusion

This study has systematically investigated the career planning perceptions, challenges, and orientations of university graduates from quantum-related disciplines in China, a critical cohort within the nation's strategy for technological advancement. The empirical analysis reveals a complex and somewhat paradoxical landscape. While an overwhelming majority of students recognize the paramount importance of career planning, a significant proportion struggle with fundamental prerequisites for its effective implementation: a clear understanding of their own strengths and weaknesses and a defined career direction within the quantum industry. This dissonance between recognition and self-awareness is a central finding of this research.

The application of K-means clustering analysis further quantified and refined this understanding, segmenting the student population into three distinct profiles: the confident Proactive Planners, the ambiguous uncertain explorers, and the skill-aware but directionally weak pragmatic undecided. This segmentation provides a nuanced lens through which to view the aggregate data, explaining the divergent post-graduation plans, a nearly equal split between pursuing further studies and direct employment, and the prevalent reliance on external guidance from parents and teachers when facing career confusion.

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