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# Learning Analytics for Bridging the Skills Gap: A Data-Driven Study of Undergraduate Aspirations and Skills Awareness for Career Preparedness

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**Abstract:** As the demands of the modern workforce evolve, universities are increasingly challenged to provide academic knowledge and the practical and transferable skills necessary for students' career success. This study investigates the alignment between undergraduate students' career aspirations, their perceived skill development, and the role of higher education institutions in bridging the skills gap. To address this issue, a comprehensive survey was conducted among undergraduate students to gather data on their career aspirations, their awareness of the skills required for their chosen careers, and their perceptions of how well their university supports their skill development. Using machine learning methods such as hierarchical clustering and *k*-nearest neighbors for classification, coupled with non-parametric statistical analysis such as the Mann–Whitney *U* and Chi-squared ($\chi^2$) tests to understand students' perceptions of their career preparedness, the findings from this study provide valuable insights into how higher education institutions can prepare students for the workforce and highlight areas where improvements are needed to better support students in achieving their career goals.

**Keywords:** career preparedness; skills identification; perception survey; higher education; learning analytics



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## 1. Introduction

Undergraduate students are increasingly confronted with a complex and competitive career landscape in the rapidly changing global economy. As they transition from higher education to the workforce, the challenges they face have intensified due to technological advancements, shifts in industry demands, and evolving societal expectations Altbach et al. (2019); L. Li (2022). Understanding students' career aspirations and ensuring they are adequately prepared to pursue their goals have become critical concerns for educators, policymakers, and employers Figueiredo et al. (2015); Goulart et al. (2021).

Career aspirations serve as a compass that guides students through their educational journey, shaping their choices of courses, extracurricular activities, and professional development opportunities. Personal interests and intrinsic motivations are other critical drivers of career aspirations Akosah-Twumasi et al. (2018). However, aspirations alone are insufficient. Students must also be aware of the steps required to achieve their goals and be prepared to meet the demands and skill requirements of the job market Baird and Parayitam (2019); Donald et al. (2018). This awareness and preparedness are often influenced

by factors such as access to career resources, quality of education, and socio-economic background. While aspirations and preparedness are interrelated, they are not always aligned. The gap between what students aspire to achieve and what they are prepared to do can lead to significant challenges, including underemployment, job dissatisfaction, and prolonged job searches after graduation González-Romá et al. (2016); Steffy (2017).

Career aspirations are shaped by a multitude of factors that begin long before a student enters university. Family background, cultural influences, and early educational experiences can play a role in forming and directing students' career goals Gomez and Beachum (2019); Gottfredson (1981); Kiuru et al. (2012); Kurlaender and Hibel (2018); Olsen et al. (2022). Consequently, career preparedness has become a multifaceted concept, encompassing academic achievement and developing a broad range of skills and competencies. The traditional view of career readiness focused primarily on subject-specific knowledge and technical skills Singha et al. (2024). However, in today's job market, employers are increasingly seeking candidates who possess a combination of hard and soft skills. This shift reflects the changing nature of work, where the ability to adapt, collaborate, and think critically is often as important as technical expertise Winterton and Turner (2019). As a result, career preparedness now requires a holistic approach that includes both academic learning and experiential opportunities. Career internships, co-op programs, service learning, and other practical coaching and experiences have become essential components of a comprehensive career preparation strategy Jackson (2018); Kayyali (2024).

The gap between career aspirations and preparedness is a well-documented issue that affects many undergraduate students. This gap can manifest in various ways, from unrealistic expectations about job prospects to a lack of understanding of the steps needed to enter a particular field Osborne and Grant-Smith (2017). In other cases, students may have a vague sense of their career aspirations but lack the knowledge or resources to pursue them effectively. This can lead to a cycle of frustration and disengagement, where students feel overwhelmed by the demands of career preparation and unsure how to proceed YouScience (2022). The consequences of this gap can be significant. Students who are unprepared for the job market may struggle to find employment, leading to periods of unemployment or underemployment. Even when they secure jobs, they may find that their roles do not align with their aspirations, resulting in job dissatisfaction and a lack of fulfillment. Therefore, institutions of higher learning have a crucial role in addressing the gap between career aspirations and preparedness. Universities and colleges are uniquely positioned to provide students with the education, resources, and support needed to achieve their career goals.

In the subsequent sections, we perform a literature review on the role of institutes of higher learning (IHLs) in seeking to gain perspectives on students' career preparedness. Next, we outline the method used in this preliminary work to investigate students' skill development, career awareness, and perception of how the university supports their skills development. Then, using a data-driven approach, we perform analytics on the survey responses to illuminate themes and techniques practitioners can adopt for advancing career preparation. Lastly, we discuss future approaches driven by learning analytics to bridge the skills gap before concluding.

## 2. Literature Review

IHLs are pivotal in preparing students for successful careers in an increasingly competitive and complex job market. As the landscape of work evolves due to technological advancements, globalization, and changing industry demands, the responsibility of universities and colleges to equip students with the necessary skills and knowledge has become more critical than ever. This section reviews how IHLs have contributed to career prepared-

ness, including curriculum design, experiential learning opportunities, career services, and partnerships with industry.

One of the strategies universities use to enhance employability is embedding career management skills within their curricula. Bridgstock (2009) emphasizes that universities must focus on developing technical competencies and career management skills that enable students to navigate the complexities of the job market. By integrating these skills into academic programs, institutions can help students become more proactive in managing their careers and better equipped to handle future career transitions. Similarly, Tymon (2013) explores how students perceive employability and the role universities play in preparing them for the workforce. This study highlights the importance of a balanced approach, where academic knowledge and practical skills are developed to meet employer expectations.

While domain skills remain essential, there is growing recognition of the importance of soft skills in the modern workplace. Andrews and Higson (2008) conducted a study that underscored the significance of soft skills, such as communication and teamwork, and hard business knowledge for graduate employability. The study found that employers increasingly value graduates who can demonstrate a combination of these skills, which are critical for adapting to dynamic work environments. Cranmer (2006) further critiques the effectiveness of employability initiatives, arguing that while universities have good intentions, the outcomes are often mixed. Specifically, Cranmer et al. found that while some employability-focused educational practices positively influence graduates' skills and readiness, others show limited or no significant impact, suggesting a need for a more nuanced understanding of what works and why. Cranmer et al. further emphasized that focusing on soft and hard skills is necessary to achieve the desired employability outcomes, suggesting that universities must continually refine their approaches to better prepare students for the job market demands. Initial effort has been made among some IHLs to provide students with a list of skills they have developed through skills tagging with human-in-the-loop artificial intelligence (AI) Lai et al. (2024). Skills tagging refers to the process of identifying and categorizing specific skills within a dataset, such as resumes, job descriptions, or educational curricula, using predefined labels or frameworks. This technique allows for systematic analysis and alignment of skill sets with career requirements. To facilitate this process, human-in-the-loop AI ensures human judgment is integrated into the AI system to guide, validate, or improve its outputs. This methodology ensures that automated processes are supplemented with human oversight to enhance accuracy and relevance, particularly in contexts requiring nuanced decision-making, such as skills mapping. The use of AI can significantly improve the efficacy and speed at which skills tagging can be performed.

Career development learning is another essential component of university efforts to enhance employability. In a report, Watts (2006) discusses the importance of integrating career development learning into higher education, arguing that it plays a vital role in helping students understand the link between their studies and future careers. This approach ensures that students are acquiring knowledge and developing a clear understanding of how to apply it in professional contexts. This is supported by another comprehensive report by Artess et al. (2017) on employability, highlighting how universities contribute to skills development and career preparation. They emphasize the importance of a holistic approach that includes career counseling, skills workshops, and opportunities for experiential learning.

Experiential learning, such as internships, co-op placements, and work-integrated learning, is a central strategy that universities use to boost employability. Wilton (2012) examines the impact of work placements on skill development and career outcomes, highlighting how these experiences are vital for cultivating technical and professional skills. By engaging in hands-on activities, students gain a deeper understanding of the practical

aspects of their chosen fields, which significantly enhances their confidence and readiness for the workforce. Similarly, Smith and Worsfold (2013) emphasize that work-integrated learning extends beyond mere experience. They argue that these programs foster essential professional skills, such as problem-solving and adaptability, which employers increasingly value in a dynamic job market. Furthermore, these experiential learning such as work-integrated learning when implemented with social equity in mind may support retention of students from less affluent background. Banerjee and Bingen (2024); Castleman and Meyer (2019); Lee et al. (2021); I. W. Li and Jackson (2023).

Beyond experiential learning, universities are increasingly implementing pedagogical approaches that prioritize employability. Knight and Yorke (2003) discuss several pedagogical strategies designed to enhance employability, including project-based learning, interdisciplinary courses, and the incorporation of real-world problems into the curriculum. These methods enable students to develop a broad set of skills that are directly applicable to their future careers, thereby increasing their attractiveness to potential employers. In addition, Cai (2012) contributes to this conversation by proposing a conceptual framework for understanding and measuring employability from the perspective of employers. Cai suggests that universities need to look beyond traditional assessments and evaluate how their programs contribute to the overall employability of their graduates. By embracing this comprehensive approach, institutions can better ensure that they are effectively preparing students for the demands of the workforce.

Despite the extensive research on the role of universities in skills development and career preparation, a significant gap remains in understanding student perceptions of these efforts. While much of the existing literature focuses on institutional strategies and employer expectations, integrating learning analytics is essential for gaining deeper insights into how effectively universities support students in their career preparation journeys. This data-driven approach enables institutions to pinpoint areas where students feel inadequately supported and tailor interventions to better align with their career aspirations. Incorporating learning analytics in this study enhances our understanding of student experiences and provides actionable insights for universities to refine their career preparation strategies. By leveraging learning analytics, universities can more accurately assess their performance in preparing students for the workforce and identify specific areas for improvement, ultimately leading to more effective and personalized support for diverse student populations.

## 3. Methodology

This study aimed to thoroughly explore the alignment between undergraduate students' career aspirations, their perceived skill development, and the role of higher education institutions in addressing the skills gap that often exists between academic training and the demands of the workforce. Specifically, this work sought to understand how well students' educational experiences and institutional support aligned with the competencies and knowledge required for their desired career paths. To investigate whether the broad range of course types offered met the intended skill development goals from which students benefited in their career preparation, a comprehensive survey among undergraduate students ($n = 143$) was conducted. The study gathered detailed insights into students' career aspirations, their awareness of the skills and qualifications necessary for their intended professions, and their perceptions of their university's effectiveness in fostering these essential skills.

A survey methodology was employed in this study, which was conducted at the Nanyang Technological University, Singapore, between January to April 2024. The target participants, aged 18 to 25, were students currently applying for an internship placement,

typically happening one to one and a half years before graduation. This group was particularly suitable for research on career preparation for several reasons. Firstly, these students were actively engaged in the career preparation stage of their professional journey, making them an ideal population to examine the processes and challenges associated with career preparation. They were in the midst of acquiring practical experience and likely had fresh perspectives on the skills and competencies required in the workplace. Additionally, as they were not yet graduating, their focus remained on bridging the gap between academic learning and professional application, providing valuable insights into how educational institutions could better support this transition. Due to this timing in their candidature, their knowledge base was another reason for selecting this target group. We expected their responses to differ from those of students in the earlier years of their candidature. Studying this group could yield critical data on the effectiveness of current career preparation programs and highlight areas for improvement to better equip students for future employment.

The survey (refer to Appendix A) consists of multiple sections designed to gather comprehensive data from students about their aspirations and awareness related to their skill development and preparation for their desired career paths. The breakdown of the goals and aims for each section section are as follows:

1. Section 1: Participant Information and Consent. This section is designed to collect participant information and to ensure informed consent. This section aims to comply with ethical standards, confirm eligibility criteria, and ensure that participants understand the study's purpose and voluntarily agree to participate. This section also identifies the participants' disciplines, majors, and any minors they are pursuing.
2. Section 2: Factors Influencing Course Selection. This section assesses the importance of different factors in students' decisions to choose non-core courses. Understanding what influences students' decisions when selecting courses that are not core requirements helps to identify areas where the university could better support students.
3. Section 3: Desired Industry and Skill Assessment. This section determines the primary industry in which participants aim to secure their first job after graduation. Additionally, students were prompted to identify the skills they consider important for their desired industry and evaluate their self-perceived readiness and development through various university activities. Lastly, how students perceive employers' priorities helps in understanding students' perceptions of employer expectations.

For context, the institution's curriculum structure for the typical undergraduate for a single-degree program is divided into three main components: Core and Major Prescribed Electives (MPEs) (50–60%), Interdisciplinary Collaborative Core (ICC) courses (20–30%), and Broadening and Deepening Electives (BDEs) (20%). Core courses and MPEs provide foundational and advanced learning specific to the student's major discipline and specialization. ICC courses, including foundational courses like effective communication, digital literacy, practical professional internship, and co-curricular learning, focus on key transferable skills and global challenges. Lastly, BDEs offer opportunities to explore interests outside of the major or deepen existing skills and knowledge. Core and ICC courses form the compulsory segment of a student's curriculum. At the same time, MPEs and BDEs allow students to choose from various classes offered institution-wide. In Section 2 of the survey, we are interested in determining the factors that influence different groups of students to choose their MPE and BDE. Students were tasked to rate, according to importance, on a Likert scale, a list of factors they might deem important when choosing elective courses.

In the final section of the survey, we explore the alignment between students' perceived skill requirements and their current competencies. The initial step involved asking each student to select the first choice industry they want to enter upon graduation. This approach

allowed the participants to focus on a career they were genuinely interested in, ensuring that their responses would be relevant and meaningful to their aspirations. The list of industries aligned with the Singapore Standard Industrial Classification Singapore Department of Statistics (2020). After selecting their desired industry, students were prompted to identify three key skills that they believe are crucial. This exercise aimed to capture the students' perceptions of the most important competencies associated with their chosen careers. Identifying these skills provided insight into the participants' understanding of the job's demands and the skills they deem essential for professional success.

Following the identification of important skills, students were asked to rate their sentiments toward a series of statements related to the skills they had identified. These statements were crafted to assess how the students acquired these skills and perceived readiness for their future careers. In the final step of the study, students were instructed to reflect on their current skill sets and identify three skills they do not yet possess but consider necessary for the job they had chosen. This self-assessment was crucial in identifying perceived skill gaps and understanding how students view their preparedness for the workforce. The exercise also helped to highlight areas where further training or education may be needed to bridge these gaps.

The invitation to participate in this study was sent by the institution's career office via electronic digital mail, targeting all eligible students across various disciplines. Participation was voluntary, and participants were assured anonymity and confidentiality to encourage honest and accurate responses.

## 4. Results and Discussion

In this section, we report the results of our survey. We received returns from 154 respondents, of which 143 provided complete sets of responses. Table 1 presents the demographic characteristics of the participants, collected in Section 1 of our survey, including their academic discipline. Here, we broadly classify academic disciplines into two categories: Science, Technology, Engineering, and Mathematics (STEM) and Social Sciences, Humanities, and the Arts for People and the Economy (SHAPE).

**Table 1.** Participant statistics for the survey.

| | **N** | **(%)** [a] |
|---|---|---|
| **Participants** | **143** | **100.0** |
| *STEM* | 74 | 51.7 |
| Sciences | 24 | 16.8 |
| Engineering | 30 | 21.0 |
| Data Science | 20 | 14.0 |
| *SHAPE* | 69 | 48.3 |
| Humanities and Social Sciences | 26 | 18.2 |
| Business | 43 | 30.1 |

[a] Percentages may not sum to 100% due to rounding errors.

We analyze the survey responses at the aggregated and discipline levels using machine learning methods such as hierarchical clustering Murtagh and Contreras (2011); Ward (1963) and $k$-nearest neighbors Cover and Hart (1967); Fix and Hodges (1989); Taunk et al. (2019) for classification, coupled with non-parametric statistical analysis such as the Mann–Whitney $U$ and Chi-squared ($\chi^2$) tests Franke et al. (2011); Mann and Whitney (1947). All statistical analyses were performed using the `Python` (version `3.11.0`) package `SciPy v1.13.0`, supported by `NumPy 1.22.4`.

### *4.1. Cluster Analysis of Factors Influencing Students' Course Choices*

In Section 2 of the survey, the students were asked to rate the importance of a list of factors in choosing elective courses. The factors and responses are recorded in Figure 1.

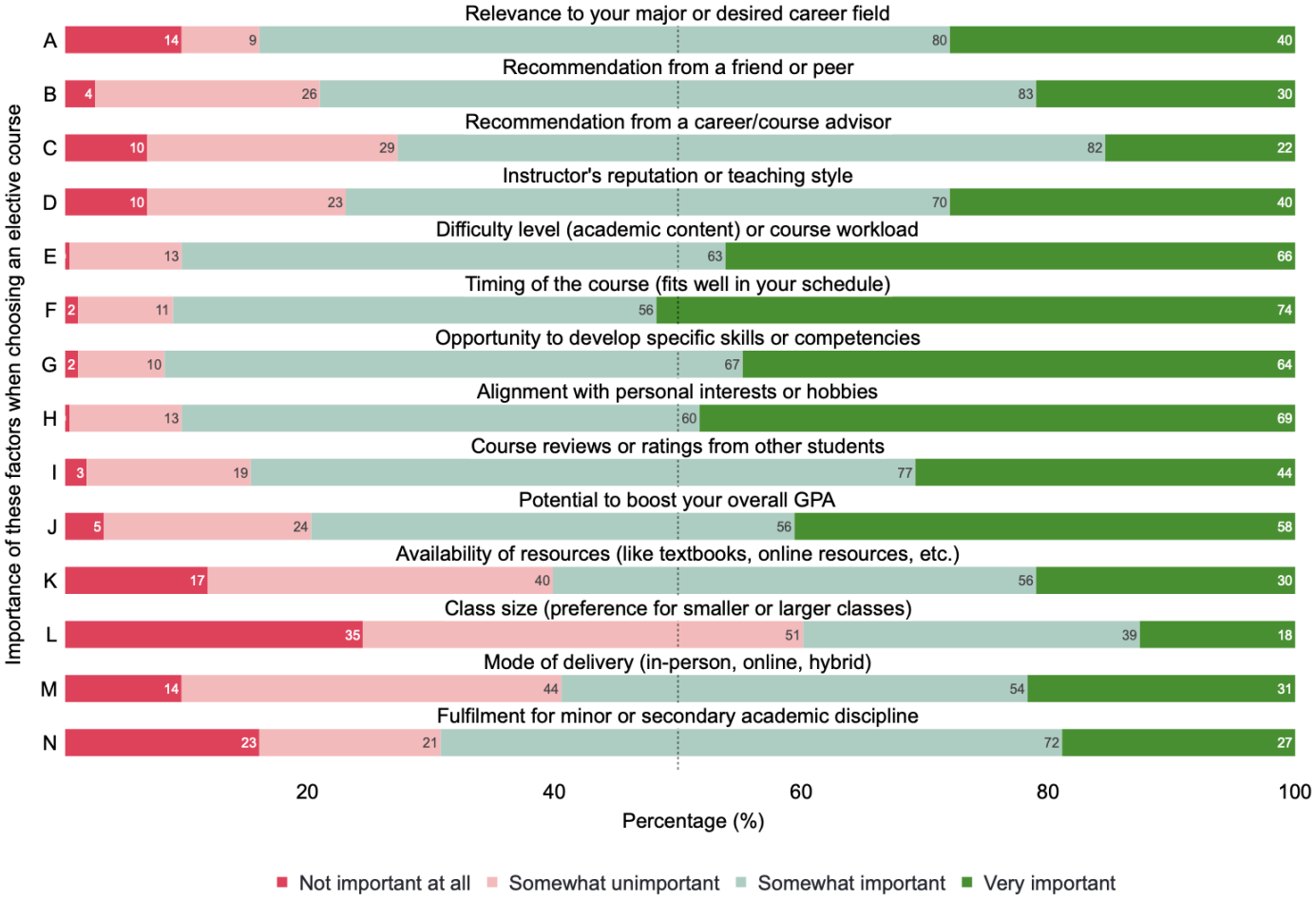


**Figure 1.** Responses to Question 2.1 of the survey. This question asks participants about the degree of importance of these factors when choosing a non-core course.

Referring to the results in Figure 1, factors E, F, G, and H are highly important (≥90% importance rating) to students when choosing non-core courses. These factors can be categorized into "Practical Considerations" and "Personal and Professional Development". In particular, students prefer courses that match their perceived ability to handle academic content and workload. They also prefer courses that fit their schedules rather than dealing with classes with conflicting schedules. The most important factor for students from our survey indicates a strong desire by students to choose courses that allow them to gain skills and competencies that will benefit their academic and professional careers. Many students also value courses that align with their interests, indicating a preference for engaging and enjoyable learning experiences. The results from statements A, B, C, D, I, and J indicate that, while important, they might not be the primary drivers of course selection (≥70% importance rating). These factors can be categorized into "Academic Relevance" and "Social Influence". When choosing an elective, a sizable number of students still take into consideration their major and its potential impact on their grade point average (GPA) (factor J). This suggests that while non-core courses are meant to broaden and deepen students' academic exposure in fulfillment of their major or secondary academic discipline (factor N), relevance to their degree program and impact on future careers is predominantly

of greater importance to students. Peer recommendations, either from a friend or past course ratings and evaluations, are moderately important in influencing decisions but are not the primary factor for most students. Lastly, the participants rated factors K, M, and N as less important, with L as the least important.

Having presented the aggregated results, it is essential to delve deeper into the nuances that underpin these findings. Understanding the aggregated data offers a comprehensive overview, yet it often conceals the diverse perspectives and considerations of individual groups. To gain a more detailed understanding, we will now analyze two distinct groups of students by their discipline of study. This analysis will explore the factors each group considers important, highlighting potential differences in priorities and decision-making processes. By examining these variances, we aim to uncover valuable insights that can inform targeted strategies and interventions, ultimately enhancing the educational experience for all students.

We perform hierarchical clustering on the responses from students from the two disciplines (STEM vs. SHAPE). Hierarchical clustering is a method of cluster analysis that seeks to build a hierarchy of clusters. It is commonly applied in bioinformatics for gene expression data analysis Ciaramella et al. (2020); Nidheesh et al. (2019); Pirim et al. (2012), marketing for customer segmentation Afzal et al. (2024); Rungruang et al. (2024), and text mining for document clustering Rong and Liu (2020); Yang et al. (2021). This method, applied here, creates a dendrogram and visually represents the inherent grouping of statements from the survey responses, which aids in interpretability Fonseca (2012); Murtagh and Contreras (2011). The process begins with each data point as its own cluster, then progressively merges pairs of clusters based on their similarity until all points are contained in a single cluster. In our case, “points" refer to the factors, and “similarity" refers to the nearest mean rating for the factors. Hierarchical clustering is particularly useful for data exploration and pattern recognition, especially in cases where the underlying structure of the data is not immediately apparent. We apply Ward’s method of agglomerative hierarchical clustering Ward (1963) to obtain the dendrograms in Figure 2. We found that the optimal number of hierarchical clusters for STEM and SHAPE disciplines are $k = 4$ and $k = 5$, respectively.

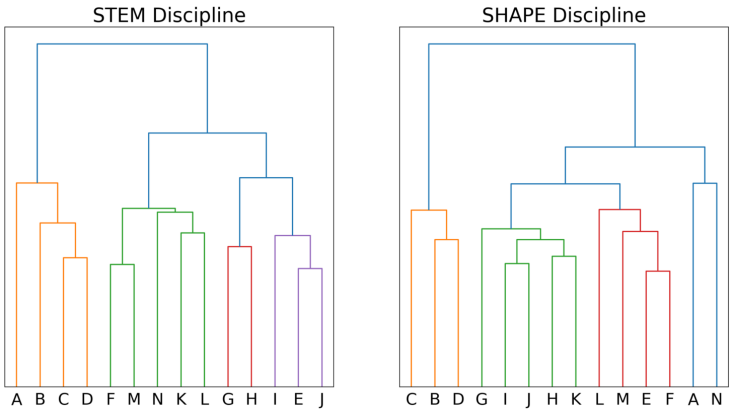


**Figure 2.** Hierarchial clustering of questions by discipline. The number of clusters for the STEM discipline is $k = 4$, while the number for the SHAPE discipline is $k = 5$.

To analyze hierarchical clustering results, we perform the Mann–Whitney *U* Test on the mean rating of the nearest cluster pairs. Although the use of mean rating is typically not recommended for ordinal data, in this instance, it is employed to provide a useful indication of the average rating for a cluster of responses rather than for individual responses. This approach allows for a straightforward comparison and summary of the data, offering valuable insights into the trends and patterns within and between the clusters. Table 2 shows

the cluster numbers, cluster members (factors A to N), and mean ratings. A comparison between the nearest clusters shows two cluster pairings with statistical significance.

**Table 2.** Mean cluster ratings for STEM and SHAPE discipline clusters.

| Cluster # | STEM Cluster Members | Mean Rating | SHAPE Cluster Members | Mean Rating |
|---|---|---|---|---|
| 1 | A, B, C, D | 2.4696 | B, C, D | 2.6860 |
| 2 | F, K, L, M, N | 2.8730 | G, H, I, J, K | 3.3681 |
| 3 | G, H | 3.3851 | E, F, L, M | 3.1196 |
| 4 | E, I, J | 3.2432 | A | 2.9130 |
| 5 | - - - | - - - | N | 3.0290 |

The Mann–Whitney *U* Test results reveal significant mutual differences between STEM Cluster 4 and SHAPE Cluster 3 ($p = 0.0229$, $r = -0.1020$), highlighting distinct preferences in their nearest cluster pairings. These findings underscore the variability in factors considered important by each group. STEM students cluster factor E (potential to boost GPA) with performance-related factors I (timing of course) and J (difficulty level or course workload). In contrast, SHAPE students cluster factor E with peer and advisement factors F (course reviews or ratings from other students), L (recommendation from career/course advisor), and M (recommendation from a friend or peer). This indicates that STEM students prioritize elements directly related to their academic performance and scheduling flexibility, focusing on how a course can enhance their GPA, fit into their schedule, and manage workload difficulty. In contrast, SHAPE students emphasize insights from peers and advisors, including feedback from past students and recommendations from advisors and peers.

These findings provide insights into the diverse priorities of each group, suggesting that tailored strategies can better support students in achieving their career aspirations. For STEM students, enhancing academic support and offering flexible scheduling can play a crucial role in their career preparedness, particularly by facilitating the selection of electives and courses that align with their professional goals. This could include providing detailed information about course difficulty and workload management, ensuring that students can make informed choices that develop the skills necessary for their future careers. Meanwhile, SHAPE students may benefit more from improvements in peer and advisement networks, which can guide them in identifying courses and opportunities that build relevant competencies for their career paths. By fostering strong advisor and peer recommendation systems and ensuring easy access to career-related course information, institutions can help SHAPE students align their academic choices with their professional ambitions. Understanding these nuances allows educational institutions to design programs and support systems that address students' academic needs and enhance their readiness for the workforce. By addressing these priorities in the context of career preparation, institutions can create a more supportive and effective learning environment that equips all students with the skills and knowledge necessary for their future careers.

### *4.2. Classification Analysis of Perceived Important Skills and Skills Gap*

Section 3 forms the bulk of the survey, focusing on skills. The first question required survey respondents to choose the industry that was their first choice after graduation. Following their response to this question, students were tasked to list three skills that they deem important for that industry. These skills were then classified using the *k*-nearest neighbor (*k*-NN) algorithm to classify these skills. Subsequently, students further listed their skills gap, and the same classification was performed.

These student inputs required standardization and normalization to address lexical inconsistencies because students entered skills freely rather than from a set list. After performing word stemming, we labeled 10% of the given responses as training data and used cosine similarity to capture semantic relationships between the rest of the skills. We then perform analysis to test hypotheses and assess whether there are statistically significant differences in the distribution of skill categories between STEM and SHAPE students when students identify important skills and their skills gap. We can further examine how perceptions shifted when students were first tasked to identify important skills and then to recognize their skills gap within each group. The number of skills identified is summarized in Table 3. Detailed results are presented in Figures 3 and 4. We used four classifications of skill types to conduct and analyze the survey responses. The four skill types are as follows:

1. Soft Skills
   - Definition: Non-technical or interpersonal skills crucial for success in the workplace.
   - Examples: Communication, teamwork, problem-solving, time management, and adaptability.
2. Functional Skills
   - Definition: Practical skills that allow individuals to work confidently and effectively.
   - Examples: Data analysis, project management, customer service, basic IT skills, and sales techniques.
3. Domain Skills
   - Definition: Technical or hard skills, specific knowledge, and abilities required in a particular field.
   - Examples: Programming languages, accounting, mechanical engineering, graphic design, and clinical research.
4. Requirement Skills
   - Definition: Mandatory certification or license that a specific job requires.
   - Examples: CPA license, teaching certification, driver's license, medical license, and real estate license.

**Table 3.** Summary table of skill types identified by survey participants. These skills were categorized using *k*-NN classification.

| | Important Skills | | Skills Gap | |
|---|---|---|---|---|
| **Skill Type** | **STEM** | **SHAPE** | **STEM** | **SHAPE** |
| Soft | 98 | 118 | 89 | 71 |
| Functional | 79 | 68 | 104 | 102 |
| Domain | 41 | 21 | 23 | 25 |
| Requirement | 0 | 0 | 0 | 0 |

We perform $\chi^2$-tests of independence to assess whether the differences in distributions are statistically significant for the following comparisons:

(a) Between STEM and SHAPE disciplines for important skills
   - H0: There is no difference between the field of study when identifying important career skills.

(b) Between STEM and SHAPE for skills gap
   - H0: There is no difference between the field of study when identifying career skills gap.

(c) Between important skills and skills gap within the STEM discipline

- H0: There is no association between the perception of importance and the reported skills gap among STEM students.

(d) Between important skills and skills gap within the SHAPE discipline

- H0: There is no association between the perception of importance and the reported skills gap among SHAPE students.

The results are presented in Table 4. Our analysis reveals both discipline groups perceive similar gaps in their skill types, especially in functional skills, suggesting a common area of concern regardless of their field. There is a notable shift within STEM students from valuing soft skills (highest in importance) to recognizing a more significant gap in functional skills. This suggests that while they understand the importance of soft skills, they feel more deficient in practical, functional skills. SHAPE students value soft skills the most, but similar to STEM students, they report more significant gaps in functional skills. This discrepancy highlights a potential misalignment between their skill priorities and perceived competencies.

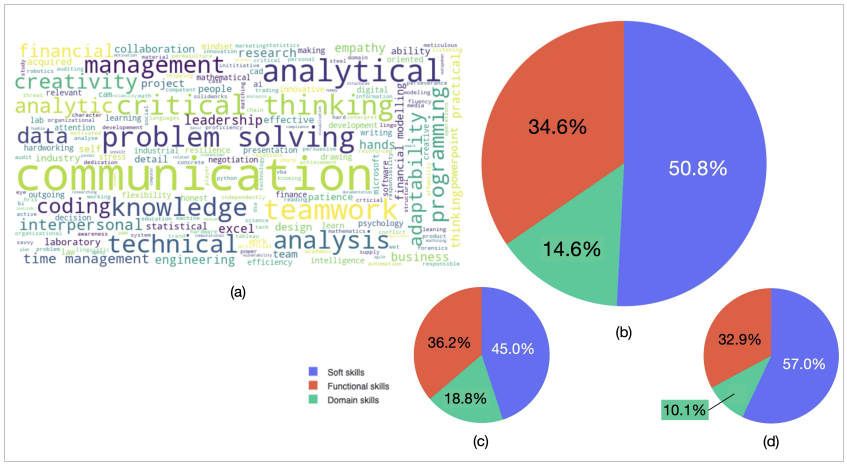


**Figure 3.** Responses to Questions 3.2 of the survey. This question asks participants to list three important skills for their desired chosen industry, collated in (**a**) a word cloud. *k*-NN clustering was used to classify the skills into four categories for (**b**) all survey participants, (**c**) among STEM participants, and (**d**) among SHAPE participants.

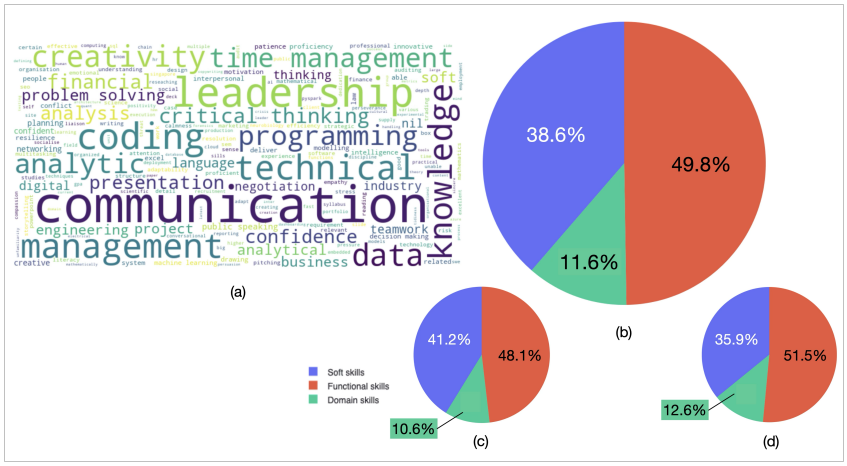


**Figure 4.** Responses to Questions 3.4 of the survey. This question asks participants to list three skills they lacked, collated in (**a**) a word cloud. *k*-NN clustering was used to classify the skills into four categories for (**b**) all survey participants, (**c**) among STEM participants, and (**d**) among SHAPE participants. The percentages may not add to 100% due to rounding errors.

BDE and ICC courses are often designed to cultivate essential skills, including both soft skills—such as communication, teamwork, and problem-solving—and functional skills, such as digital literacy, computational thinking, and interview techniques. These skills are increasingly recognized as crucial for career success across various fields, helping students navigate complex, real-world scenarios that require adaptability and specialized knowledge. However, despite these intentions, there appears to be a significant disconnect between the courses' intended outcomes and students' perceptions of their effectiveness. This disconnect raises concerns about whether the educational objectives of these courses are being fully realized, particularly in the areas that students value most for their career preparedness.

**Table 4.** Summary of $\chi^2$-test results.

| H0 | $\chi^2$-Statistic | df | $p$-Value | Significance ($\alpha = 0.05$) |
|---|---|---|---|---|
| (a) | 9.06 | 2 | 0.011 | Significant |
| (b) | 1.35 | 2 | 0.51 | Not Significant |
| (c) | 8.81 | 2 | 0.012 | Significant |
| (d) | 18.71 | 2 | 0.00009 | Significant |

Interestingly, students perceive that they develop many important skills through their Core and MPE courses, likely because these courses are closely aligned with domain-specific skills and knowledge. While this focus on domain skills is valuable, it raises questions about where functional skills are being developed within the curriculum. Students deem functional skills, such as digital literacy and critical thinking, crucial. Yet, our findings suggest that BDE and ICC courses may not adequately address these competencies. This highlights a significant skills gap in the curriculum that warrants closer examination.

When students are explicitly asked whether they have developed the skills they identified as important through BDE and ICC courses (see Figure 5), their responses indicate below-average agreement. This suggests that, despite the focus on fostering soft and functional skills, students may not feel that they are gaining the desired competencies or fully recognize the value of the skills they acquire. The perceived disparity between developing domain-specific skills in core courses and acquiring functional skills in other parts of the curriculum is particularly concerning. The misalignment between the goals of these courses and students' experiences highlights a critical need for educators to re-evaluate the structure and content of BDE and ICC programs. It may be necessary to enhance the way these courses integrate and emphasize both soft and functional skills, ensuring that students not only acquire these competencies but also clearly understand their relevance and application to their career aspirations.

Additionally, this gap underscores the importance of improving communication about the purpose and benefits of these courses, helping students better appreciate the role of both soft and functional skills in their overall education and career preparedness. Addressing these issues could lead to more effective educational programs that better meet the needs of students, bridging the gap between domain-specific knowledge and the functional skills necessary for the demands of the modern workforce.

Finally, we note that none of the surveyed students identified requirement skills as important or a skills gap. We can provide some reasons for this phenomenon. Students might not yet be at a stage in their education or careers where skills such as certifications or licenses are required immediately. For example, many certifications are only required upon entry into the workforce rather than during their course of study. Therefore, students may be more focused on acquiring knowledge and skills directly applicable to their current coursework and less concerned with future certifications or licenses, which may seem distant or irrelevant at this stage. Furthermore, students may assume that obtaining require-

ment skills is something they will naturally achieve as part of their professional journey. They might see these as a standard part of their future career process, not as a current skill gap or pressing concern. Crucially, this is not indicative of the perceived lack of importance on the part of the students. When asked to rank the skill groups in order of importance, according to how they perceive employers will rank them, requirement skills were ranked in the top 2 by more than half (73 out of 143 students, see Table 5). Thus, the absence of focus on requirement skills among students likely reflects their current educational stage and priorities. While these skills are undoubtedly required for employment, students may not yet feel the urgency to address them, especially if they view them as future concerns that will be dealt with as they approach graduation and entry into the workforce.

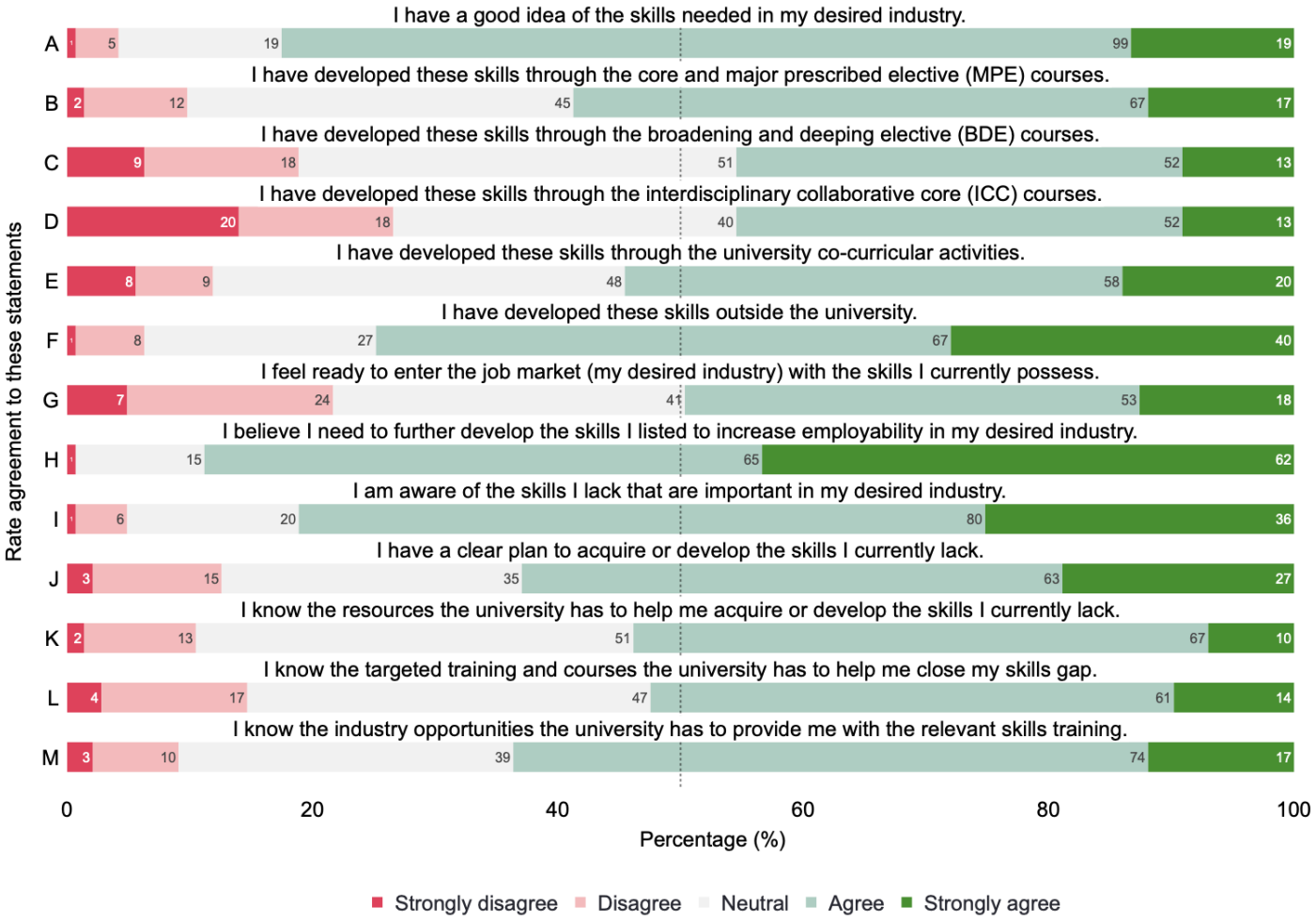


**Figure 5.** Responses to Questions 3.3 and 3.6 of the survey. This question asks participants to rate their agreement with these statements about the industry and skills identified.

**Table 5.** Results of the distribution of responses. Students ranked the four skill categories according to how they perceived employers would rank them, with the skill type of highest importance ranked "1".

| | Rank | | | |
|---|---|---|---|---|
| **Skill Type** | **1** | **2** | **3** | **4** |
| Soft | 51 | 37 | 27 | 28 |
| Functional | 28 | 39 | 54 | 22 |
| Domain | 30 | 28 | 39 | 46 |
| Requirement | 34 | 39 | 23 | 47 |

The findings of our study highlight both strengths and areas for improvement in how the university supports student awareness and utilization of resources for skills development. According to our results, as compiled in Figure 5, a significant portion of the respondents agree with the statement about their awareness of skills that are important in their desired industry (81%, Statement I), and naturally, fewer students have a clear plan to acquire or develop these skills. (62.9%, Statement J). Of interest, then, is how the university has supported these students. From our survey, while the majority of students recognize the availability of resources (53.8%, Statement K) and targeted training (52.4%, Statement L) within the university, this is significantly lower than the former two, suggesting that there may be a gap in how effectively these resources are integrated into their academic and career planning. Conversely, when it comes to industry opportunities, the university is seen to facilitate this (63.6%, Statement M). This indicates that while the university has been successful in sharing industry-related opportunities to close skills gaps, it may need to do more to help students connect these opportunities with their academic pathways.

To better support students in their career aspirations, the university should focus on enhancing its efforts to help students develop clear plans for skills development and improve the clarity and visibility of how its courses and training programs align with important career-related skills. By addressing these gaps, the university can strengthen its role in preparing students for the workforce, ensuring that they not only recognize the available resources but also effectively leverage them in their career development.

## 5. Future Work

This study provides valuable insights into students' perceptions of their career aspirations and skill development. However, there are several avenues for future research and continuing work that can build on these findings. Future research can focus on longitudinal studies that could be conducted to track changes in students' perceptions of their skills and preparedness over time, from their initial years of study through to graduation and entry into the workforce. A deeper investigation into specific elements of unrestricted and interdisciplinary courses that either succeed or fail in developing the desired soft and functional skills needs to be conducted. This could involve qualitative studies, such as interviews or focus groups, to gain deeper insights into students' experiences and identify specific areas for improvement in curriculum design and delivery. Another promising direction for future work is developing and testing targeted interventions that can bridge the gap between students' career aspirations and perceived skills gaps. These interventions could include enhanced career counseling, skill-building workshops, or revised course structures that effectively integrate skills development.

Additionally, several areas are ripe for further exploration. One critical direction involves investigating whether students' current jobs or internships align with their future career goals. This alignment, or lack thereof, could significantly shape students' perceptions of their skill development and career readiness. Recognizing the importance of this factor, we have already initiated a follow-up study to examine the influence of these roles on career outcomes in more detail. Another promising area for further research is the unique experiences of students, in particular, first-generation students. These students often face distinct challenges, such as navigating unfamiliar academic and career landscapes without the benefit of prior family experience. A deeper exploration of their specific needs and the effectiveness of existing institutional support systems could provide actionable insights for creating more inclusive and equitable educational environments. In a similar vein, examining socioeconomic status and affluence differences across students could illuminate how access to resources affects access to skill development opportunities and experiential learning programs. For example, unpaid internships may disproportionately exclude

students from lower-income backgrounds, potentially exacerbating inequalities in career preparedness. A more detailed investigation of these issues could help identify strategies to mitigate such disparities and ensure equitable access to career development opportunities for all students. Addressing these areas in future studies would contribute to a more nuanced and comprehensive understanding of the diverse factors that shape students' career outcomes and the role of higher education institutions in supporting their success.

Integrating AI and learning analytics in skills and course advising presents a transformative opportunity for higher education institutions to enhance student success. By leveraging AI, educational institutions can analyze vast amounts of student data, including academic performance, career aspirations, and skill development progress, to provide personalized course recommendations tailored to individual needs and goals. Integrated career preparation platforms enable learning analytics for real-time tracking of student engagement and skill acquisition, offering insights to guide targeted interventions and support. This approach ensures that students select courses that align with their academic and career objectives and focus on areas where they may have skills gaps. Additionally, AI-powered advising systems can predict future career trends and emerging skill demands, helping students stay ahead in a rapidly evolving job market. Overall, using AI and learning analytics in advising can create a more dynamic, responsive, and effective educational experience, ensuring students are well-prepared for their future careers.

## 6. Conclusions

In conclusion, this study has explored the complex relationship between career aspirations and preparedness among undergraduate students, highlighting the multifaceted challenges they face as they transition from academia to the workforce. The hierarchical clustering analysis of course selection factors shows distinct preferences between STEM and SHAPE students. STEM students emphasize academic performance and scheduling flexibility, while SHAPE students value peer recommendations and advisement. This indicates the need for tailored strategies in higher education to address the unique priorities of different student groups.

Our survey-based analysis reveals significant insights into students' perceptions of essential skills and the gaps they identify in their competencies. While STEM and SHAPE students prioritize soft and functional skills, there are clear differences in how they perceive their preparedness and the support they receive from their educational institutions. Moreover, the classification of skills highlights a common concern across disciplines regarding functional skills, with both groups identifying significant gaps in this area. Despite emphasizing soft skills in unrestricted and interdisciplinary courses, students report a disconnect between these courses' intended outcomes and their perceived effectiveness. This suggests that institutions need to reassess the structure and delivery of such courses to ensure they meet students' needs and adequately prepare them for the evolving job market. By addressing these issues, higher education institutions can better support students in aligning their aspirations with the realities of the workforce, ultimately enhancing their career readiness and success.

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## Appendix A. Survey Questions

Q1.1–Q1.3: Demographic questions.
Q2.1: This question is about the degree of importance of these factors when choosing an elective course. [1—not important at all, 2—somewhat unimportant, 3—somewhat important, 4—very important].

A: Relevance to your major or desired career field
B: Recommendation from a friend or peer
C: Recommendation from a career/course advisor
D: Instructor's reputation or teaching style
E: Difficulty level (academic content) or course workload
F: Timing of the course (fits well in your schedule)
G: Opportunity to develop specific skills or competencies
H: Alignment with personal interests or hobbies
I: Course reviews or ratings from other students
J: Potential to boost your overall GPA
K: Availability of resources (like textbooks, online resources, etc.)
L: Class size (preference for smaller or larger classes)
M: Mode of delivery (in-person, online, hybrid)
N: Fulfillment for minor or secondary academic discipline

Q3.1: Which industry is the FIRST (1st) choice for your first job after graduation?

- Accounting and Audit
- Aerospace and Aviation
- Agriculture
- Banking and Finance
- Biomedical Sciences
- Chemicals
- Commodity and Natural Resources
- Consumer Business
- eCommerce
- Education
- Energy
- Engineering and Manufacturing
- Food, Beverages, and Tobacco
- Healthcare
- Hospitality and MICE

- Information and Communication Technology
- Insurance
- Logistics
- Management and HR Consulting
- Maritime and Shipping
- Media and Marketing
- Non-Profit
- Oil and Gas
- Public Service
- Real Estate, Building and Construction
- Research and Development
- Retails Trade
- Transportation
- Utilities
- Water and Environment
- Wholesale Trade
- Others

Q3.2: For my desired first choice, the skills that are important (in my opinion) are: [please give 3 skills]
Q3.3: This question is about your response to Q3.1 and Q3.2. Please rate your agreement with the following statements:

A: I have a good idea of the skills needed in my desired industry.
B: I have developed these skills through the core courses.
C: I have developed these skills through the elective courses.
D: I have developed these skills through the interdisciplinary courses.
E: I have developed these skills through the university co-curricular activities.
F: I have developed these skills outside the university.
G: I feel ready to enter the job market (my desired industry) with the skills I currently possess.
H: I believe I need to further develop the skills I listed to increase employability in my desired industry.
I: I am aware of the skills I lack that are important in my desired industry.
J: I have a clear plan to acquire or develop the skills I currently lack.

Q3.4: The important skills that I currently lack are: [please give 3 skills]
Q3.5: Based on your response to Q3.4, how do you know these are important skills?
Q3.6: Please rate your agreement with the following statements:

K: I know the resources the university has to help me acquire or develop the skills I currently lack.
L: I know the targeted training and courses the university has to help me close my skills gap.
M: I know the industry opportunities the university has to provide me with the relevant skills training.

Q3.7: Rank the following skill groups, in order of importance, according to how you perceive employers will rank them. [1—most important, 4—least important].

- Soft skills
- Functional skills
- Domain skills
- Requirement skills

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